L'ÉVÉNEMENT DES GRANDES CULTURES

Les Culturales® 2023

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SUMMARY

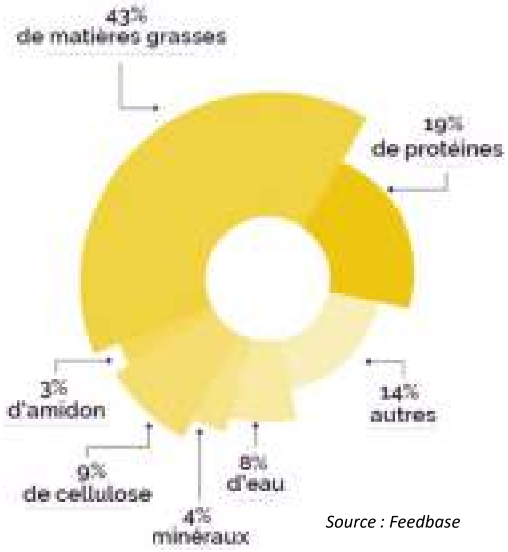
SPACE 2 : PLANT HEALTH P.53

Space 1 :

FOOD SAFETY

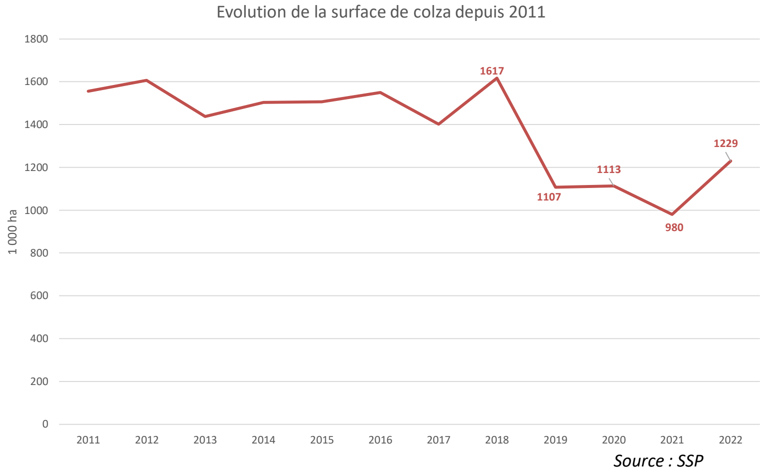
The French rapeseed sector

A seed rich in oil



Source : Feedbase

A decrease in rapeseed acreage since 2018



Source : SSP

Because of climate contraints and strong pest pressure

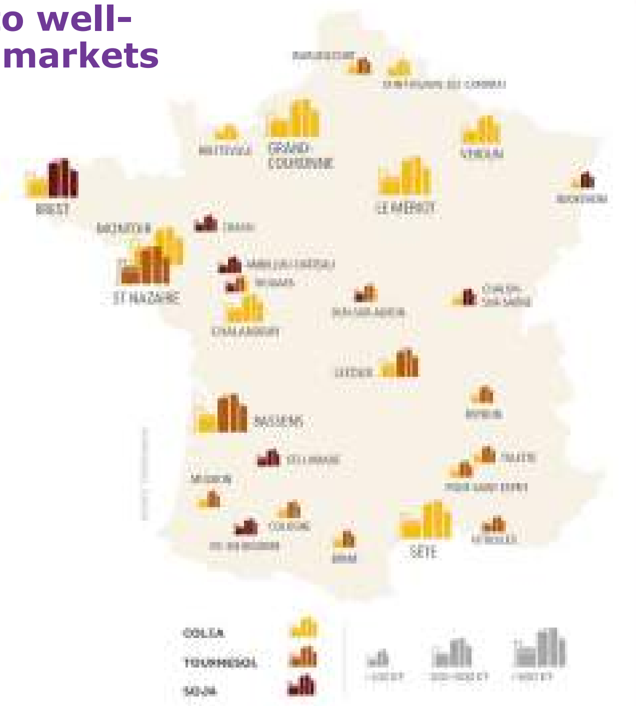
A seed mostly crushed in France thanks to well-established and structuring downstream markets

Ressources for 2021/22 :

- Production : 3,3 million tonnes (Mt), most of which is collected : 3.2 Mt = 97% of collection.
- Imports : 1,6 Mt (mainly from Australia, Canada, EU et Ukraine). (mainly from Australia, Canada, EU and Ukraine).

Uses for 2021/22 :

- **Crushing : 4 Mt, which represent 80% of the resources, in about twenty factories all around France.**
- Exports : 0,9 Mt, 90% to the EU (mainly Germany, Belgium and the Netherlands).



Uses of processed products

Unrefined oils
1,8 Mt produced in 2021
Source : FEDIOL

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Biodiesel production

- **Structuring outlet for the sector**, highly dependent on regulation.
- **Positioning of the French sector on low GHG emissions biodiesel** for export to northern European countries.
- Process: transesterification and incorporation into diesel.

1/3

Food

- Distribution as **edible oil**, use in the formulation of various products.
- Nutritional quality: oil with very good balance of fatty acids, **rich in unsaturated fatty acids and especially omega-3 (☐ 9%)**

Oilseed cakes
35% proteins
2,5 Mt produced in 2021
Source : FEDIOL

Feed

- **Consumption of 2.5 Mt => self-reliance. Importance of this sector for the search of protein autonomy.**
- Mainly for ruminants and pigs.

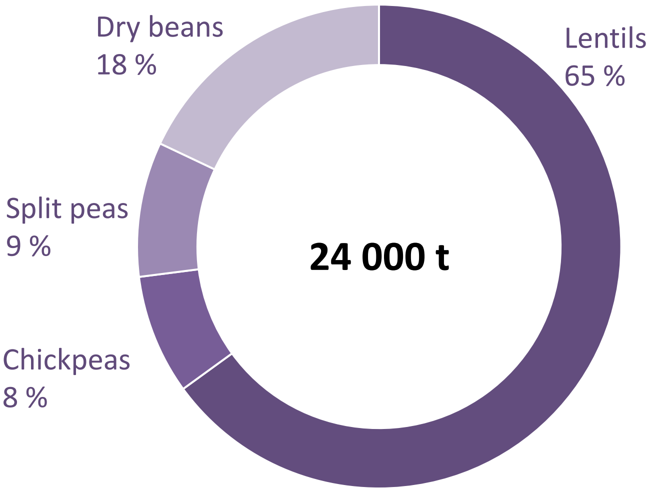
E1_01_1

Uses of lentils and chickpeas in France

Data for 2021

	Lentil	Chickpea
Area	34 700 hectares (ha) including 51% of organic	18 900 ha including 39% of organic
Production	23 500 tonnes (t)	25 400 t
Import	32 100 t	9 500 t
Export	4 000 t	23 500 t

Sales of bagged pulses in supermarkets in 2021

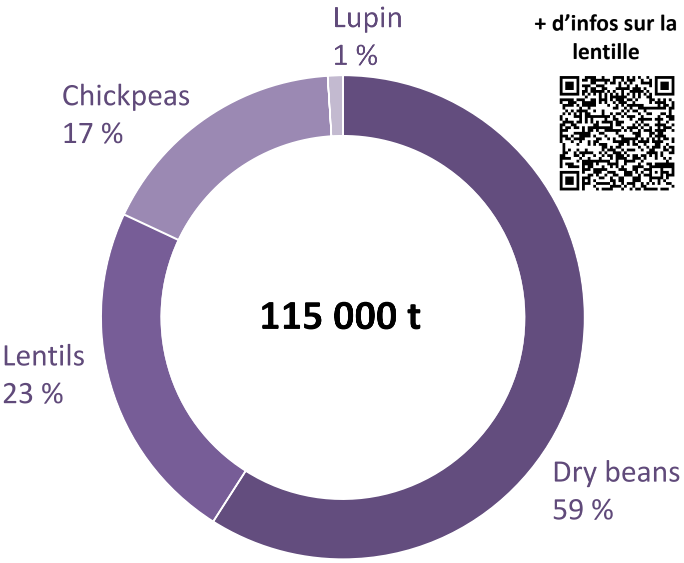


GMS : grandes et moyennes surfaces

- About 820 t of ready meals containing lentils were sold in supermarkets in 2021 against 40 t for chickpeas.
- In 2021, chickpeas are the only pulse incorporated into fresh supermarket spreads (hummus) and are experiencing dynamic sales in France as in northern Europe!
- About 3,200 t of lentils and 200 t of raw chickpeas were purchased by out-of-home catering in 2021 compared to 1,800 t of lentils and 3,100 t of pre-cooked chickpeas that make it possible to avoid the time of soaking chickpeas.

- Pulses are often contractualized before sowing, which enable the producer to secure his outlet and the collector and the downstream manufacturers, their supply.
- Quality standards are high, especially for unprocessed grains (size, colour, absence of pea weevil damage …).
- The production of lentils in France, mainly green lentils, remains insufficient compared to the growing market.
- Imports are mainly blond and red lentils, and large chickpeas, which are not produced in France.

Sale of canned pulses in supermarkets in 2021



+ d'infos sur la lentille

Sources : Terres Univia d'après FranceAgriMer, AgenceBio, Douanes et autres sources professionnelles

E1_01_2

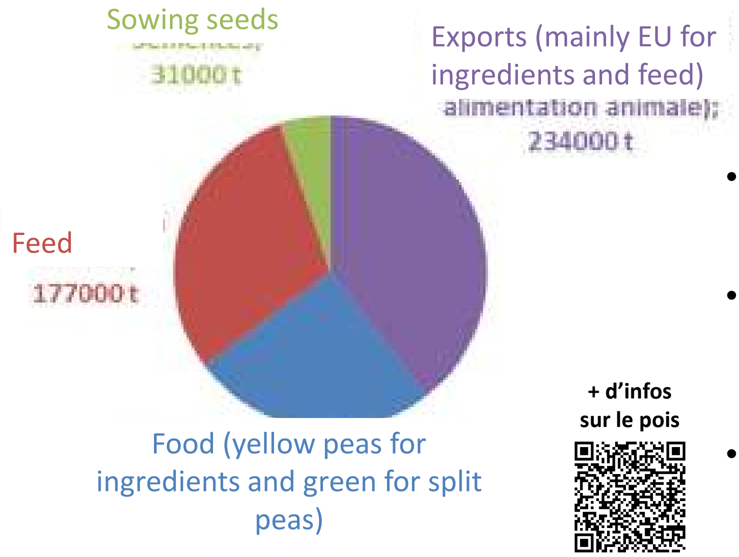
Uses of field peas and field beans in France

Les Culturales 2023 14-15 juin

Data for 2021

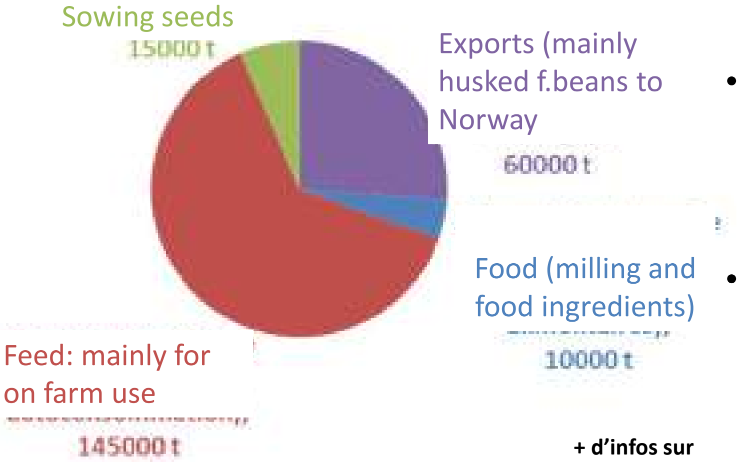
	Pois	Féverole
Area	195,000 hectares (ha) including 6%of organic (pure crops)	77,000 ha including 26% of organic (pure crops)
Yield	28.4 quintals (q)/hectare (ha)	23,6 q/ha
Production	555 000 tonnes (t)	182 000 t
Import	57 000 t 🇷🇺 🇱🇹	54 000 t 🇬🇧

Uses of peas in 2021/2022



+ d'infos sur le pois

Uses of field beans in 2021/2022



+ d'infos sur la féverole

- Rich in starch and protein, low in anti-nutritional factors (peas and some varieties of field beans), non-allergenic, peas and field beans offer prospects for development in food and feed.
- The food outlet is most often contractualized; Quality standards are higher than for feed.
- The grains are splitted into protein, starch and fibre and then used as ingredients for food in an increasing number of products.
- Uses by feed manufacturers remain limited by the lack of grains and their high substitutability for other raw materials.
- Belgium represents a strong market for French peas for ingredient manufacturing and feed.
- French field beans are no longer exported to Egypt for human consumption (weewil), but it has found a market in Norway, in husked form, for fish farming.
- A small part of green peas production are used for split peas or bird feed. A small part of field beans are used in flour milling industry

Terres Univia

Sources : Terres Univia d'après FranceAgriMer, AgenceBio, Douanes et autres sources professionnelles

E1_01_3

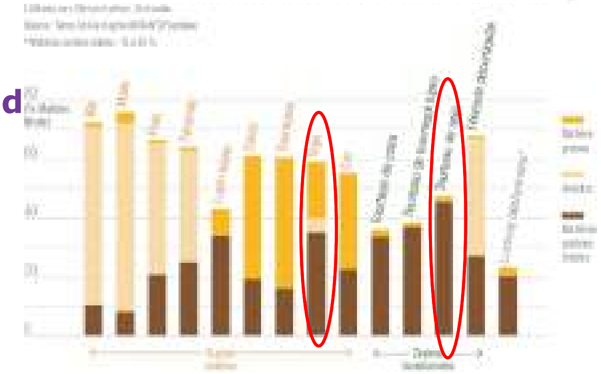
The French soybean sector

Acreage reach a ceiling

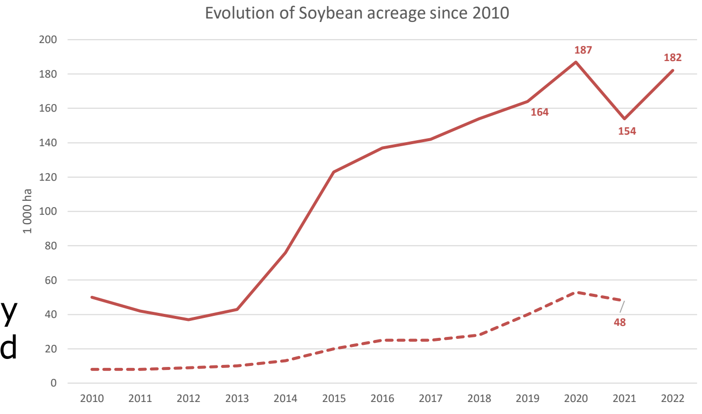
Due to yields variations related to climatic conditions, and a lack of competitiveness.

Simplified nutritional content of seeds and meals

seed



Proteins represent about 40% of the dry matter + a good amino acid balance and good digestibility.



Source : SSP

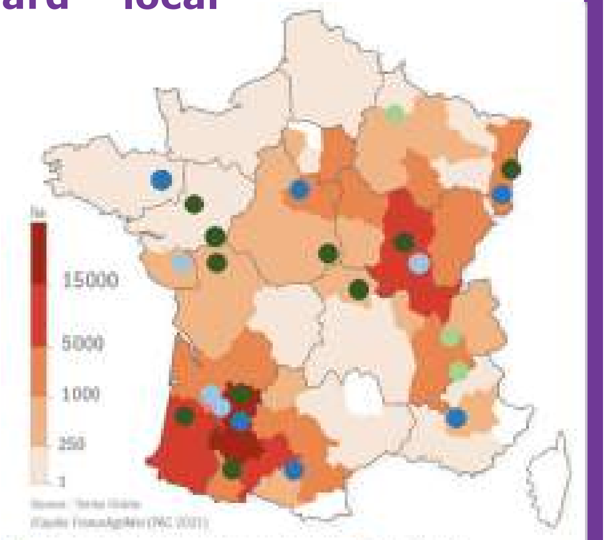
A production mainly oriented toward local market…

For feed :

- Structuring around 10 regional processing units, producing more and more fatty expeller cakes.
- Highly integrated units for grain supply and oilcake sales.

For food :

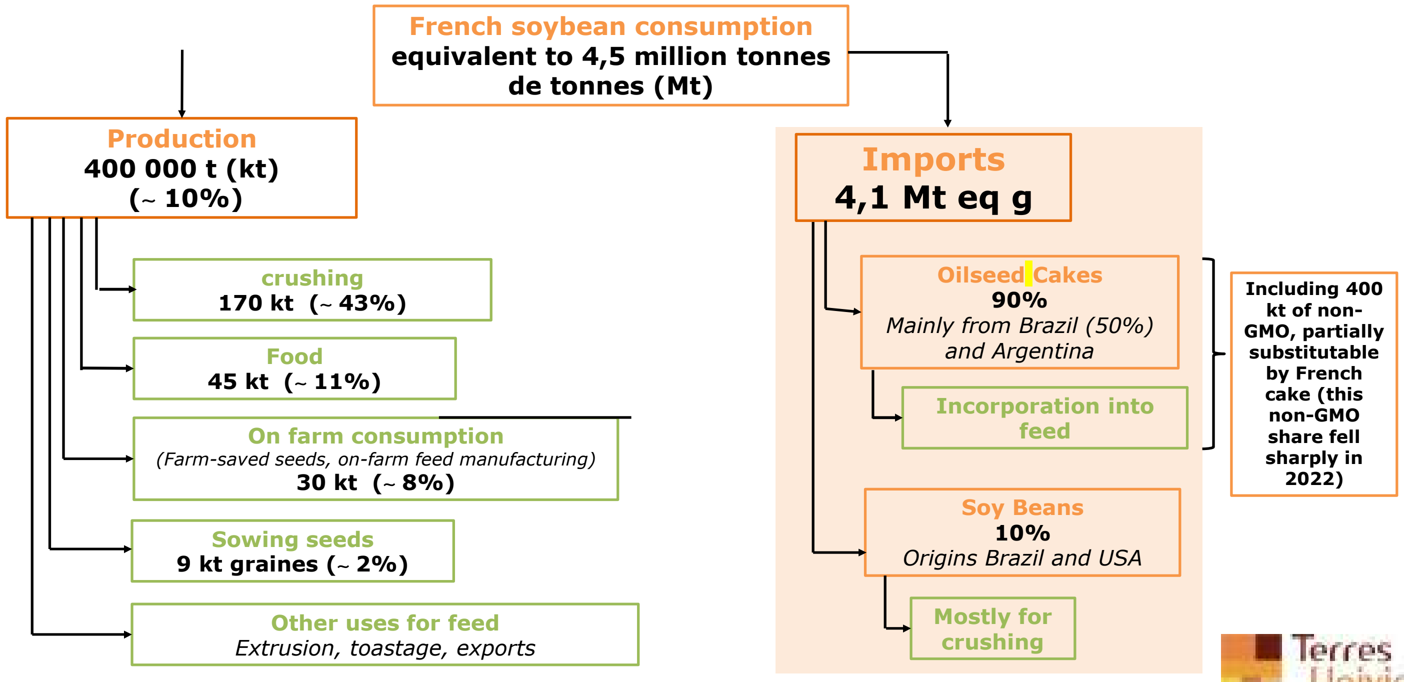
- Production of soyfood (drinks, desserts, tofu, etc.) or textured proteins.
- A 100% French or even regional supply.



● Processing units (functionning) ● Soyfood
● Processing units (future) ● Texturised proteins

Source : Terres Univia

… but which remains far below the needs



French soybean consumption equivalent to 4,5 million tonnes de tonnes (Mt)

Production
400 000 t (kt)
(~ 10%)

crushing
170 kt (~ 43%)

Food
45 kt (~ 11%)

On farm consumption
(Farm-saved seeds, on-farm feed manufacturing)
30 kt (~ 8%)

Sowing seeds
9 kt graines (~ 2%)

Other uses for feed
Extrusion, toastage, exports

Imports
4,1 Mt eq g

Oilseed Cakes
90%
Mainly from Brazil (50%) and Argentina

Incorporation into feed

Including 400 kt of non-GMO, partially substitutable by French cake (this non-GMO share fell sharply in 2022)

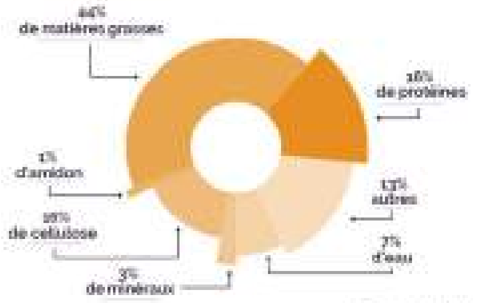
Soy Beans
10%
Origins Brazil and USA

Mostly for crushing

Sources : Estimations Terres Univia d'après sources diverses et sur base de moyennes quinquennales 2017-2021

The French sunflower sector

A seed rich in oil



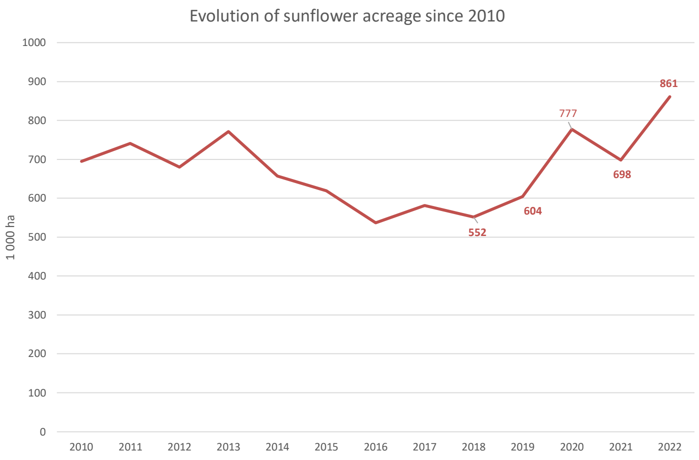
Source : Feedbase

2 types of sunflower :

- **Classic or linoleic:** rich in linoleic acid (omega 6), 30% of acreage ;
- **Oleic:** rich in oleic acid (omega 9), 70% of acreage (which is an exception in the European Union (EU), where 95% of acreage is cultivated with linoleic).

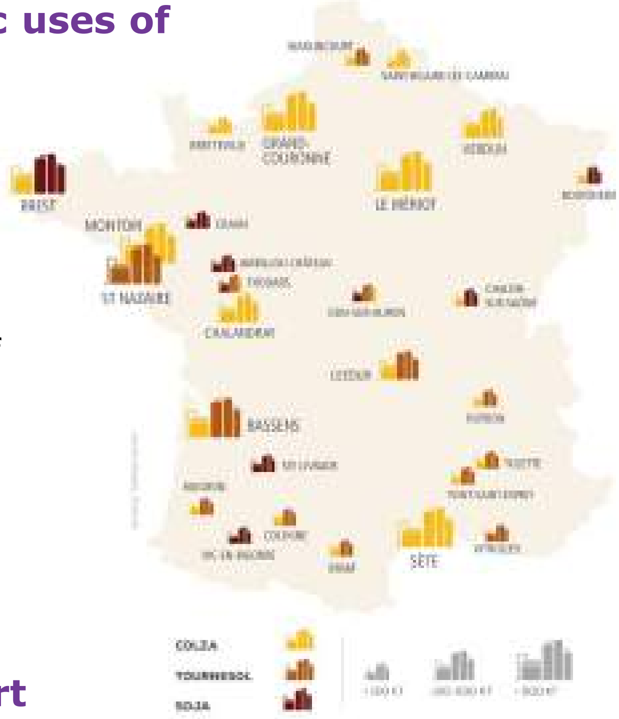
Increasing acreage

Sunflowers may become more important due to their rusticity (low input requirements) and good drought tolerance in the context of climate change.



Source : SSP

Domestic production covers domestic uses of seeds



Ressources for 2021/22 :

- Production : 1.9 Mt, most of which 1.7 Mt are collected (89%).
- Imports : 0,2 Mt (73% from Romania).

Uses for 2021/22 :

- Crushing : 1.3 Mt, which represent 68% of resources, in a dozen factories all around France. *3 possibilities for quality of cake: Low, Mid and High-Pro*, depending on the level of husking.
- Exports : 0.6 Mt, 96% to the EU (mainly Spain, the Netherlands and Belgium).

Uses of triturated products and import needs

Unrefined oils
530 kt produced in 2021
Source : FEDIOL

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Food

- **The most consumed oil in France, above olive oil.**
- **Two qualities :** linoleic oil (rich in omega 6, used for bottled oil and margarine production) and oleic oil (used for frying or making compound oils).

1/4

Biodiesel or oleochemicals production
Minority outlet, varying according to market conditions.

The balance of trade is balanced, but exports of oleic oil and imports of linoleic oil.

Oil Cake
Low et Mid-Pro
690 kt produced in 2021
Source : FEDIOL

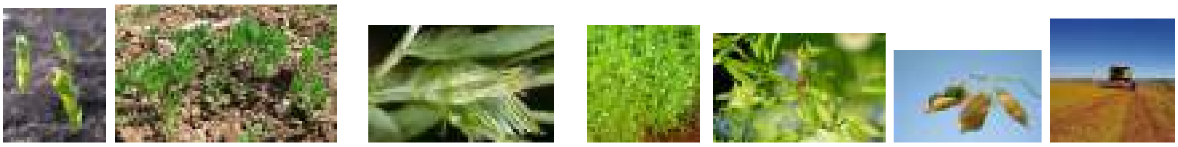
Feed

- Very flexible to use (no antinutritional compound).
- Incorporation according to the species dependent on the quality of the oilcakes.

Consumption of 1.3 Mt (excluding exports) in 2021, which represent a deficit of 53%.
More of 700 kt are imported (mainly from Ukraine, Argentina, Belgium and Russia).
Mostly High-Pro quality.

Lentil – Common itinerary

Lentil in conventional agriculture



Sowing | Emergence | Leaves | Flower buds | Flowering | Pods | Maturity | Harvest

Certified seed 270 gr/m² — 150 €

P: 30 kg/ha, **K** : 60 kg/ha — 180 €

Pre-emergence
Challenge 600 3 l/ha + Nirvana S 1 l/ha — 97 €

Post emergence
Challenge 600 1 l/ha — 25 €

Antigrasses
Etamine 1,2 l/ha — 33 €

Sitona + aphids
Cythrine max 0,05 l/ha + Mavrik Smart 0,2 l/ha — 14,5 €

Ascochytosis / Grey rot
AMISTAR 0,5 l/ha + Prosaro 0,5 l/ha — 45 €

Brown rust
Amistar
0,5 à 0,8 l/ha
Pay attention to the deadline to be respected before harvest — 15 €

Seed	150 €/ha	Fertilization	180 €/ha	Herbicides	155 €/ha
Insecticides	14,5 €/ha	Fungicides	60 €/ha	**Operating costs 560 €/ha**	

Average yield: 15 - 25 q/ha
Indicative selling price: 500 to 650 €/t
Coupled aid (CAP 2023 prices): 104 €/ha

Indicative gross margin: **294 to 1169€/ha**

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Lentil in organic farming

Sowing | Emergence | Leaves | Flower buds | Flowering | Pods | Maturity | Harvest

Certified seed 310 gr/m² — 240€

Pre-emergence
Weeding with harrow comb possible — 14 €

Post emergence:
Weeding with harrow comb possible from 3/4 leaves up to 6/7 leaves — 14 €

Post emergence:
Possible weed topping — 30 €

Seed	240 €/ha
Weeding	58 €/ha

Operating costs 298 €/ha

Average yield: 7 - 15 q/ha
Indicative selling price: 1100 to 1400 €/t
Coupled aid (CAP 2023 prices): 104 €/ha

Indicative gross margin: **576 to 1906 €/ha**

Positives	Negatives
• Adapt to many types of soils • Nitrogen input in rotation → Atmospheric nitrogen fixation through symbiosis • Good precedent for cereals	• Sensitive to drought/heat strokes • Low competition at the beginning of the cycle • Grain quality degraded by bruchus weevils

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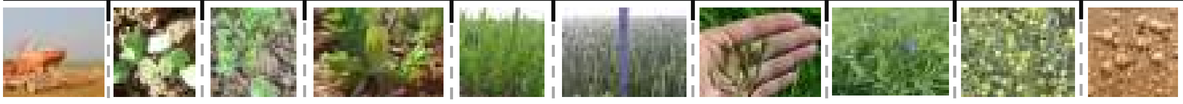
E1_01_6

Oilseed flax –Common itinerary

Winter oilseed flax



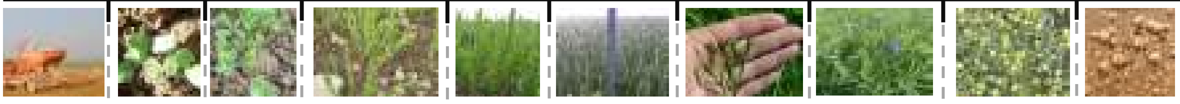
	Sowing	Emergence	2 to 5 cm	1st ramifications	20 cm *Recovery*	30 to 50 cm	E5 Corymb	Beginning of flowering	End of flowering	Maturity Harvest
Seed 50 €/ha	**Certified seed Zc coating**									
Fertilization 320 €/ha	**P :** 40 kg/ha **K :** 40 kg/ha				**N :** 80 kg/ha					
Herbicides 80 to 130 €/ha			**Early POST EMERGENCE**	**Foliar antigrass**		**If necessary POST EMERGENCE**				
Growth regulator 23 €/ha					**Regulator** TOPREX 0.3l/ha					
Insecticides 0 €/ha										
Fungicides 39 to 62 €/ha			**Kabatiellose/ septoriosis** SCORE 0.25l/ha				**Septoriosis/powdery mildew** SCORE 0.25 à 0,5 l/ha			

Yield: 1,5 to 2,5 T/ha
Selling price: 650 – 700 €/T

Input costs: 512 to 585 €/ha

Gross margin = 400 to 1150 €/ha

Spring oilseed flax



	Sowing	Emergence	2 to 5 cm	10 cm	20 cm	30 to 50 cm	E5 Corymb	Beginning of flowering	End of flowering	Maturity Harvest
Seed 90 €/ha	**Certified Seed Zc coating**									
Fertilization 320 €/ha	**P :** 40 kg/ha **K :** 40 kg/ha				**N :** 80 kg/ha					
Herbicides 50 to 110 €/ha			**Early POST EMERGENCE**	**Foliar antigrass (option)**						
Growth regulator 0 to 15 €/ha					**Regulator** No treatment to TOPREX 0.15l/ha					
Insecticides 16 €/ha			**Altises (option)** DECIS PROTECH 0,5l/ha				**Thrips (option)** MAGEOS MD 0,07kg/ha			
Fungicides 39 €/ha								**Septoriosis/powdery mildew** SCORE 0,5 l/ha		

Yield: 1,5 to 2 T/ha
Selling price: 650 – 700 €/T

Input costs: 515 to 590 €/ha

Gross margin = 385 to 885 €/ha

Positives	Negatives Winter oilseed flax	Négatives Spring oilseed flax
• Diversifies rotation • False host of the broomrape (orobanche) • Good previous crop • Contractualized crop	• Sensitive to lodging • little coverage	• Sensitive to dry/hot strokes

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Chickpeas – Common itinerary

Chickpeas in conventional

Sowing | Emergence | 2 nodes | 8 nodes | Pre-flowering | Beginning of flowering | End of flowering | Pod formation | Maturity harvest

Certified seed
170 €/ha

Certified seed
55 grains/m²

Fertilization
74 €/ha

P : 20 kg/ha
K : 20 kg/ha

Herbicides
122 €/ha

Insecticides
36 €/ha

Fungicides
40 €/ha

Pre emergence
NIRVANA S 1.7 l/ha
KERB FLO 1,875 l/ha
(early sowing only)

70 €

Post emergence
ONYX 1,5 or 2x 0.75l/ha

52 €

The strategy depends on the stage and the beginning of the flight

Héliothis

DIPEL DF 1 kg/ha ou HELICOVEX 0,2 l/ha

28 €

KARATE ZEON 0,075 l/ha

8 €

Ascochytosis

AMISTAR 0.8l/ha

AMISTAR 0.8l/ha

2 x 20 €

Operating costs
442 €/ha

Indicative gross margin = 652 to 1037 €/ha

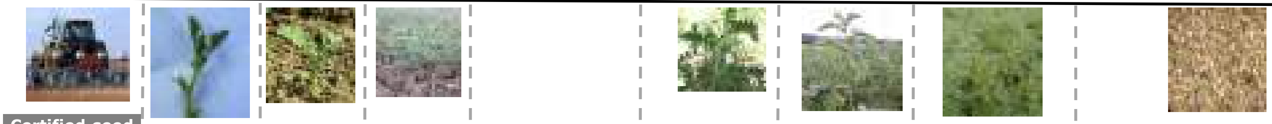
Yield:	18 to 25 q/ha
Selling price:	550 €/t

Gross revenue = 990 to 1375 €/ha
+ Coupled aid: 104 €/ha (CAP 2023)

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Chickpeas in organic farming

Sowing | Emergence | 2 nodes | 8 nodes | Pre-flowering | Beginning of flowering | End of flowering | Pod formation | Maturity harvest



Certified seed
200 €/ha

Certified seed
65 grains/m²

Post emergence:
Possible seed toppling

30 €

Mechanical weeding
84 €/ha

Pré Levée
Tine harrow

14 €

Post emergence
Tine harrow from 2-3 leaves
Hoeing possible if single-seed seeder, from 4-5 leaves

40 €

Operating costs
284 €/ha

Indicative gross margin = 450 to 1170 €/ha

Yield:	7 to 15 q/ha
Selling price:	900 €/t

Gross revenue = 630 to 1350 €/ha
+ Coupled aid: 104€/ha (CAP 2023)

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E1_01_8

Soybeans – Common itinerary

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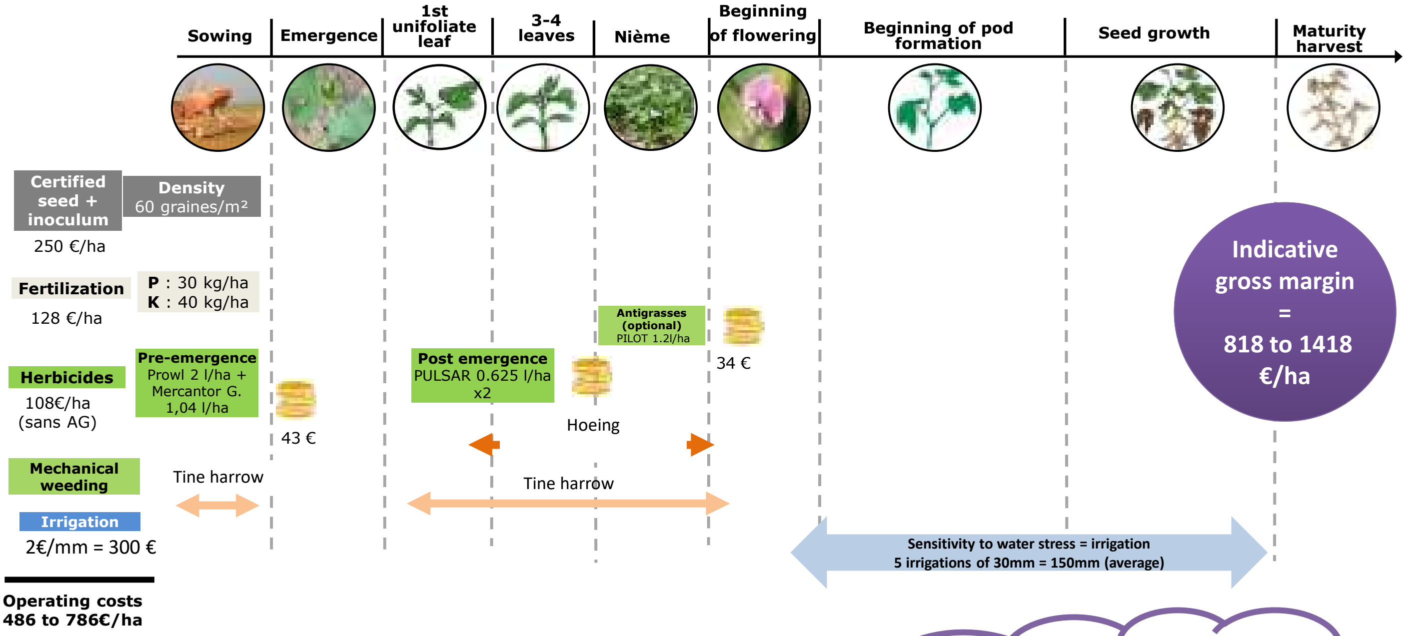
Conventional soybeans



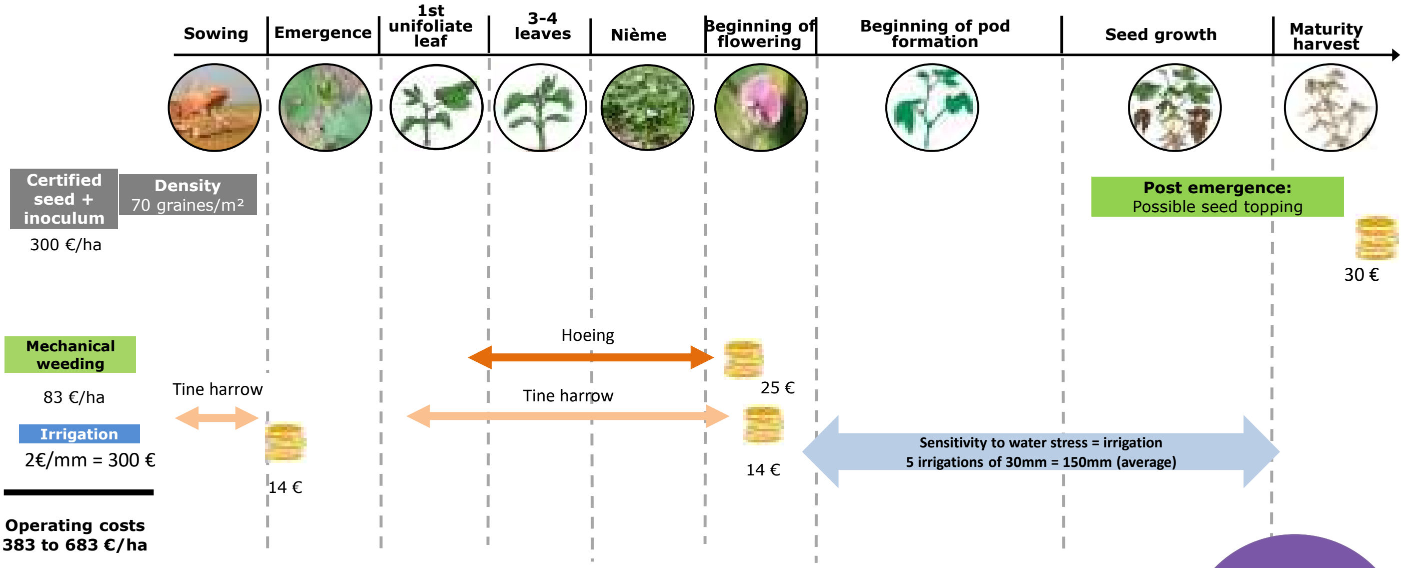
Indicative gross margin = 818 to 1418 €/ha

	Dry:	Irrigated:
Yield:	20-25 q/ha	25-35 q/ha
Selling price:	600 €/T	
Gross revenue:	1200 to 1500 €/ha	1500 to 2100€/ha

+ Aide couplée : 104€/ha (CAP 2023)

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Soybeans in organic farming



Indicative gross margin = 421 to 1800 €/ha

	Dry:	Irrigated:
Yield:	10-15 q/ha	20-25 q/ha
Selling price:	700 à 950 €/T*	
Gross revenue:	700 to 1425 €/ha	1400 to 2375€/ha

+ Coupled aid: 104€/ha (CAP 2023)

*Food or feed outlet

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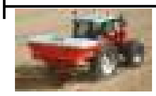
E1_01_9

Camelina: a small seed to discover

Main crop

about 100 days

Before sowing	Sowing	Emergence	Crop establishment	Active growth	Flowering	Maturity harvest



Seed
40 €/ha

Fertilization
324 à 368 €/ha

Pests

Herbicides
25 €/ha

Maladies

Operating costs
389 to 433 €/ha

P : 40 kg/ha
K : 40 kg/ha
148 €/ha

Density
5 kg/ha
N : 80 to 100 kg/ha
176 to 220 €/ha

Antigrass
Centurion R 0.8l/ha

8-10% humidity
Change from green to creamy yellow

Yield: 10 to 25 q/ha
Selling price: 480 €/t
Gross product = 480 to 1200 €/ha

Indicative gross margin = 47 to 811 €/ha

Catch crop

Previous crops	Sowing	Nitrogen	Weeding
Legume type (winter peas/lentil) or winter barley (by removing straws)	Sowing as close as possible to the harvest of the previous crop within 48 hours Direct sowing 8 kg/ha	40 kg/ha of nitrogen at sowing on previous cereals	Foliar antigrasses (e.g. Centurion R 0.8 l/ha in post-emergence to control cereal regrowth)
	64 €/ha	**88 €/ha**	**25 €/ha**

Operating costs
64 to 177 €/ha

Yield: 4 to 20 q/ha
Selling price: 480 €/t
Gross product = 192 to 960 €/ha

Indicative gross margin = 15 to 896 €/ha

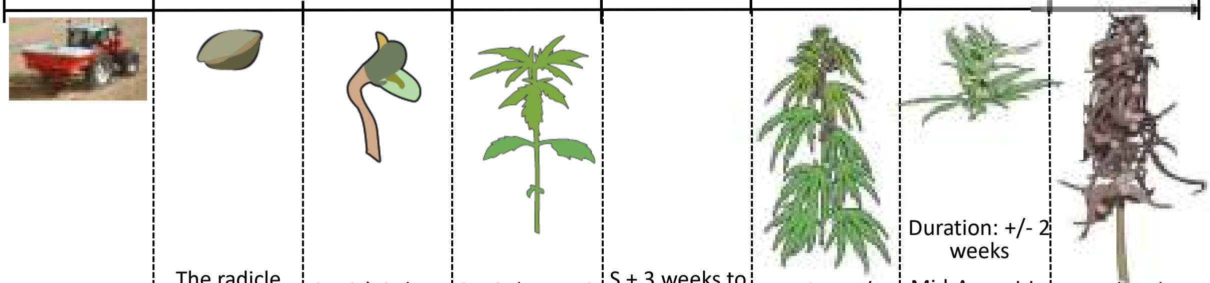
Outlets

Biofuel for aviation

Interest	Needs
• Diversifies rotation • Low nutrient requirements • Little phytosanitary treatment in vegetation • Short-cycle plant • Can be grown as a main crop or as a catch crop • Well adapted to an "organic" system • No specific equipment for sowing	• Can withstand temporary drought conditions but requires sufficient rainfall until flowering • Need for moisture to promote germination especially as catch crop , the main reason for failure • Rooting very sensitive to soil structure

Hemp

Common itinerary



Before sowing	Sowing (S)	Emergence	crop establishment	Active growth	Beginning of flowering	Full/End of flowering	Maturity Harvest
	The radicle comes out of the seed	S + 0 à 9 days Cotyledons are fully developed	S + 9 days to 3 weeks The 1st pair of leaves is fully unfolded	S + 3 weeks to 3 months The 8th pair of leaves is totally unfolded	Duration: +/- 1 week 10 % flowers are open. Appearance of the first pistils	Duration: +/- 2 weeks Mid-August to the end of August At the end of flowering, the beginning of the formation of the fruit is visible	Total cycle time: 120 to 150 days 95% of seeds are hard and dehiscent

Certified seed

214 €/ha

Density
45 – 50 kg/ha + CVO

Fertilization

P : 50 kg/ha
K : 150 kg/ha

N : 100 kg/ha

575 €/ha

355 €/ha

220 €/ha

Mechanization harvesting costs
Threshing
Mowing
Tedding
Swathing
Pressing
Handling
Storage
= 500 to 600 €/ha

Operating costs
789 €/ha

Grain yield: 0,6 à 1 t/ha
Selling price: 850 €/t
Straw yield: 6 à 9 t/ha
Selling price: 115 €/t
Coupled aid (base 2022): 98 €/ha
Gross product = 1298 to 1983 €/ha

Indicative gross margin with coupled aid
=
509 to 1194 €/ha

Semi-net margin
=
10 to 594 €/ha

Outlets

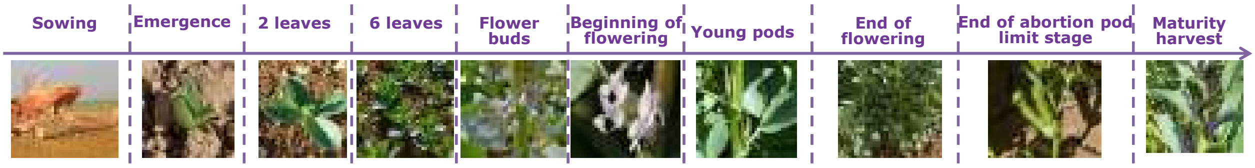
	Marché en %	Indice de prix	Tendances
Hemp chaff			
Litter for animals	50 %	1	→
Horticultural mulch	22 %	1,1	→
Building	14%	1,2	↗
Other outlets	14 %		→
Fibre			
Special papers	56%	2	→
Insulation	29%	2,5	→
Biosourced plastics	9%	3	↗
Other outlets	6%	3	
textile	émergent	4,5	↗
Hempseed			
Birds and fishing	84%	4	→
Human food	15%	5	↗
cosmetics	1%	6	↗

A regulation that evolves and allows the valorization of the flower

Positives	Negatives
• Diversifies rotation • Good preceding crop • No phytosanitary treatment in vegetation • Good drought resistance • Moderate nitrogen requirements • Little intervention in culture • Short-cycle plant • A reservoir of biodiversity • Well adapted to an "organic" system	• Mechanization, organization at harvest • Plant sensitive to compaction • Requires a storage building • Very fragile seed (must be dried within 12 hours after harvest – H ≤9% • broomrape: non-chlorophyll parasitic plant of hemp

Fababean – Common itinerary

Winter fababean



Certified seed 152 €/ha — **Density** 25 seeds/m²

Fertilization 239 €/ha — **P** : 60 kg/ha, **K** : 70 kg/ha

Herbicides 128 €/ha
- **Pre-emergence** Nirvana S 2l/ha Challenge 600 2l/ha — 88 €
- **Antigrasses** Kerb Flo 1.875 l/ha — 40 €

Insecticides 24 €/ha
- **Aphis fabae** Teppeki 0.14 kg/ha — 24 €

Fungicides 44 €/ha
- **Botrytis / Ascochytosis** Amistar 0.8l/ha — 22 €
- **Rust** Amistar 0.8 l/ha — 22 €

Operating costs 573 €/ha

Yield: 35 to 45 q/ha
Selling price (feed outlet): 320 €
Coupled aid: €104/ha (CAP 2023)

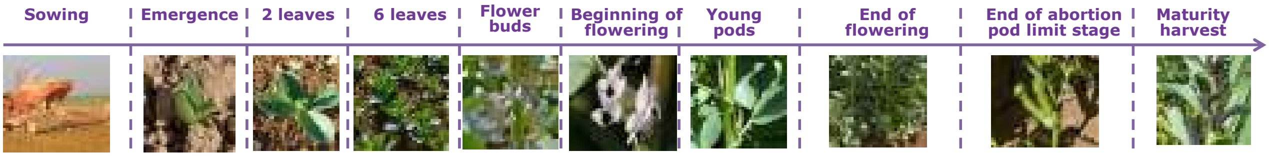
Operating costs: 573 €/ha

Gross margin = 651 to 971 €/ha

Advantages	Points of attention
• Diversifies rotation • Less exposed to pests • Good preceding crop (nitrogen gain, yield) • Less exposed to end-of-cycle water and heat stress • Has a taproot improving soil structure for the next crop • Species very efficient in nitrogen fixation	• More exposed to winter frosts • More exposed to foliar diseases • Weeding: post émergence control more difficult • Not suitable for alkaline soils (pH>7.5) • Sensitive to winter hydromorphy

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Spring fababean



Certified seed 236 €/ha — **Density** 45 seeds/m²

Fertilization 239 €/ha — **P** : 60 kg/ha, **K** : 70 kg/ha

Herbicides 121 €/ha
- **Pre-emergence** Nirvana S 2l/ha Challenge 600 2l/ha — 88 €
- **Antigrass** Foly R 1l/ha — 33 €

Insecticides 30 €/ha
- **Sitona linetus** Decis Protech 0.42 l/ha — 6 €
- **Aphis fabae** Teppeki 0.14 kg/ha — 24 €

Fungicides 22 €/ha
- **Botrytis / Ascochytosis** Amistar 0.8l/ha — 22 €

Operating costs 648 €/ha

Yield: 30 to 40 q/ha
Selling price (feed outlet): 320 €/t
Coupled aid: 104 €/ha (CAP 2023)

Operating costs: 648 €/ha

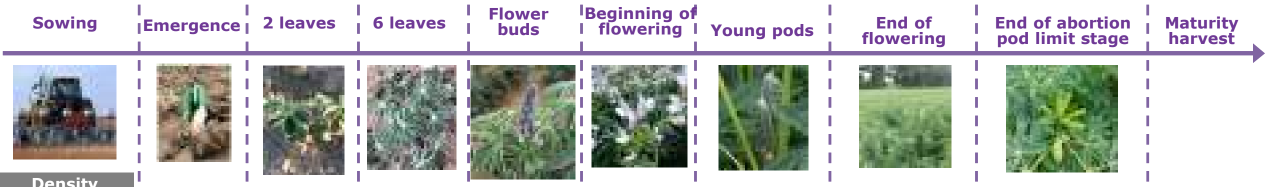
Gross margin = 416 to 736 €/ha

Advantages	Points of attention
• Diversifies rotation • Less exposed to foliar diseases • Good preceding crop (nitrogen gain, yield) • Less exposed to frost • Has a taproot improving soil structure for the next crop • Species very efficient in nitrogen fixation	• More exposed to pests • Weeding: post émergence control more difficult • Not suitable for alkaline soils (pH>7.5) • More exposed to end-of-cycle water and heat stress

Terres Inovia
l'agronomie en mouvement

Lupine – Common itinerary

Winter Lupine



Certified inoculated seed – **Density** 25 seeds/m²

200 €/ha

Fertilization – **P** : 30 kg/ha, **K** : 40 kg/ha

128 €/ha

Herbicides

112 €/ha

Fungicides

46 €/ha

Operating costs 486 €/ha

Pre-emergence Prowl 400 2.5 l/ha + Centium 36 SC 0.2 l/ha – 58 €

Antigrasses Kerb Flo 1.875 l/ha – 40 €

Post emergence Cent7 0.4l/ha – 14 €

Botrytis/Colletotrichum lupini Amistar 0.8l/ha – 20 €

Rust Sunorg Pro 0.8 l/ha – 26 €

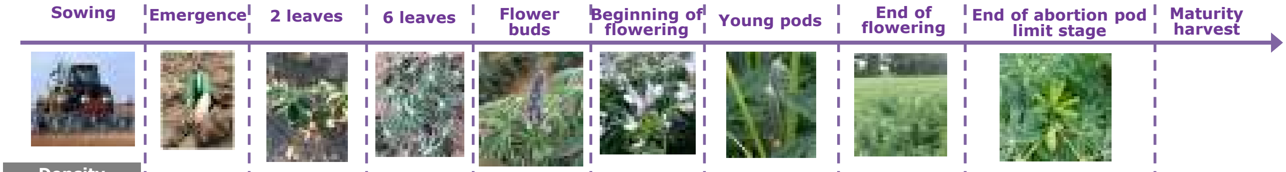
Yield: 20 to 30 q/ha
Selling price: 400 €/t

Gross product = 800 to 1200 €/ha
+ Coupled aid: €104/ha (CAP 2023)

Indicative gross margin with coupled aid = 418 to 318 €/ha

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Spring Lupine



Certified inoculated seed – **Density** 50 seeds/m²

230 €/ha

Fertilization – **P** : 30 kg/ha, **K** : 40 kg/ha

128 €/ha

Herbicides

72 €/ha

Insecticides

7 €/ha

Fungicides

46 €/ha

Operating costs 483 €/ha

Pre-emergence Prowl 400 2.5 l/ha + Centium 36 SC 0.2 l/ha – 58 €

Post emergence Cent7 0.4l/ha – 14 €

Thrips and Sitona Mandarin Pro 0.2 l/ha

Botrytis/Colletotrichum lupini Amistar 0.8l/ha – 20 €

Rust Sunorg Pro 0.8 l/ha – 26 €

Yield: 20 to 30 q/ha
Selling price: 400 €/t

Gross product = 800 to 1200 €/ha
+ Coupled aid: €104/ha (CAP 2023)

Indicative gross margin with coupled aid = 421 to 821 €/ha

Positive points of winter & spring lupine	Negative points of the winter & spring lupine
• Diversifies rotation • Few insects • Non-aphanomyces host • **Good previous crop** • **Contractualized crop** •	• Sensitive to weeds competition and active limestone → Choosing the right plot • Sensitive to disease in wet years

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l'agronomie en mouvement

Pea

Common itinerary

Winter pea

Sowing | Emergence | 2 leaves | 6 leaves | Flower buds | Beginning of flowering | Young pods | End of flowering | End of abortion pod limit stage | Maturity harvest

Certified seed 138 €/ha — **Density** 90 seeds/m²

Fertilization 236 €/ha — **P** : 50 kg/ha, **K** : 80 kg/ha

Herbicides 128 €/ha
- **Pre-emergence** Nirvana S 2l/ha — 42 €
- **Antigrasses** Kerb Flo 1.875 l/ha — 40 €
- **Post emergence** Colt 0.5L/ha + Corum 0.5L/ha — 46 €

Insecticides 27 €/ha
- **Green aphids** Teppeki 0.14 kg/ha — 24 €
- **Cydia nigricana** Karis 10 CS 0.063 l/ha — 3 €

Fungicides 44 €/ha
- **Ascochytosis/Botrytis** Amistar 0.8l/ha — 22 €
- **Ascochytosis / Botrytis** Amistar 0.8 l/ha — 22 €

Operating costs 573 €/ha

Yield: 45 to 55 q/ha
Selling price (food): 304 €/t
Selling price (feed): 324 €/t
Coupled aid: €104/ha (CAP 2023)

Operating costs: 573 €/ha

Gross margin (food) = 899 to 1 203 €/ha
Gross margin (feed) = 989 to 1 313 €/ha

Advantages	Points of attention
• Diversifies rotation • Less exposed to pests and aphanomyces • Good previous crop (nitrogen gain, yield) • Food : contract according to the varieties • Less exposed to end-of-cycle water and heat stress	• More exposed to frosts and bacteriosis • More exposed to foliar diseases

For french farmers - Eco-schemes CAP 2023 : 5 % to 10 % of total hectares cultivated with legumes allow to acquire 2 to 3 points on eco-schemes, significant bonus to unlock an amount of 60 to 80 euros/ha on total field surface

Spring pea

Sowing | Emergence | 2 leaves | 6 leaves | Flower buds | Beginning of flowering | Young pods | End of flowering | End of abortion pod limit stage | Maturity harvest

Certified seed 164 €/ha — **Density** 90 seeds/m²

Fertilization 236 €/ha — **P** : 50 kg/ha, **K** : 80 kg/ha

Herbicides 104 €/ha
- **Pre-emergence** Nirvana S 2l/ha — 42 €
- **Antigrasses** Foly R 1l/ha — 33 €
- **Post emergence** Basagran SG 0.3 kg/ha + Colt 0.5 l/ha — 29 €

Insecticides 33 €/ha
- **Thrips and Sitona** Decis Protech 0.42 l/ha — 6 €
- **Green aphids** Teppeki 0.14 kg/ha — 24 €
- **Cydia nigricana** Karis 10 CS 0.063 l/ha — 3 €

Fungicides 22 €/ha
- **Ascochytosis/ Botrytis** Amistar 0.8l/ha — 22 €

Operating costs 559 €/ha

Yield: 35 to 45 q/ha
Selling price (feed): 304 €/t
Selling price (food): 324 €/t
Coupled aid: 104 €/ha (CAP 2023)

Operating costs: 559 €/ha

Gross margin (feed) = 609 to 913 €/ha
Gross margin (food) = 679 to 1003 €/ha

Advantages	Points of attention
• Diversifies rotation • Less exposed to foliar diseases • Good previous crop (nitrogen gain, yield) • Food : contractual crop • Breaks the weed cycle	• Sensitive to aphanomyces • More exposed to pests • Sensitive to water stress → requires good soils

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l'agronomie en mouvement

Test your knowledge of durum wheat and its sector ?

Is France self-sufficient in durum wheat?	✓	True, 75% of the production is exported. France produces more than the total french consumption : equivalent of 0.9 Mt of grains
Does pasta consumed in France come mostly from abroad ?	✓	True, 63% of pasta are imported
Is Panzani an Italian brand?	✗	False, French
Are there only 3 semolina companies in France?	✓	True, 5 factories belonging to Alpina Savoie, Panzani and Pastacrop-Lusturcu
Are pasta of supermarkets brand mostly imported?	✓	True, the top suppliers of supermarkets brand are Spain and Italy
From the production to the consumption, is the cooking of pasta at the consumer's places the largest item of energy consumption in the sector?	✓	True, 50% of the energy consumption in an LCA comes from cooking
Does the most important carbon impact of the sector come from transport of grains and finished products?	✗	False, 80% come from production and 60% from nitrogen fertilization

2ÈME EXPORTATEUR MONDIAL DE BLÉ DUR

- **80 %** VERS **UNION EUROPÉENNE**
- **20 %** VERS **PAYS TIERS**

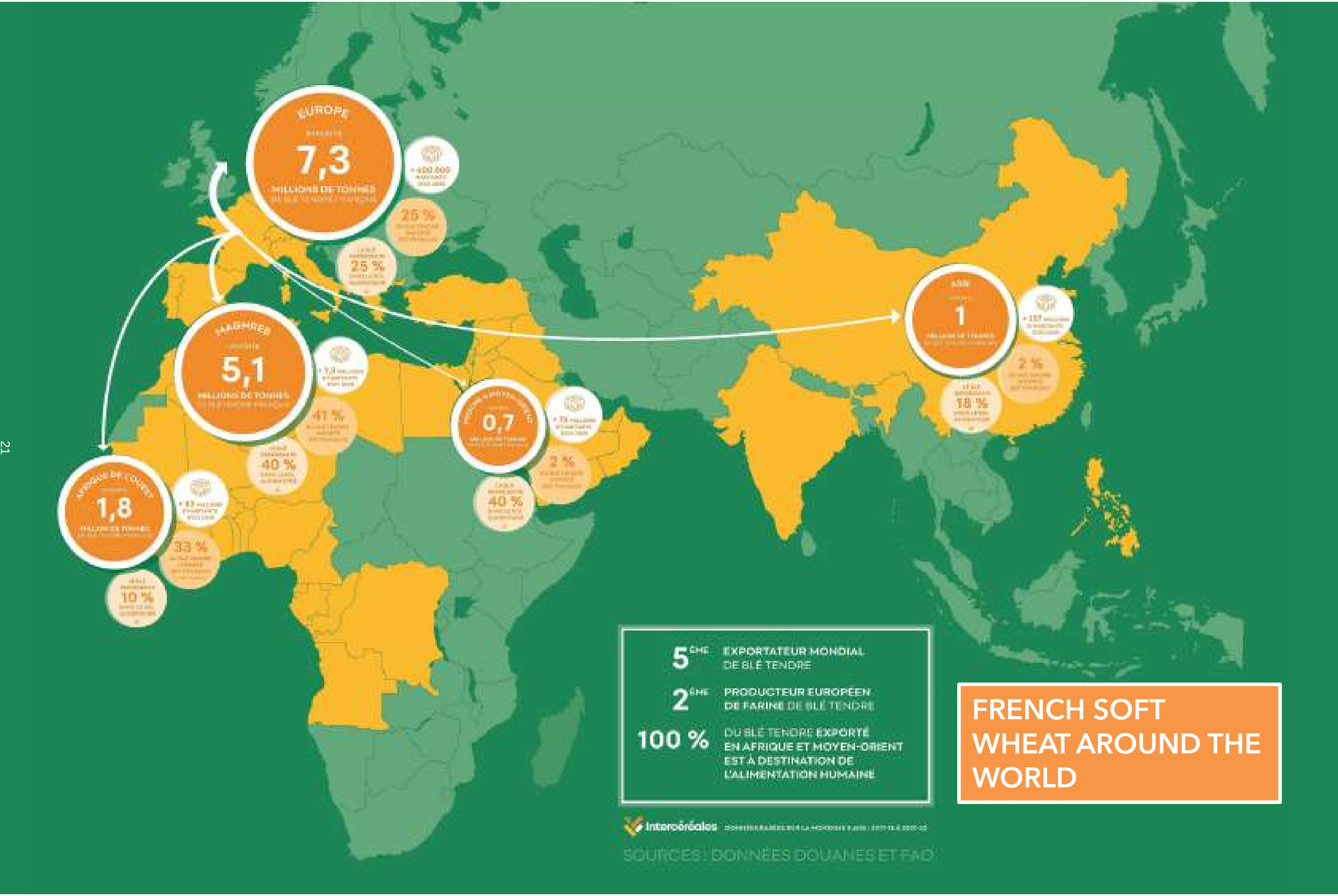
2ÈME PRODUCTEUR EUROPÉEN DE SEMOULE DE BLÉ DUR

DONNÉES BASÉES SUR LA MOYENNE 5 ANS : 2017-18 À 2021-22

SOURCES : DONNÉES DOUANES ET FAO

FRENCH DURUM WHEAT AROUND THE WORLD

FRENCH SOFT WHEAT AROUND THE WORLD



5^{ÈME} EXPORTATEUR MONDIAL DE BLÉ TENDRE

2^{ÈME} PRODUCTEUR EUROPÉEN DE FARINE DE BLÉ TENDRE

100 % DU BLÉ TENDRE EXPORTÉ EN AFRIQUE ET MOYEN-ORIENT EST À DESTINATION DE L'ALIMENTATION HUMAINE

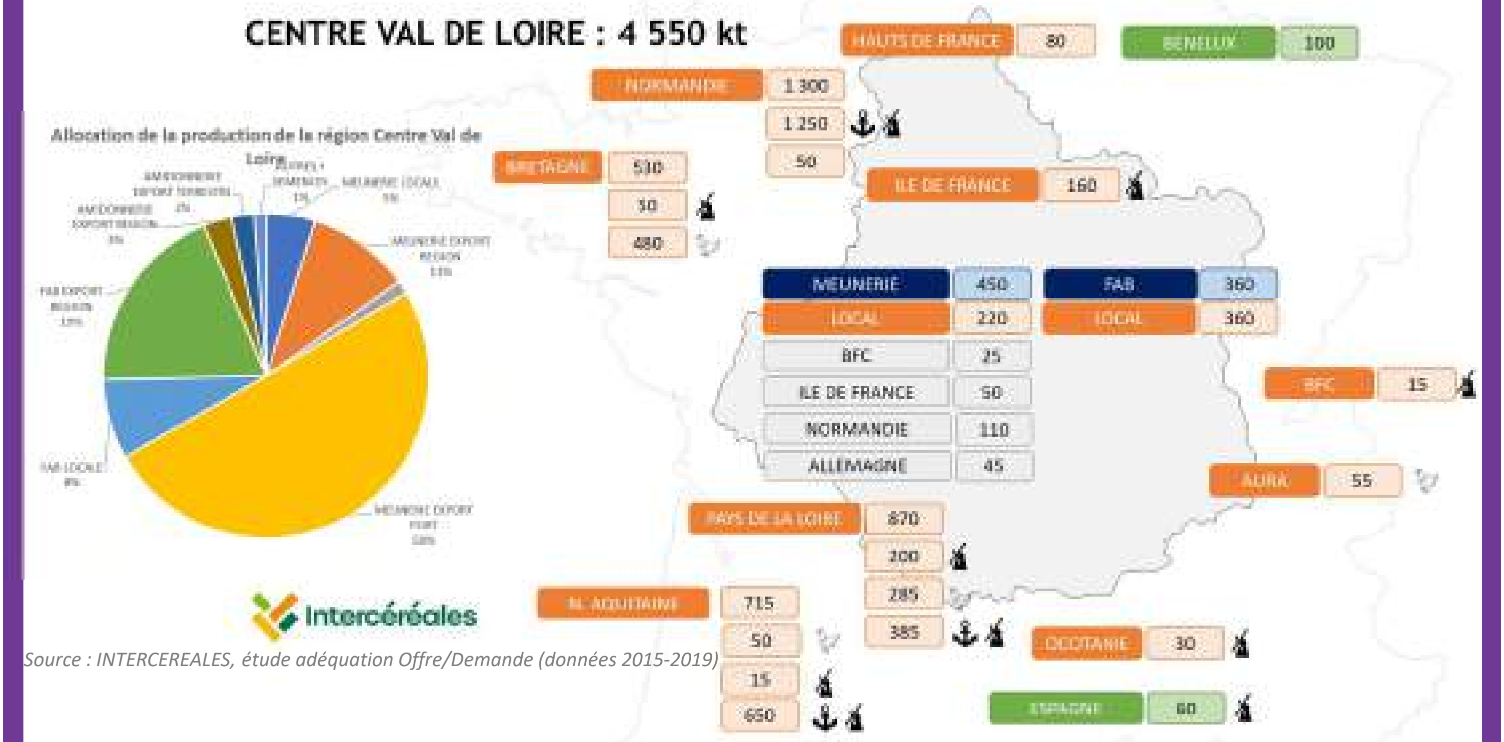
Intercéréales

SOURCES : DONNÉES DOUANES ET FAO

Matching between supply and demand for soft wheat: work of Forum Blé tendre Cœur de France - Center area

Les Culturales 2023 14-15 juin

Mapping of markets and flows of different regions



Source : INTERCEREALES, étude adéquation Offre/Demande (données 2015-2019)

List of market segments, quantitative/qualitative expectations, and diagnosis of the current offer

				AIMED CRITERIA					Center of France				
Classe	Segment	Current volume	Qualitative potential (varieties)	PROT	PS	W	TCH	H%	PROT	PS	W	TCH	H%
B : Very demanding markets, which can only be fed by specific sowing													
B	BAF milling - pastries	200 kt - 4%	8%	14	76	350	220	15	0/10	8/10	0/10	9/10	10/10
B	CAMEROON	60 kt - 1%		12	78.5	210	300	<12.5	3/10	2/10	3/10	6/10	4/10
L : Markets requiring specific protein management													
L	BPMF miling - baguette	490 kt - 11%	44%	11.5	76	170	220	15	7/10	8/10	8/10	9/10	10/10
L	PORTUGAL	100 kt - 2%		11.5	76	170	220	15	7/10	8/10	8/10	9/10	10/10
L	MOROCCO	280 kt - 6%		11.5	78	180	250	<13.5	7/10	4/10	7/10	8/10	9/10
L	ALGERIA - after Nov 2021	890 kt - 20% ?		11.5	77	180	240	<14	7/10	6/10	7/10	8/10	10/10
L	SENEGAL	60 kt - 1%		11.5	78	200	250	<13.5	7/10	4/10	4/10	9/10	9/10
E : the most frequently accessed markets													
E	~~ALGERIE - CDC avant nov 2021~~	~~890 kt - 20%~~	56%	11	77	160	240	<14	10/10	6/10	10/10	8/10	10/10
E	IVORY COAST	110 kt - 2%		11	78	180	220	15	10/10	4/10	7/10	9/10	10/10
E	STARCH FACTORY	230 kt - 5%		11	76	/	220	<15	10/10	8/10	NS	9/10	10/10
S : The most multipurpose markets													
S	FAB	1230 kt - 27%	92% (hors BAF)	/	76	/	/	15	10/10	8/10	NS	NS	10/10

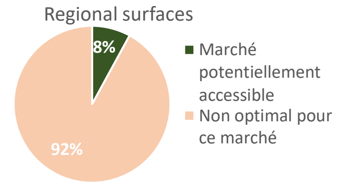
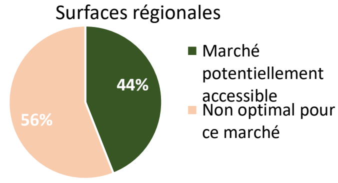
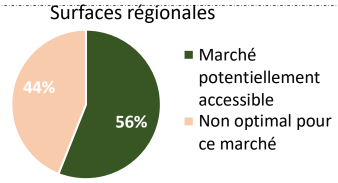
Diagnosis of the current offer based on the collector surveys about entrances in silos during 2004-2021 (ARVALIS-FRANCEAGRIMER)

Animation / coordination:

With the collaboration of:

Matching between supply and demand for soft wheat

Recommendations for varieties, cultural practices, grain trades by market segment

	Genetics		Cultural pratices	Grain trades
B	❖ **BAF : 11 variétés** ❖ Cameroon segment : **Possible blends of varieties with specific assets (Pure protein note ≥ 7 ou W ≥ 240 ou PS ≥ 6)** and varieties balanced on all criteria		1) Fertilization management at the flag leave stage 2) Last fertilizer application : 60-80 kgN/ha, split in 2 between flag leave stage and ear emergement. Use solid form Irrigation to enhance the efficiency of nitrogen applications Prefer leguminous previous crop and organic fertilizer application	**Mandatory zone management**
L	3 priority criteria = **PS ≥ 5-6** **❖ Note protéines pures ≥ 3-4** **❖ W ≥ 170-180**		1) Fertilization management according to quality needs 2) Last fertilizer application between flag leave and boot stages. Use solid form	Allows very often to ensure the requested specific weight
E	**Limit area of varieties with PS ≤ 5**		1) Fertilization management according to quality needs 2) Last fertilizer application between flag leave and boot stages. Harvest firts in rainy weather, risk for specific weight	Vigilance to ensure good specific weight
S	❖ Varieties with high potential ❖ Very wide varietal range		1) Nitrogen dose adjusted to target potential 2) Last fertilizer application between Node 2 and flag leave stages	No special constraints

Source : enquête répartition variétale, historique FranceAgriMer, 2022 ARVALIS

Adapted varieties by market segment

Varieties	2022 (%)	Pure proteins	GPD	SW	Note W	Classe Arvalis	B	L	E	S
Mélange intra	22.3%	*non identifié*								
CHEVIGNON	14.5%	2	6	5	160-215	BPS	🟧	◻	🟩	■
KWS ULTIM	7.9%	3	6	7	185-240	BPS	🟧	■	■	■
COMPLICE	6.6%	3	6	6	150-200	BPS	🟧	■	■	■
REBELDE	3.6%	9	9	9	310-430	BAF	■	■	■	■
RGT CESARIO	3.4%	3	6	6	170-225	BPS	🟧	■	■	■
RGT SACRAMENTO	3.0%	4	7	7	155-195	BPS	🟧	■	■	■
LG ABSALON	2.7%	5	6	7	185-210	BP	🟧	■	■	■
OREGRAIN	2.3%	4	5	7	145-195	BPS	🟧	◻	■	■
FORCALI	1.9%	9	9	8	245-365	BAF	■	■	■	■
PROVIDENCE	1.7%	4	7	7	185-240	BPS	🟧	■	■	■
KWS EXTASE	1.7%	3	6	5	160-210	BPS	🟧	■	🟩	■
MACARON	1.5%	3	6	7	185-245	BP	🟧	■	■	■
IZALCO CS	1.5%	9	9	9	345-440	BAF	■	■	■	■
DIAMENTO	1.2%	4	6	6	175-210	BPS	🟧	■	■	■
SYLLON	1.2%	5	7	8	185-205	BPS	🟧	■	■	■
APACHE	1.1%	5	5	6	160-210	BPS	🟧	■	■	■
TENOR	1.1%	3	6	6	180-220	BPS	🟧	■	■	■
UNIK	1.1%	6	8	9	160-240	BPS	🟧	■	■	■
HYLIGO	1.0%	2	7	6	165-200	BPS	🟧	◻	■	■
ASCOTT	0.9%	3	6	6	170-210	BP	🟧	■	■	■
PILIER	0.8%	3	5	6	115-195	BPS	🟧	🟧	🟧	■
TALENDOR	0.7%	4	7	7	205-250	BPS	🟧	■	■	■
PRESTANCE	0.7%	4	8	8	205-270	BPS	🟧	■	■	■
RUBISKO	0.6%	5	6	5	135-195	BP	🟧	◻	🟩	■
FILON	0.6%	5	8	6	140-185	BPS	🟧	◻	■	■
BOREGAR	0.6%	5	6	5	165-175	BPS	🟧	🟩	🟩	■

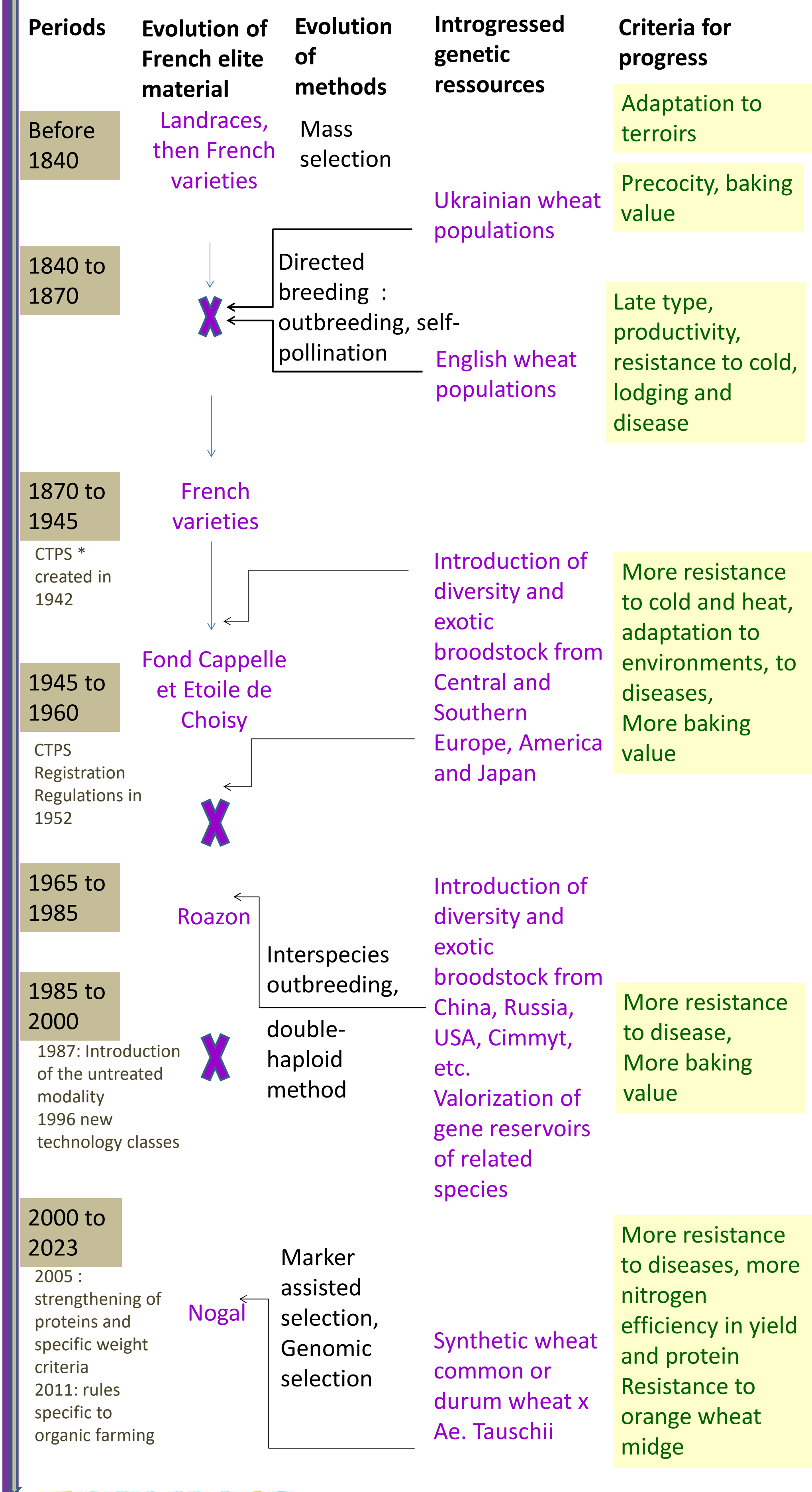
Legend of the adaptation of varieties to different segments :

🟧	Not optimal for this outlet
◻	Accessible outlet with vigilance on protein and/or W
🟩	Accessible outlet with vigilance on specific weight (SW)
■	Optimal for this outlet

Source : enquête répartition variétale, historique FranceAgriMer, 2022 ARVALIS

Animation / coordination :
With the collaboration of:

Characteristics that evolve with the needs of progress and breeding techniques : the case of soft winter wheat



Periods	Evolution of French elite material	Evolution of methods	Introgressed genetic ressources	Criteria for progress
Before 1840	Landraces, then French varieties	Mass selection		Adaptation to terroirs
			Ukrainian wheat populations	Precocity, baking value
1840 to 1870	X	Directed breeding : outbreeding, self-pollination	English wheat populations	Late type, productivity, resistance to cold, lodging and disease
1870 to 1945 CTPS * created in 1942	French varieties		Introduction of diversity and exotic broodstock from Central and Southern Europe, America and Japan	More resistance to cold and heat, adaptation to environments, to diseases, More baking value
1945 to 1960 CTPS Registration Regulations in 1952	Fond Cappelle et Etoile de Choisy X			
1965 to 1985	Roazon	Interspecies outbreeding,	Introduction of diversity and exotic broodstock from China, Russia, USA, Cimmyt, etc.	
1985 to 2000 1987: Introduction of the untreated modality 1996 new technology classes	X	double-haploid method	Valorization of gene reservoirs of related species	More resistance to disease, More baking value
2000 to 2023 2005 : strengthening of proteins and specific weight criteria 2011: rules specific to organic farming	Nogal	Marker assisted selection, Genomic selection	Synthetic wheat common or durum wheat x Ae. Tauschii	More resistance to diseases, more nitrogen efficiency in yield and protein Resistance to orange wheat midge

Illustrative varieties

Rouge de St Laud (Landraces)

Noe, Gros Bleu… (Ukrainian wheat populations)

Chiddam d'Automne (English wheat populations)

Dattel 1883 : first variety resulting from directed breeding, Bon Fermier…
Vilmorin 23,27, 29
Cappelle 1946

Etoile de Choisy 1950 (precocity from Italian Ardito)
Champlein 1959 (Quality of Red Fife du Canada, Lodging resistance rht8 of the Italian Fortunato)
Hardi 1969 et Camp Rémy 1980 (Stem black rust of Thatcher from USA)
Maris Hunstman 1973 et Thésée 1983 (resistance to powdery mildew of related species)
Courtot 1974 (Introduction of dwarfism genes Rht1 et Rht2 by Norin 10, Japanese variety)
Roazon 1974 and Renan 1989 (introduction of eyespot disease resistance genes (Pch1) et yellow rust by related species)
Introduction in 50% of varieties of rust resistance genes Yr17, Lr37 et Sr38
Florin 1985 : 1st variety obtained by haploidisation method
Courtel 1985 : 1st common wheat hybrid
Soissons 1988 : The combination of its precocity, productivity and quality has been a reference
Trémie 1993 : Highly productive wheat for other utilisation (BAU)
Apache 1998 : Resistance to fusariumear blight, Diversification of resistance sources to yellow rust,
Welford, Robigus 2002 : tolerance to orange midge
Nogal 2009 : from synthetic wheat, tolerance to septoria Stb16
Skerzzo, Hendrix, 2012 : 1st registrations with specific rules for organic farming
Rubisko 2012 : Resistant to orange midge
Jaceo 2013 : introduction of the Sumai 3 fusarium ear blight resistance gene
LG Absalon, 2016 : Multiresistance to foliar diseases
Chevignon 2017 : Good nitrogen efficiency ; Orloge 2017 : GPD++
RGT Tweeteo 2020 : resistance to barley yellow dwarf virus (BYDV)

*CTPS
= French technical committee for breeding

Les Culturales 2023 14-15 juin

How do I choose my variet~~y~~ies ?

Never sow a single variety!

Diversify varietal types = 1st security lever

- Limit the risk of climatic accidents (frost, heat stress …)
- Smooth the year effect of varietal behaviour

BASIC CRITERIA

SATISFY THE OUTLET

Locally, minimum high breadmaking quality

EARLINESS

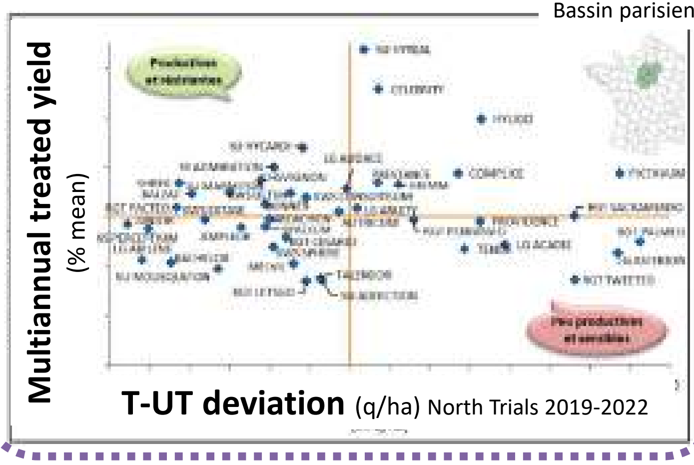
Range adapted to its soil and climate conditions

- Deep/shallow soil
- Climate offer
- Sowing period

POTENTIAL & LIMITED T-UT DEVIATION

1-Yellow rust resistance

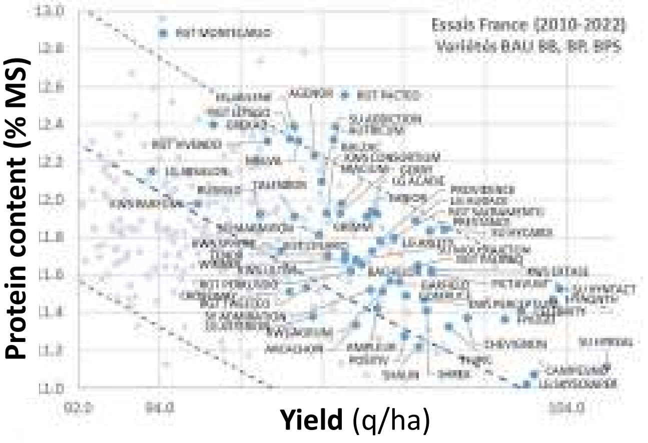
2-Septoria resistance



ADDITIONAL or COMPROMISE CRITERIA depending on the plot context, contractual specifications ...

COMBIN YIELD & PROTEIN

→Note GPD



WEEDS PRESSURE

- Chlortoluron tolerance
- Early variety for late sowing period

LODGING RESISTANCE

MOSAIC RESISTANCE

ORANGE WHEAT MIDGE RESISTANCE

PREVIOUS CROP

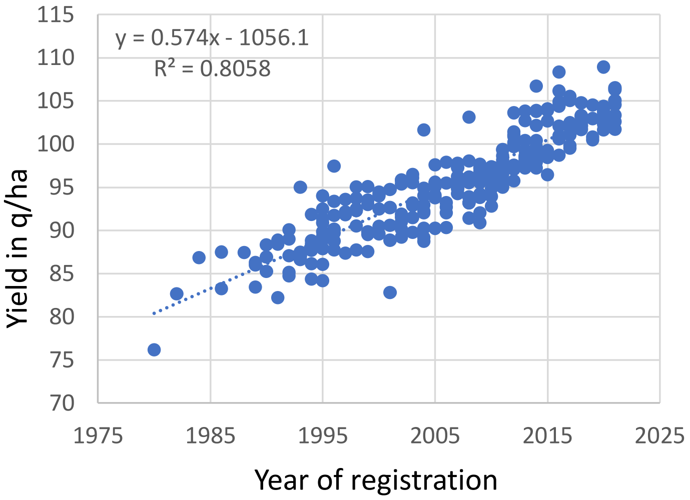
- **Maize :** Fusarium & DON resistance
- **Wheat** : Eyespot resistance

TO HELP YOU: Choix des variétés Blé tendre

ARVALIS

E1_05_2

Genetic progress of bread wheet



YIELD : +0,57 q/ha/year in Central area

Abiotic stress

- Genetic progress mitigates the effect of climate change on the yield.

Evolution of average yields by variety according to the year of registration

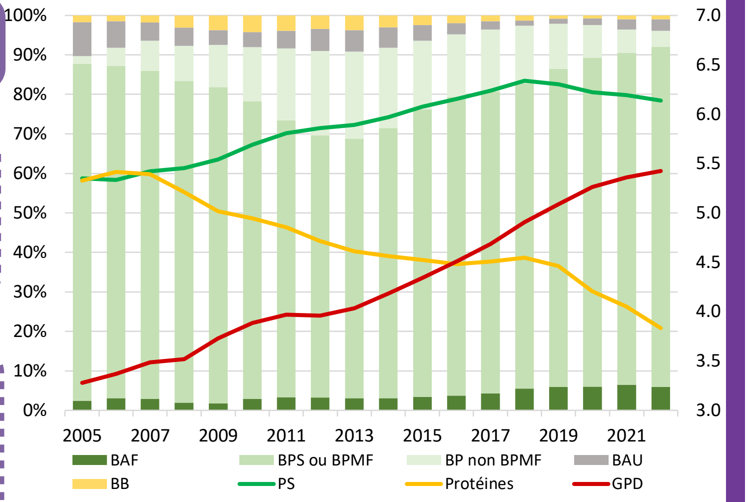
QUALITY : ↗ SW et ↗ GPD

Grain quality

- 90 % bread wheat areas grown with BPS/BPMF varieties in 2022

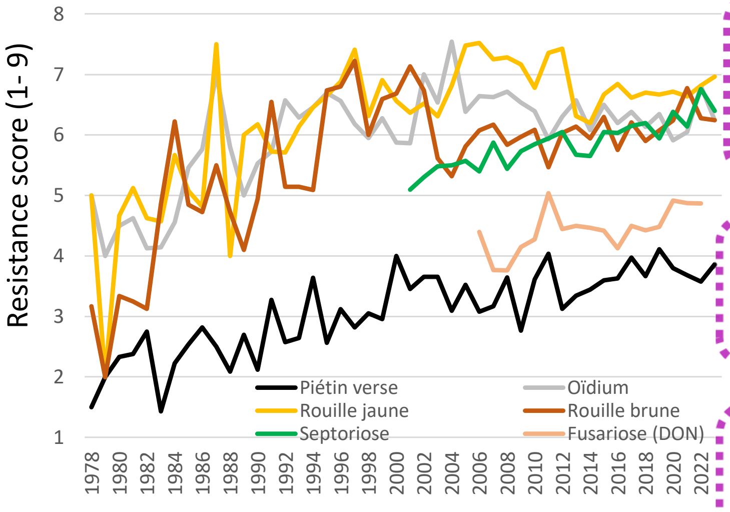
GPD / Proteins content

- Grain Protéin Deviation - > for equal yield, + 0,5% of protein content
- Limitation of drop of protein content by 0,4%



Evolution of cultivated areas according to the varietal profil

DISEASES : SEPTORIA resistance in net progress



Evolution of diseases resistance scores according to the year of registration

Mildew, Yellow Rust, Brown Rust

- Strong progress between 1980 and 2000
- High and stable snice 2000

Septoria

- Steady progression since 2000

Eyespot

- 25 % of bread wheat areas cultivated with Pch1 varieties in 2022

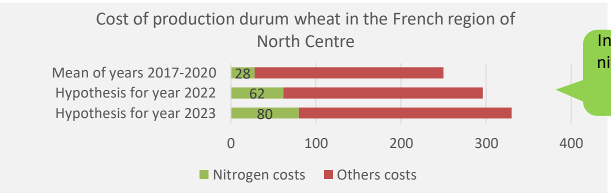
Les Culturales 2023 14-15 juin

Fertilization and economy

Finding the good compromise

Impact of economic conditions on costs and margins

Production costs impacted by the price of nitrogen

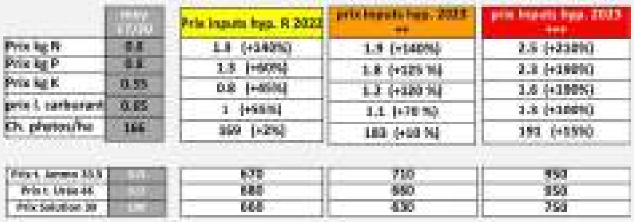

Cost of production durum wheat in the French region of North Centre

In conventional conditions, nitrogen represents 10% of production costs, 20 to 25% tomorrow

Cost of production 2017-2020
190€/t in bread wheat
241€/t in high protein wheat
250€/t in durum wheat

	Yield (q/ha)	N input (kgN/ha)
Milling wheat	78	205
Hard wheat	63	230
Durum wheat	67	240

Source: Arvalis Unigrains Observatory (based on CERFrance data) +


Source : Observatoires & expertises Arvalis, mai 2022

Despite a greatly rising input cost, durum wheat remains an interesting crop for the region

Full margin	Average situation 17/20	2022 harvest hypothesis	2023 harvest hypothesis
Durum wheat	≈ 0€/ha	≈ +600€/ha	≈ +220 to +470€/ha
Bread wheat	≈ -30€/ha	≈ +180€/ha	≈ -50 to +120€/ha
High protein wheat	≈ +75€/ha	≈ +120€/ha	≈ +300 to +500€/ha

Calculate the average techno-economic challenges and adjust its splitting

Calculation of dose adjustments and their impacts

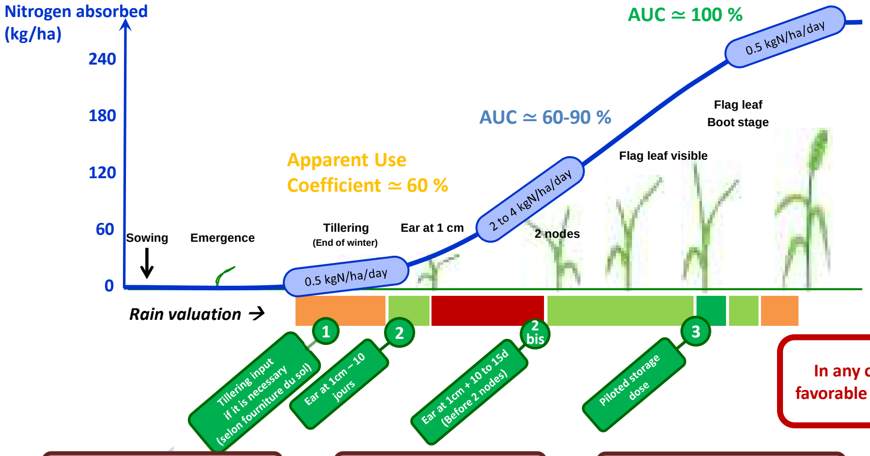
	Scenario	2022 harvest hypothesis	2023 harvest hypothesis	2023 harvest hypothesis +++
Durum wheat	N Price	1.90 €/kgN	1.90 €/kgN	2.50€/kgN
	Durum wheat price	360€/t	350€/t	350€/t
	Wheat/N ratio	1.9	1.8	1.4
	Dose	-7 kgN/ha	-8 kgN/ha	-21 kgN/ha
	Yield	-0.3 q/ha	-0.4 q/ha	-1.2 q/ha
	Protein content	-0.1 %	-0.1 %	-0.3%

Reference : N : 0.95€/kgN / Durum wheat 220€/t

In a very expensive input scenario, an adjustment of -20 to -30 kgN/ha is preferable.

The yield and protein impact can be partly offset by good nitrogen positioning.

Optimization of nitrogen inputs on durum winter wheat



Varieties of durum wheat	Bq *Nitrogen requirement per quintal produced at 14% protein*	Storage dose to be carried before heading (quality contribution) (Kg/ha)
RGT VOILUR	**3,7**	**40**
ANVERGUR KARUR MIRADOUX **RGT KAPSUR**	**3,9**	**60**
CANAILLOU RELIEF **RGT BELALUR** **RGT SOISSUR**	**4,1**	**80**

In any case, only put nitrogen in favorable periods (each unit counts!)

Possible deadlock
Quantity involved: ~40 kg N/ha

Tillering input: A mediocre valuation for an input not always justified. To decide with soil mineral nitrogen residue at the end of winter

Possible reduction
Q. involved : ~40 kg N/ha

Start of ear ascent: important plant needs. Aim for good conditions for nitrogen valorization and not a precise growth stage. Input anticipation or splitting before and after ear at 1cm growth stage to maximize nitrogen valorization by rainfall is recommended

Quality challenge
No dose reduction

End of ear ascent : High interest yield / proteins with good conditions of valorization.

Use agronomic field levers to meet the sector's quality criteria

The requirements of durum wheat buyers have three objectives:

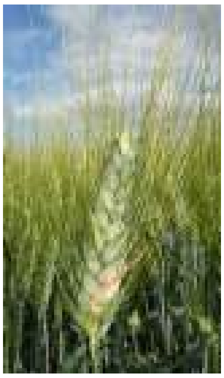
- Comply with sanitary quality standards
- Achieve high semolina yield
- Produce pasta of good organoleptic quality

Sanitary quality

Fusarium and mycotoxins including deoxynivalenol = DON

Max regulated content: 1750 µg/kg durum wheat today / **1500 µg/kg from 1/07/2024**

1. Previous crop: maize / sorghum 👎
2. Tillage: ploughing and/or grinding residues 👍
3. Varietal choice 👍
   + 0.5 DON accumulation Note = - 12% de DON



4. Flowering fungal protection 👍
5. Irrigation management 👍

Ranking of the agronomic levers that can be mobilized: accumulate them to limit the DON risks.

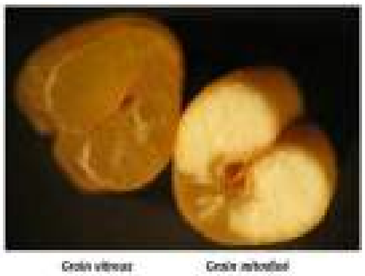
Technological qualities

Protein content

Target threshold of 13.5%
+ 40 KgN/ha = + 0.6% protein

1. Varietal choice: nitrogen requirements of varieties : $bq_{14\%}$ 👍
2. Nitrogen fertilization: splitting the total dose into 3 to 5 inputs 👍
3. Setting aside the last nitrogen input for its annual adaptation and management 👍

Mitadinage: loss of vitreous aspect. Decrease in semolina yield



Maximum permissible threshold of 20 to 25%
+ 1 mm of rain from pasty grain = + 1% mitadinage

1. Optimal nitrogen fertilization 👍
2. Varietal choice 👍
3. Late harvest date, after rain 👎

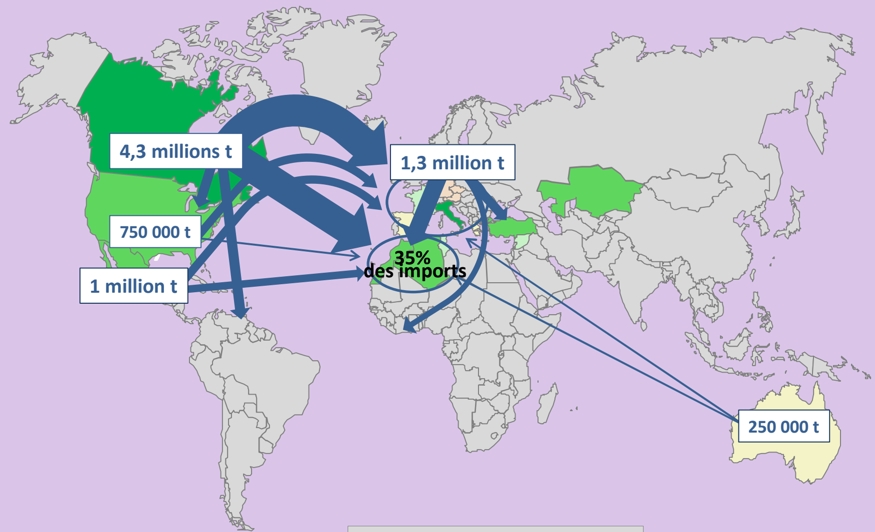
Speckling: black discoloration of the furrow or around the germ

Maximum tolerated threshold of 5%
If **+ 60 mm of rain after heading** → high risk of **exceeding 5% speckled gains**

1. **Environment:** high density, rainy period between heading and milky grain, late irrigation, lodging risk 👎
2. Varietal choice 👍
3. Fungal protection of the ear 👍

Durum wheat market

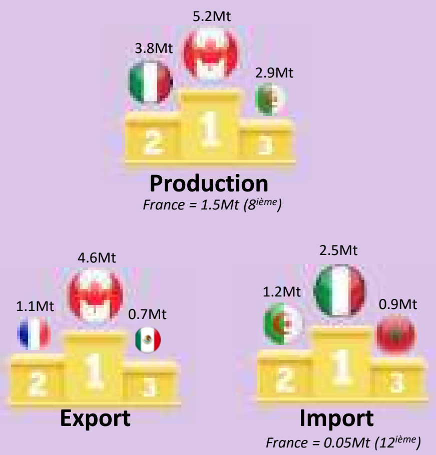
A global market led by Canada, Italy and the Maghreb



World Trade 2015:
7.7 millions t

Production 2015 (x1000t) : IGC
🟩 > 4000
🟩 > 2000
> 1000
> 500
< 500

2015 global production:
37.3 millions t

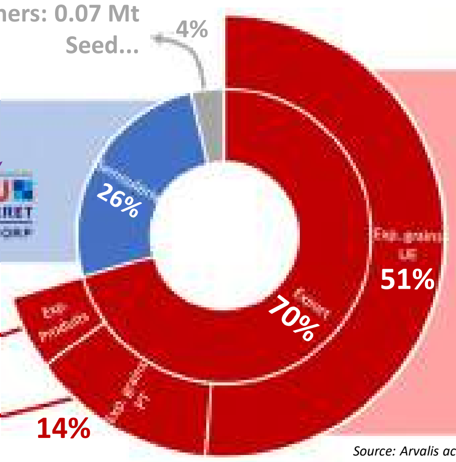


Podium – période 2018-2022

Canada, Italie, Algérie, France, Mexique, Maroc

French durum wheat valuations: French semolina milling, Italy and Spain

Destination of durum wheat produced in the Centre



French semolina: 0.50 Mt

PANZANI, ALPINA SAVOIE, LUSTUCRU RIVOIRE & CARRET GROUPE PASTACORP, Ebly

Product export: 0.1 Mt

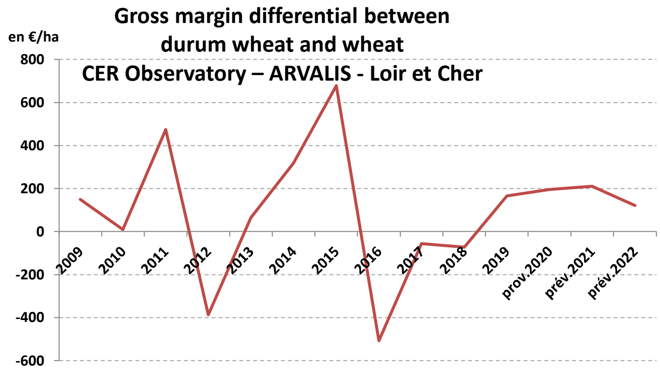
Export grain third countries: 0.26 Mt
Morocco, Tunisia, Sub-Saharan Africa, Algeria

EU grain export: 1Mt

Top 12 pays destinataire	moyenne 5 ans (x 1000t)	En % du total
Italie	373.7	29%
Espagne	151.8	12%
Belgique	129.0	10%
Pays-Bas	80.7	6%
Allemagne	75.2	6%
Afrique sub-saharienne	71.9	6%
Portugal	57.9	5%
Royaume-Uni	56.5	4%
Maroc	52.8	4%
Luxembourg	51.1	4%
Tunisie	48.3	4%
Algérie	41.8	3%

Source: Arvalis according to FRANCEAGRIMER, average last 5 campaigns

An economic interest for farms according to multi-year average results



Source: Arvalis based on the Arvalis-Unigrains Observatory and CER data in the french department of Loir et Cher

- Observatory = actual data with prices paid (with penalties) + different marketing strategies
- On average over 14 years in the Loir et Cher, the difference in gross margins between durum wheat and wheat is €100/ha → an economic asset for the region (with 10 years out of 14 favorable)
- The quality / return risk is real but not impactful every year. Negative years = major climatic accidents:
  - 2012: significant end-of-cycle rain = Hagberg Falling Number and fusarium grains
  - 2016: record rain after heading = Hagberg Falling Number, Specific weight degraded, speckle, very low yield
  - 2017: rain at harvest = Hagberg Falling Number

Durum wheat research

For better varieties

Genetic progress

Estimated genetic progress at national level on varieties registered over the last 25 years: significant gains for most criteria.

Agronomic criteria	Genetic progress (unit/year)
Yield (q/ha)	**+0.42**
Harmfulness (q/ha)	**-0.38**
Cold (%)	**-0.58**
Lodging (%)	*0.02 (NS)*
Fusarium on ears (%)	*0.04 (NS)*
Powdery mildew (%)	**-0.34**
Brown rust (%)	**-0.48**
Septoriosis (%)	*0.2 (NS)*

Technological Quality Criteria	Genetic progress (unit/year)
Protein (%)	**-0.03**
Yellow index	**+0.14**
Brown index	*-0.02 (NS)*
Speckle (%)	*-0.04 (NS)*
Mitadin (%)	Stable
Weight of Thousand Grains (g)	Stable
Specific weight (kg/hl)	Stable

Source: ARVALIS, based on Post-Registration (ARVALIS) and CTPS (GEVES) trials or specific Genetic Progress trials.

History of the main targets for varietal improvement

1980’ **Processing quality**
Colour

1990’ **Yield**

2000’ **Disease tolerance** *[CASDAR ENDURO, FSOV DURABLÉ]*

2010’ **Protein and quality**
Mosaic resistance *[CASDAR MOSADURUM, FSOV README]*

Actuel **Tolerance to abiotic stresses** *[CASDAR DUROSTRESS]*
Sanitary quality *[ANR BSWheat]*

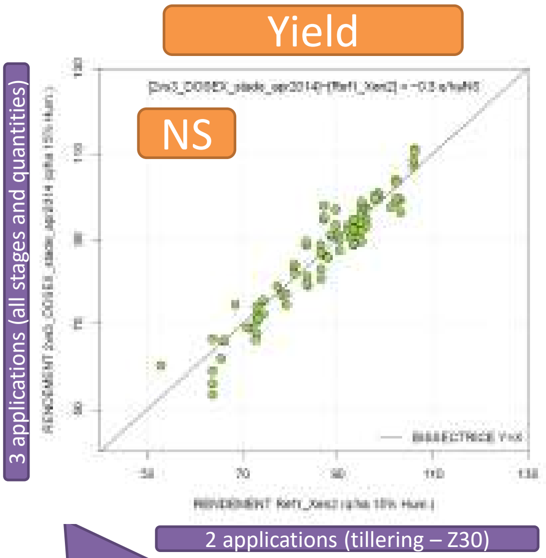
Variety is not the only solution, which is why agronomic projects are also carried out on durum wheat: ADAPT (Adapting technical itineraries to cope with to climate change), EXQUALIDUR (Genetics, Agronomy and Quality)

Main partners in durum wheat research

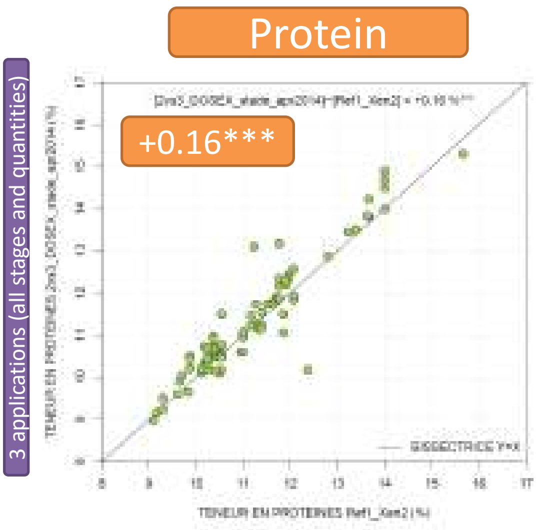
All the regional actors of the 4 production basins

Malting barley: how to ensure protein content?

- No risk to split fertilization nitrogen input into 3 applications



Summary of tests "nitrogen fertilization of winter barley" ARVALIS and partner 1994-2022 – 360 trials – Northern half France – 38 varieties (more than half of which are ESTEREL and ETINCEL)



Summary of tests "nitrogen fertilization of winter barley" ARVALIS and partner 1994-2022 – 360 trials – Northern half France – 38 varieties (more than half of which are ESTEREL and ETINCEL)

At nitrogen equivalent quantity :
- No yield effect regardless of stage or quantity of the 3rd application
- Risk of yield loss due to splitting of small doses (<130 kgN/ha)

At nitrogen equivalent quantity :
- 0.16% increase in protein content
- To split in 3 nitrogen applications doesn't favor overrun of 11.5% limit for protein content.

Stronger increase in protein for late stages and high quantities at 3rd application

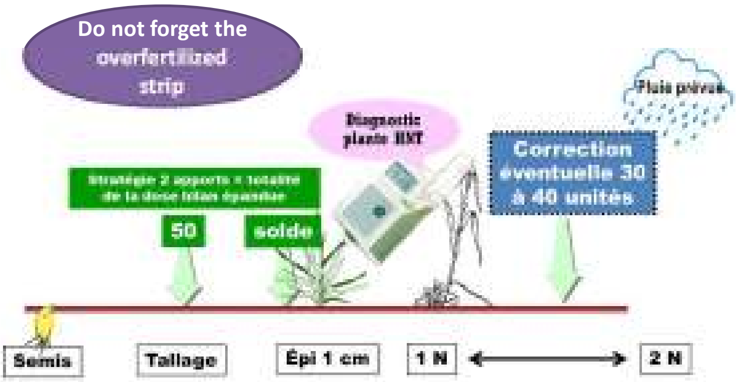
➔ For malting barley, a final application of 30 to 40 kgN/ha around the "2 nodes" stage will be preferred.

- How to manage the 3rd nitrogen application?

Example: HNTester Extra Method

WB et SB

atfarm YARA



Example: Farmstar Method

WB

Progressive nitrogen storing for high forecast total quantities:

- **if TQ<160u**
- **if 160u ≤ TQ<180u**
- **if 180u ≤ TQ<200u**
- **if 200u ≤ TQ**

FARMSTAR

TQ= total quantity of nitrogen fertilizer to apply

An advice for the 3rd application between 0 and 40u.

Underfertilized situations could be corrected thanks fertilization management.

(underestimated total quantity, yield-friendly year)

ARVALIS

Key figures for the brewing industry in France and around the world

The France grows 1 million ha of malting barley : 50% winter barley and 50% spring barley

France produces 4 Mt of malting barley

1 ha of malting barley can produce 35,000 L of beer, that is to say 140,000 glasses of 25 cl!

A structured sector

- Nearly 115,000 farms grow barley in France.
- France is the 1st producer of malting barley in the EU.
- Since 1967, France has been the world's No. 1 exporter of malt: 75% of French production is exported.
- 15% of beers brewed worldwide are brewed from French malting barley and french malts.
- The french malting sector is represented by 3 groups (among the top 5 in the world!).
- France has nearly 2500 breweries on its territory!

L'abus d'alcool est dangereux pour la santé, les boissons alcoolisées sont à consommer avec modération.

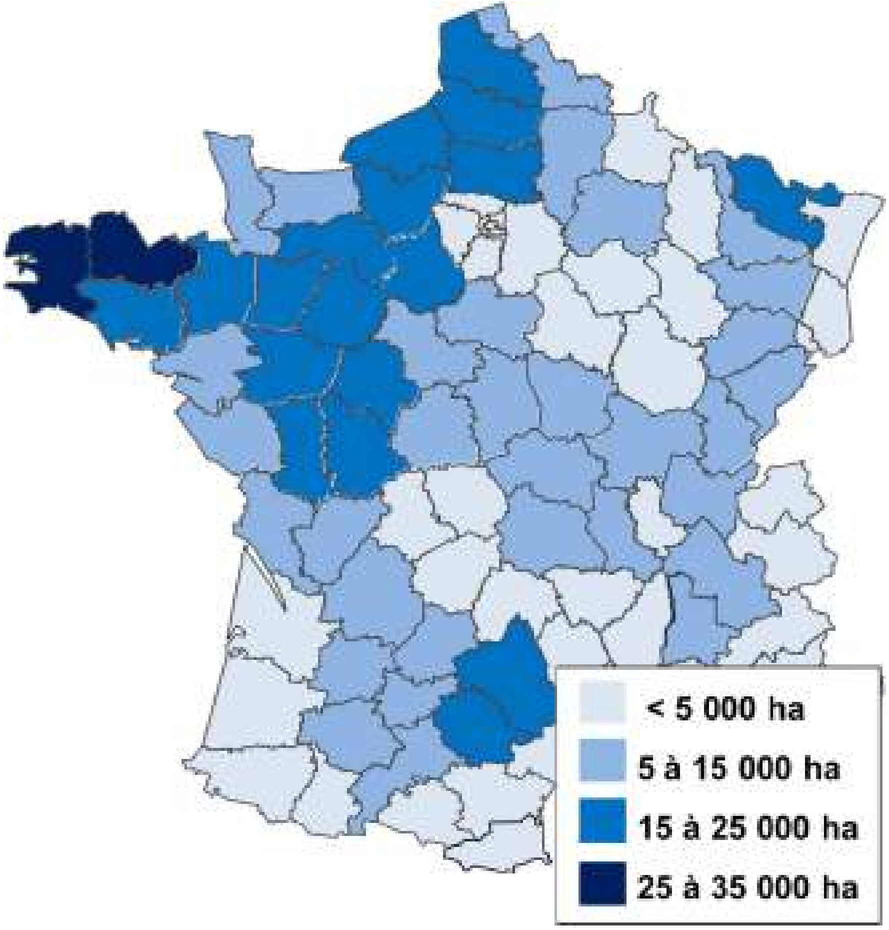
Good to know!

6-row winter malting barley is a French specificity, with great importance for the sector in France and worldwide.

Sources IFBM, Malteurs et Brasseurs de France, Agreste, FAM, Intercéréales

Winter feed barley in France

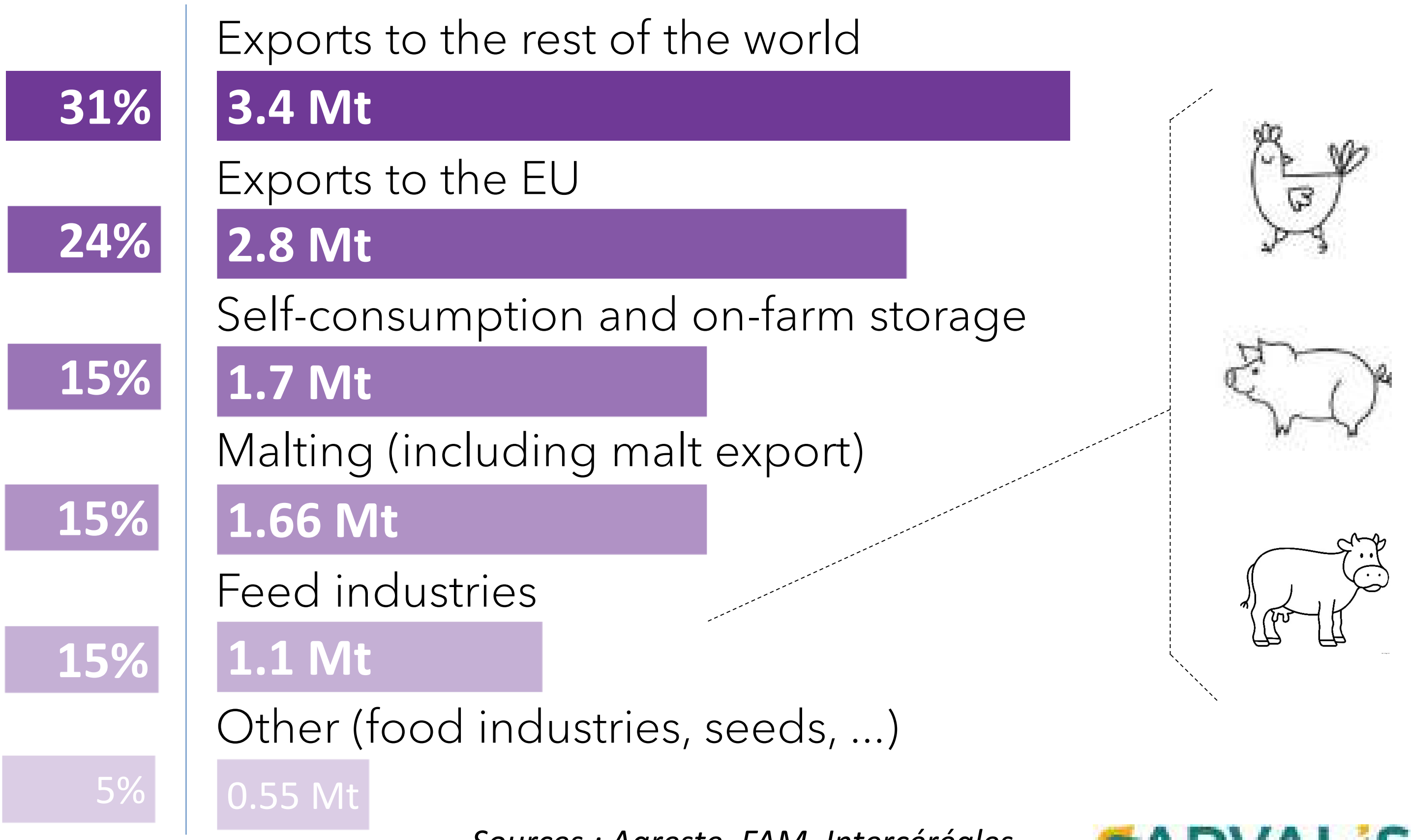
Winter feed barley areas



In France, on 1.8 million hectares of barley grown and 11 Mt produced, the share of feed barley represents 850,000 have an 8 Mt.

Barley is the 3rd cereal intended for feed (after wheat and corn).

The main uses of barley in France



Sources : Agreste, FAM, Intercéréales

ARVALIS

TRUE-FALSE about Autumn Sown Spring Barley *(in French OPsa)*

To sow SB in autumn secures yield ☑

This is mainly the case in shallow soils: secured ears number/m^2, Less exposure to end-of-cycle water and heat stress, increase in yield (+15%) compared to spring sowing.

To sow spring barley in autumn is totally safe ☒

This barleys are subject to a risk of freezing, to amplified leaf scald *(Rhynchosporium)* pressure, grass weed pressure, pests (autumn aphids) and to mosaics

Our recommendations :

→ To sow in the first half of November.

→ Avoid blends of autumn herbicides.

→ Regardless of the leaf disease tolerance rating, leaf scald *(rhynchosporim)* pressure will be early and high.

Yield losses q/ha	KWS FARO October Sowing	RGT Planet November Sowing	RGT Planet Spring sowing
	10	16	6

Disease tolerance rating for leaf scald (rhynchosporium) are established on spring crops.

RGT Planet goes from 6 to 3

Lauréate Goes from 6 to 4

To sow spring barley in autumn, ensures a very correct grain quality ☑

Good or very good calibration and protein content meeting the brewing specifications.

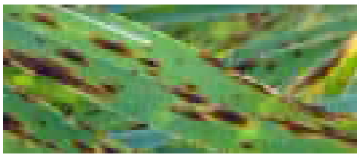
Brewing quality also more regular than spring sowing.

ARVALIS

Barley – Dynamic research

Collaborative research programs with all stakeholders in the sectors

Leaf scald and *Net blotch*



CASDAR Rhyno

Helmo

- Building of a collection of mushroom strains
- Tools for the selection of tolerant varieties
- Identified genetic markers for Leaf scald (ongoing for Leaf streap)
- Calibration of a risk assessment tool to help make decisions about diseases control

Barley Yellow Dwarf Virus (BYDV)

JNorge

CASDAR Virocap

DURAVI

Ecophyto Plantserv

ARVALIS

- Understanding of tolerance mechanisms: Ryd2 gene acts at different stages of life cycle.
- Knowledges about viruses
- Study about the yield losses of the main viruses under different stress conditions (temperature, water and nitrogen supply) (in progress).
- Study about durability of resistance (forthcoming)
- Service plants (in test)
- BYDV risk assesment tool based on an agro-climatic model : being calibrated

Wheat Dwarf Virus (WDV)

VWDV

- Enrich the range of solutions to limit or even eliminate the incidence of this disease.
- Research and evaluation of genetic sources of resistance/tolerance

Which proteins of interest for brewing quality ?

PROsIT

- Variety has a significant impact on protein composition

➔ **Genetic selection as possible lever**

- Some protein peaks predict the technological quality of malt (for the group of varieties studied))
- **PROsIT2** : Expand the range of varieties and refine the number of protein peaks carrying information for brewing quality

Optimizing maize canopy structure through rank spacing and plant density

Plant biomass production is closely linked to its **photosynthesis** efficiency, which dependent on the ability of the **crop canopy to intercept light**. Leaf Area Index (LAI) provide a way to estimate this interception.

Adapting sowing density to maize earliness groups

For a same sowing density, **a late cultivar have a better light interception than an early one**, due to its higher leaf number per plant. Sowing density must be adapted to cultivar earliness group.

Earliness group (grain maize)	Density - Limited situations	Density - favorable situations
Very early - G0	100	110
Early - G1	95	105
Medium early - G2	85	95
½ Early à ½ Late - G3	80	90
½ Late - G4	75	85
Late - G5	70	80

Groupe précocité (fodder maize)	Density - Limited situations	Density - favorable situations
Very early - S0	105	115
Early - S1	100	110
Medium Early - S2	90	100
Medium Early - S3	85	95
Medium late - S4	80	90

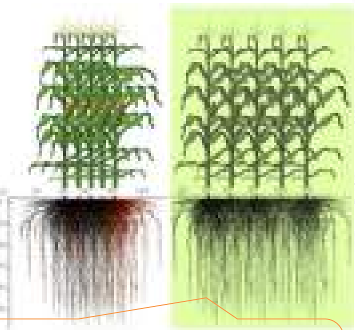
Yield response to density is higher in favorable siations

Can we reduce maize rank sapcing ? What potentiel effects ?

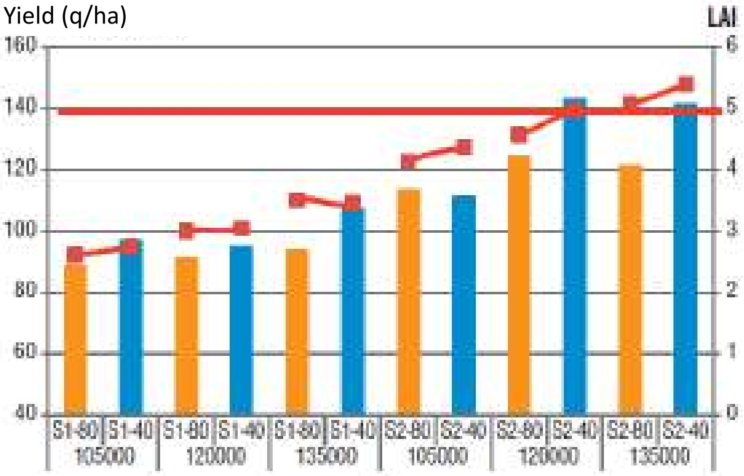
A reduce rank spacing (40-50 cm) could rise LAI by modifying crop canopy structure. This could be translate in a **higher yield at high density.** But **diminishing rank spacing will not modifie the optimal density** expressed in plant/ha.

Rank spacing

Plant spacing on the rank



For same cultivar and sowing density, a reduce rank spacing could diminish plants competition for ressources and for light interception.



Why optimizing canopy structure?

- ➢ **A yield at least equivalent (even higher)** with a smaller rank spacing and a higher plant density
- ➢ **A more efficient canopy** to intercept available light
- ➢ **A better root distribution** allowing a better ressources exploitation (water, nitrogen…)
- ➢ A sustanaible track **to manage weeds** thanks to a quicker closing of the inter-space between maize ranks
- ➢ A chance to **mutualise the sowing and mechanical weeding material** between crops

Attention : **high lodging risk** at higher density and reduced rank spacing (cultivar choice is important)

ARVALIS

What adaptations should be considered to optimize the profitability of grain maize?

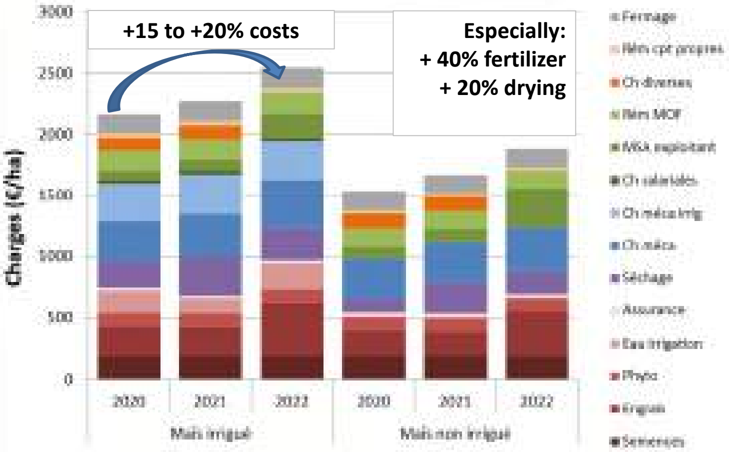
An increase of costs impacting the profitability of maize

Several possibilities of varietal precocities depending on the climatic offer

Continue to look for yield potential to offset higher costs : Delay?

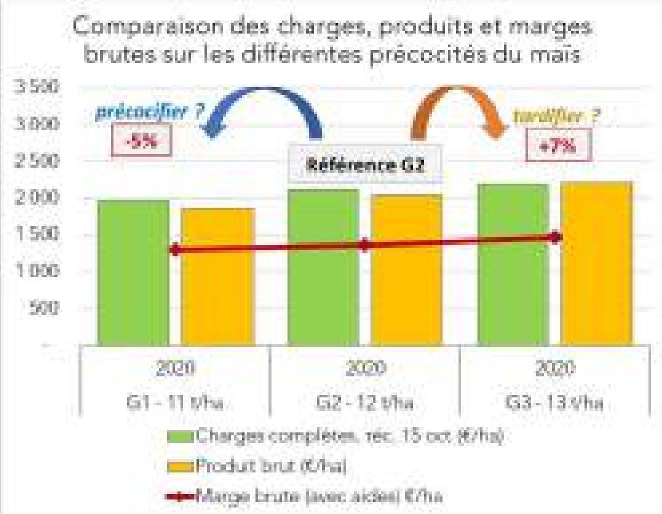
Reduce costs without compromising potential too much : Precocify?

- Reduce moisture at harvest?
- Reduce nitrogen needs?
- Save 1 round of water?

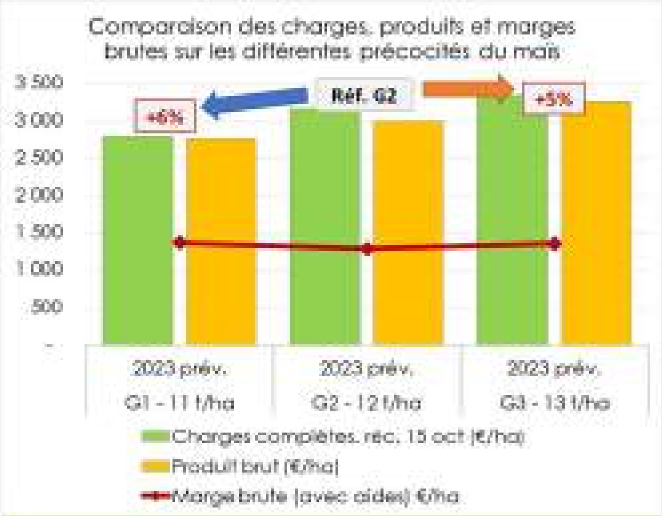


Source : Fermothèque grandes cultures Arvalis

Should it be adapted to the context of costs?



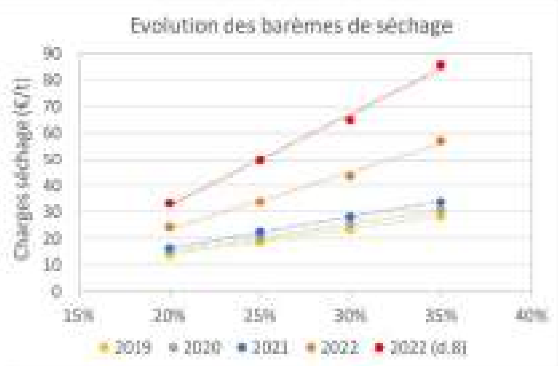
In historical context (low selling prices, low costs), it seemed appropriate to choose a later precocity variety of maize to improve gross margin.



In a context of high costs, balances can be disturbed: similar situations between precocities

Hypotheses for a farm located south of Paris with irrigation

Technical hypothesis		**Precocity**		
		G1	**G2**	**G3**
Potential yield (q/ha)		110	120	130
kg N /ha		202	224	246
Irrigation (mm)		180	215	215
Grain moisture	Harvest 30 Sep	27%	31%	33%
	Harvest 15 oct	24%	28%	30%
	Harvest 30 oct	21%	25%	27%



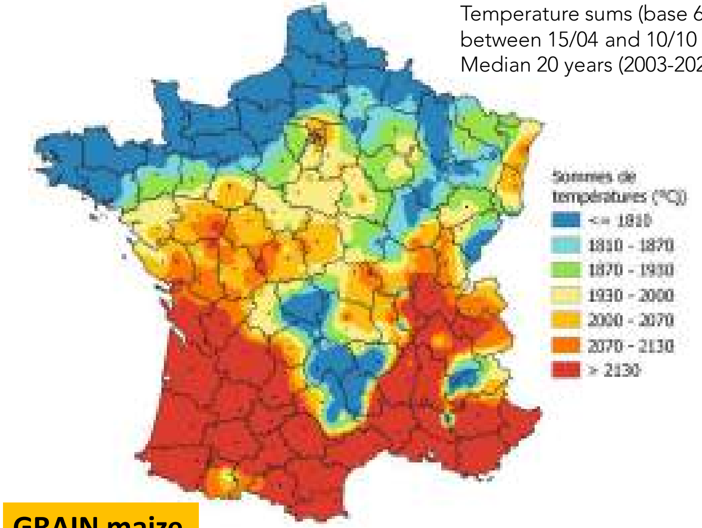
Economic hypothesis (April 2023)

	2020	**2023 prév.**
Selling price	170 €/t	250 €/t
Nitrogen	0.74 €/kgN	1.50 €/kgN
Irrigation	0.61 €/mm	2.50 €/mm
Drying	cf. scale (€/t) 2023 prév. = 2022 (d.8)	

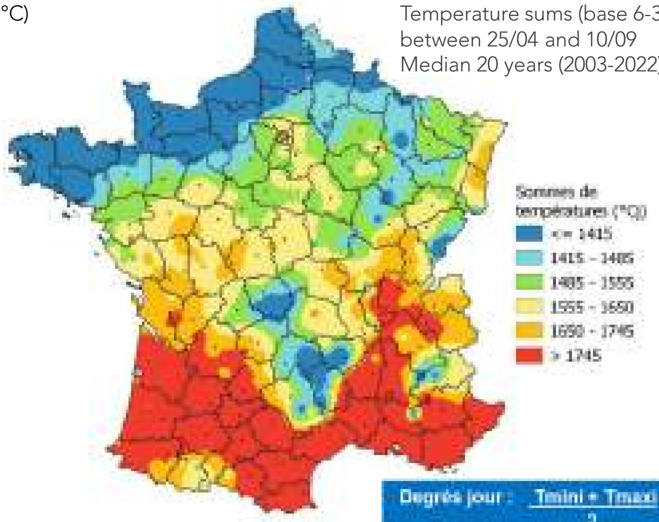
Economic profitability of maize = multifactorial!
Depending on the choice of precocity, the technical itinerary must be adapted::
PROPERLY **IMPLANT, PROTECT, FEED, HARVEST** your maize

Precocity and sowing date: how to reason with them?

Know my climatic offer to define my varietal precocity



Temperature sums (base 6-30°C)
between 15/04 and 10/10
Median 20 years (2003-2022)



Temperature sums (base 6-30°C)
between 25/04 and 10/09
Median 20 years (2003-2022)

GRAIN maize

Code groupe	Dénomination	Besoins en degrés-jours semis - 32% H2O (base 6-30°C)	Besoins en degrés-jours semis - 25% H2O (base 6-30°C)	Approximation indice FAO
G0	Très Précoce	< 1680	< 1810	190 à 240
G1	Précoce	1680 à 1740	1810 à 1870	240 à 280
G2	Demi-Précoce	1740 à 1800	1870 à 1930	280 à 310
G3	Demi-Précoce à Demi-Tardif	1800 à 1875	1930 à 2005	310 à 400
G4	Demi-Tardif	1870 à 1940	2000 à 2070	400 à 470
G5	Tardif	1940 à 2015	2070 à 2145	470 à 570
G6	Très Tardif	2015 à 2085	2145 à 2215	570 à 700

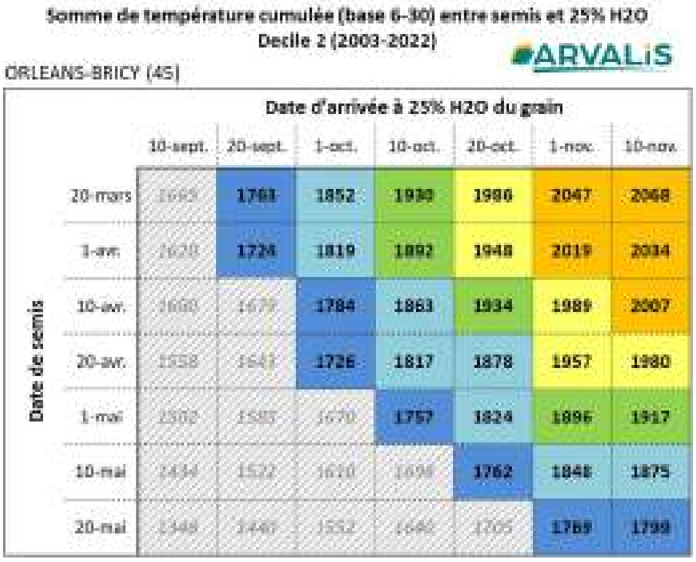
Degrés jour : $\frac{Tmini + Tmaxi}{2} - 6$
6°C = zéro de végétation
30°C = optimum thermique

FODDER maize

Code groupe	Dénomination	Besoins en degrés-jours semis - 32% MS (base 6-30°C)	Approximation indice FAO
S0	Très Précoce	< 1415	190 à 240
S1	Précoce	1415 à 1485	240 à 280
S2	Demi-Précoce	1485 à 1555	280 à 310
S3	Demi-Précoce à Demi-Tardif	1555 à 1650	310 à 380
S4	Demi-Tardif	1650 à 1745	380 à 430

Optimize my precocity, my sowing date and my harvest date

- ❖ **Grain maize:** enhance the climate offer, the potential of varieties without exposing to significant drying costs in cold years (aim for a goal of around 25% grain moisture)
- ❖ **Fodder maize**: aim = 32-35% DM → Best compromise between yield, quality and storage

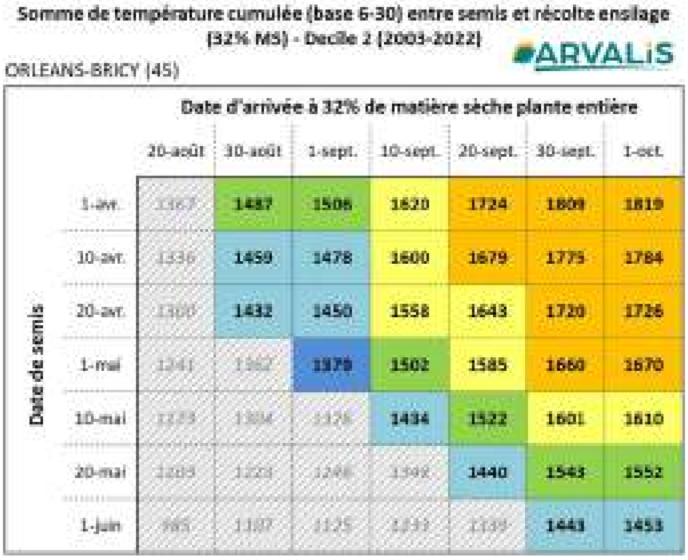


Somme de température cumulée (base 6-30) entre semis et 25% H2O
Decile 2 (2003-2022)

ORLEANS-BRICY (45)

Date d'arrivée à 25% H2O du grain

Date de semis	10-sept.	20-sept.	1-oct.	10-oct.	20-oct.	1-nov.	10-nov.
20-mars	1695	1763	1852	1930	1986	2047	2068
1-avr.	1620	1724	1819	1892	1948	2019	2034
10-avr.	1600	1679	1784	1863	1934	1989	2007
20-avr.	1558	1643	1726	1817	1878	1957	1980
1-mai	1502	1585	1670	1757	1824	1896	1917
10-mai	1434	1522	1610	1698	1762	1848	1875
20-mai	1348	1440	1552	1640	1705	1769	1799



Somme de température cumulée (base 6-30) entre semis et récolte ensilage
(32% MS) - Decile 2 (2003-2022)

ORLEANS-BRICY (45)

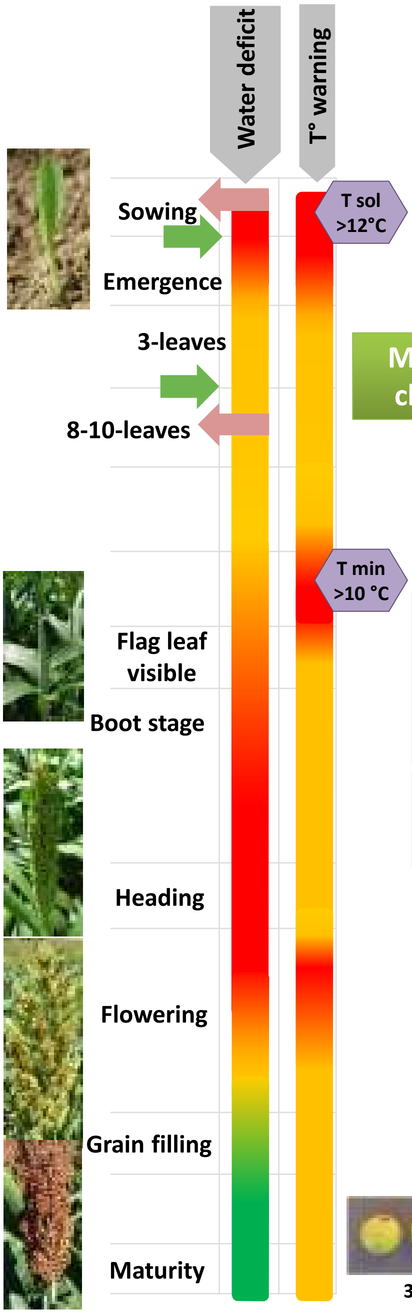
Date d'arrivée à 32% de matière sèche plante entière

Date de semis	20-août	30-août	1-sept.	10-sept.	20-sept.	30-sept.	1-oct.
1-avr.	1367	1487	1506	1620	1724	1809	1819
10-avr.	1336	1459	1478	1600	1679	1775	1784
20-avr.	1309	1432	1450	1558	1643	1720	1726
1-mai	1241	1362	1379	1502	1585	1660	1670
10-mai	1179	1304	1326	1434	1522	1601	1610
20-mai	1209	1223	1246	1399	1440	1543	1552
1-juin	985	1107	1125	1233	1339	1443	1453

- ❑ **Early sowing:** the crop establishment must be secured→ promote a quick start of maize with a starter fertilization, adapt the protection against soil pests (if risk) and birds
- ❑ Beware of **late harvests**: risk of deterioration of health quality, climatic risk (lodging)

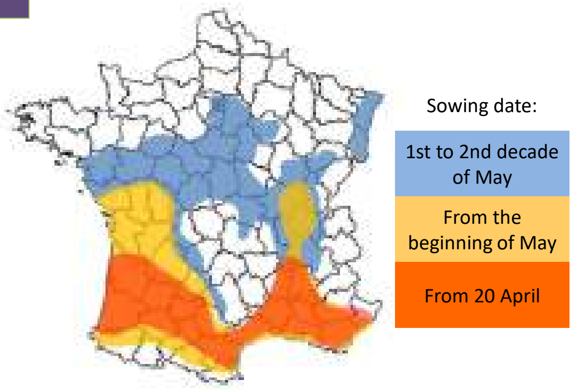
Technical itinerary of grain sorghum

For more information (in french)



Sowing date: Sowing on sufficiently warmed soil

Plant density: an objective to adjust according to the earliness and growing conditions



Mechanical and/or chemical weeding

Fertilization N,P,K

Cultivar choice: based on the very early cultivars of the northern group (Sinai, Arsky, RGT Dodgge).

Aim is to harvest **around 25% moisture** in October for a correct threshing without water recovery

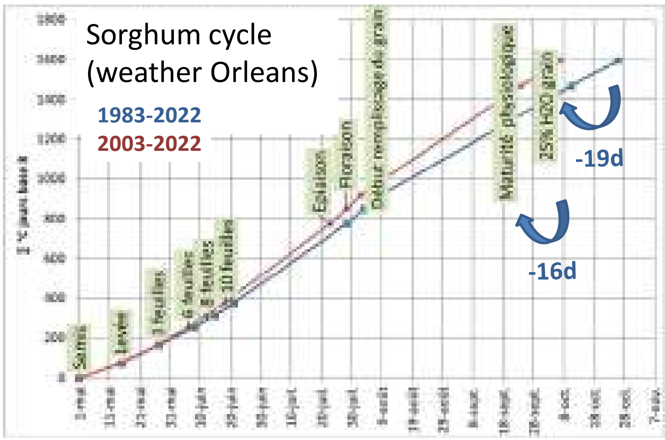
Pollen meiosis and flowering:
It is around these stages that the number of grains/spikelet is fixed and therefore the number of grains/m²

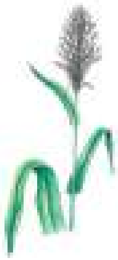
→ Stages very sensitive to specific accidents (cold T°, lack of radiation)

Boot stage - Flowering :
Setteling of the number of grains

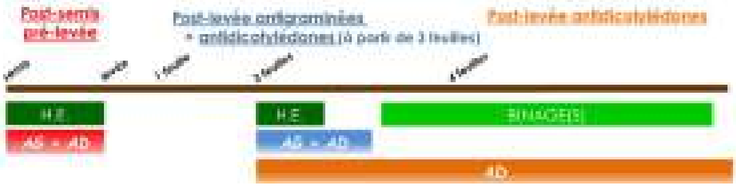
→ **Period most sensitive to water deficit**

30% grain moisture





Weeding



Examples of strategies: Resistant ryegrass* + Dicots

Preemergence	Post-emergence 3 leaves
	Isard 1l + Starship 0.5l
Si TS Concep® III S-Métolachlore 960g	Isard 0.8-1l + Starship 0.5l

**Variable efficiencies depending on pressure level*
Before sowing: several false seedlings, clean plot
Additional weed control is possible through mechanical weeding during cultivation

Fertilization

Starter — *Improves crop start-up*

N (40kg/ha max) — *If N residual <60kg/ha*

Main N input

**Varies according to yield potential*

- Nitrogen needs
  = yield target × N requirement per t
- Subtract the amount provided by the soil *(nitrogen residual, mineralization)*
- Low K requirements, medium P requirements

0.25 kg/ha N/t* on average

The nutritional qualities of potatoes

Potato rhymes with light

Thanks to a high proportion of water (78% on average) and a very low amount of lipids, the caloric density of the potato is moderate with **only 85 kcal per 100g cooked in water** which makes it a light accompaniment to integrate into dishes in sauce, soups or salads to restore the balance of carbohydrates.

Vitamin C for a well assimilated iron.

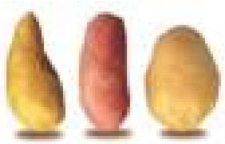
The potato provides 0.80 mg of iron per 100 g on average, which is identical to cereals.

But the high proportion of Vitamin C contained in a portion of unpeeled potatoes covers **about 20% of the adult's iron needs (12g / day).**

Potassium in quantity!

With 564 mg of potassium in the unpeeled potato, a 300 g serving covers more than half (56%) of the human daily requirement, estimated at 3g per day, 38% if peeled. It provides more potassium than banana.

Boiled potato		
Per 100g	**Unpeeled**	**Peeled**
Caloric value (Kcal)	85	
(kJ)	20	
Water (%)	78	
Carbohydrates (g)	19	
Fibers (g)	2.5	1.5
Lipids (g)	0.1	
Protein (g)	2	
Vitamins (mg)		
B1	0.09	0.08
B2	0.03	0.03
B3	1.5	1.2
B6	0.2	0.18
B9	0.01	0.01
C	13	9
Minerals (mg)		
Potassium	564	376
Magnesium	27	18.6
Iron	0.8	0.4
Manganese	0.25	0.14
Copper	0.19	0.09
Chromium	0.02	
Zinc	0.41	0.28



Fibers too!

A 300 g serving of potatoes covers 15% of the recommended daily intake of fiber, 25% with the skin of the potato.

The richest starch in vitamins and minerals!

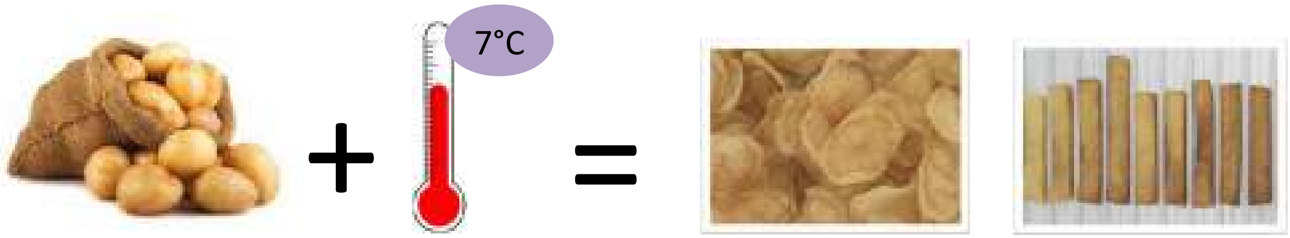
The potato has a good nutrient density of minerals: potassium, iron, magnesium, zinc, copper and chromium. As well as a wide range of vitamins of group B: B1, B2, B3, B6 and B9 and especially **the only starchy source of vitamin C!**

The quality of fries and crisps

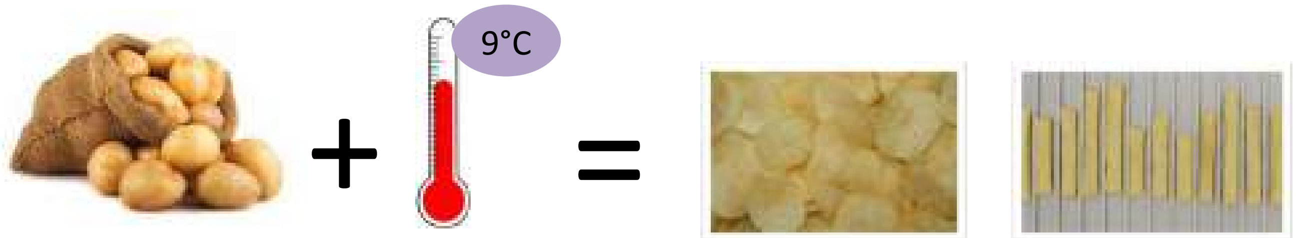
Storage
(1 month and more)

Crisps **Fries**

(E.g.: top of the fridge...)



(E.g.: vegetable drawer...)

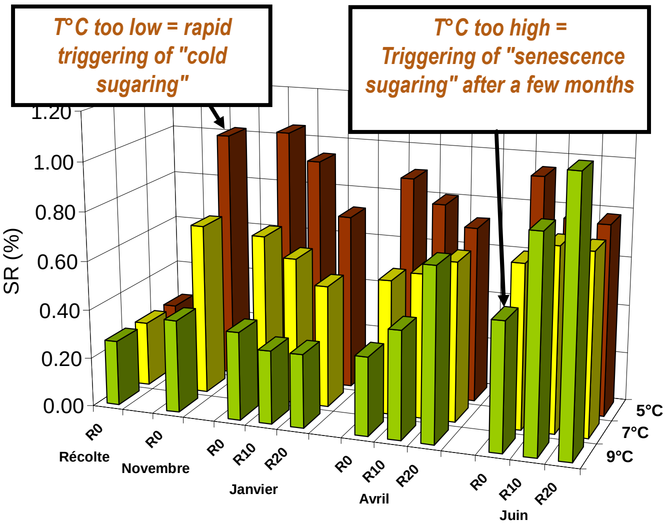


(Example: cellar...)

In potatoes, **the sugar content** in the juice is on average responsible for almost 85% of the color of the fried product.

The control of the chosen variety and the storage temperature is therefore essential to control this quality parameter.

The storage time, the temperature and the repackaging are all factors that influence this sugar content and therefore the color. (Fig. 1).



T°C too low = rapid triggering of "cold sugaring"

T°C too high = Triggering of "senescence sugaring" after a few months

Fig. 1 : Evolution of reducing sugars in potatoes stored at different temperatures. Effect of reconditioning of 10 days (R10) and 20 days (R20) at 15 °C.

The **variety** and **storage temperature** are 2 essential levers influencing the color of fried products

The quality of steamed potatoes

Characters of use

The varieties are classified, taking into account mainly **their degree of disintegration during cooking** (Fig 1), the firmness of their flesh and their flouriness in groups A, B, C and D.

Group A

Fine flesh, little or not floury, aqueous to moderately aqueous, and do not show disintegration during cooking.

Group B

Flesh quite fine, a little floury disintegrating little when cooked.

Group C

Flesh mealy, dry, coarse and showing a rather pronounced disintegration.

Group D

Very floury flesh, dry, disintegrating almost entirely when cooked.

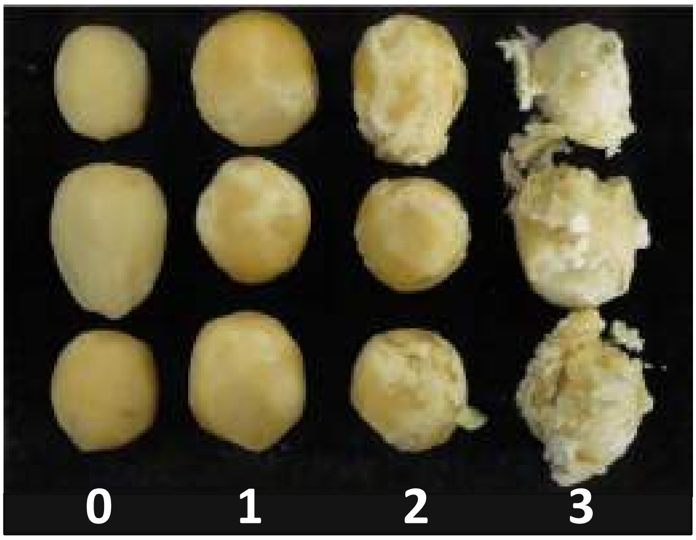


Fig.1: Disintegration scale

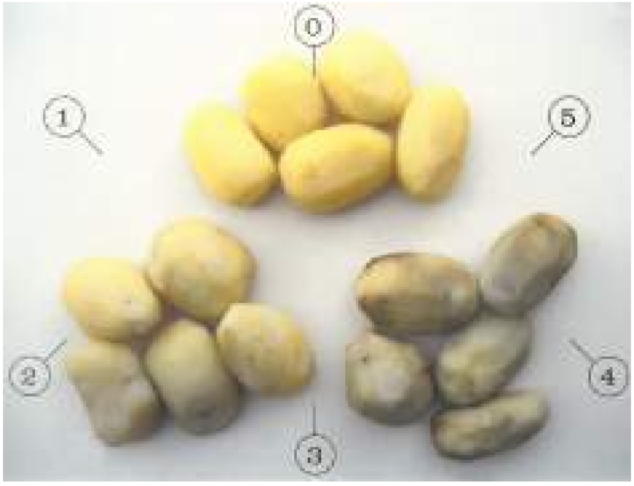


Fig.2: Blackening scale after cooking

Blackening after cooking

Also called "graying" of the flesh, it appears especially when the tubers are cooked in water or steamed, peeled, or cut and kept exposed to air. The sensitivity to this factor is on the one hand varietal but also depends on the pedo-climatic context with a negative effect of an unbalanced K management, a soil rich in organic matter and cold and rainy seasons.

Texture homogeneity

Texture is one of the most complex traits of the potato. It is strongly influenced by environmental conditions and cultivation techniques but depends largely on the varietal factor. The more or less pronounced tendency of the tissues of the tuber to disintegrate during cooking, the finesse, or the flouriness of the flesh are essential elements of the quality and for the outlet ..

Fig.3: Texture homogeneity scale

1,4-DMN (Dimethylnaphtalene) Commercial product: DORMIR (1,4 SIGHT)

Active ingredient

1,4 DMN is a substance naturally present in potato tubers in low concentration. Synthesised for large scale use, it is applied by hotfogging as a preventive action to increase the tubers dormancy period.

Application advices

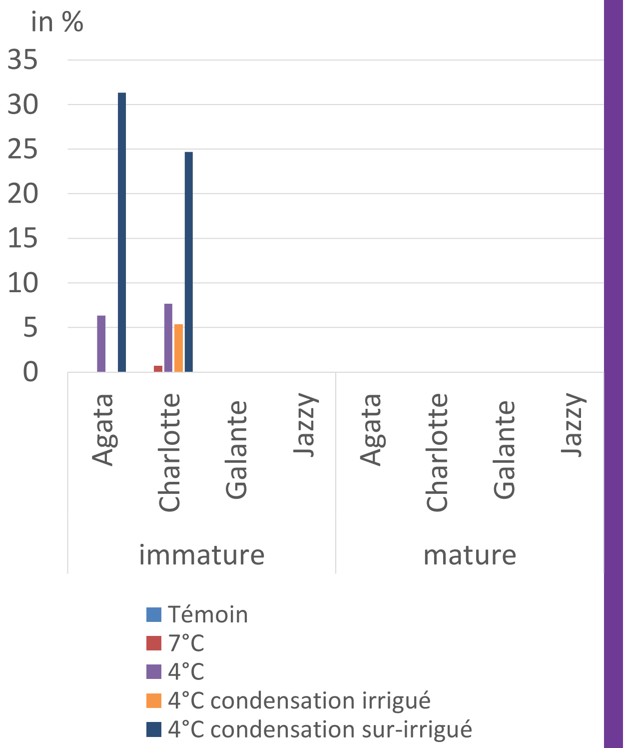
- Good tubers healing
- Apply on dry and mature tubers
- Apply before sprouting developpment or at the early sprouting stage
- Sufficiently airtight storage
- Do not apply on immature thin skinned tubers, with condensation or after over irrigation which favours lenticels opening
- Possibility to delay the first treatment in storage by applying maleic hydrazide in field.

Benefits of use

- Good preventive efficacy
- Easy to apply

Registrated dose
120ml/t per season
6*20ml/t

Tubers with selectivity defetcs



Tubers affected by symptoms of lack of selectivity after an early treatment with 15ml/t of Dormir

Points of attention

- **Mature**, **dry and healed** tubers
- Be careful with thin skinned varieties ➔ treatment 8 to 10ml/t
- Period treatment – sale 30 days

Indicative cost

8 to 14€/t for 8 months of storage between 4°C and 8°C.

L'Ethylene
Commercial product: BIOFRESH et RESTRAIN

Active ingredient

This growth hormone is registrated for organic farming. Ethylene is continuously applied in the cell by two types of equipment, either by compressed gas bottles or by a generator producing ethylene from ethanol.

Application advices

- Start the treatment on dry and healed tubers
- Increase the concentration very gradually
- Sufficiently airtight storage
- Maintain CO_2 concentration < 4000ppm

Processing varieties

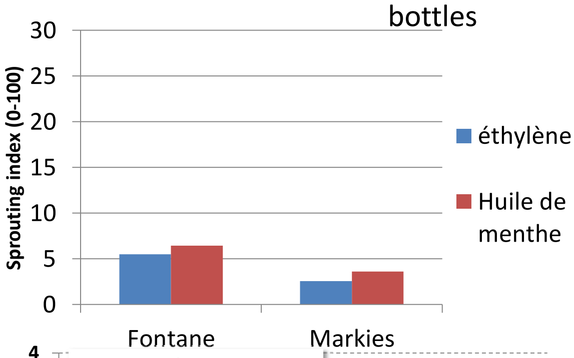
Many questions are being asked about using ethylene on processing varieties because of its attractive cost. Depending on the variety, it can have a more or less important impact on the fried products colouration. Markies and Fontane show a little risk of increased colouration with ethylene treatment. Nevertheless, it is necessary to :

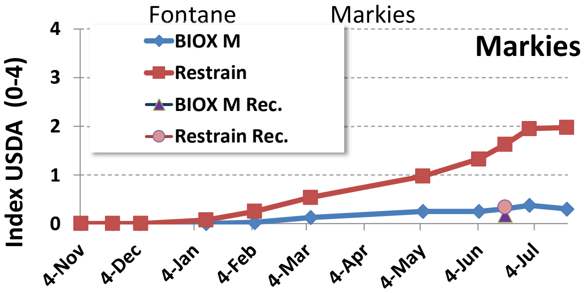
- Warn the industrialist
- Regularly monitor the colouration after frying.

Registrated dose
10ppm continuously

Restrain
Ethanol transformed in ethylene

Biofresh
Ethylene compressed in gas bottles





Coll. Restrain

Frying colouration and sprouting index after 8 months of storage at 7°C with ethylene treatment at 4% of Restrain vs BIOX M (2019/2020).

An increase of the frying colouration can often be recovered by reconditionning as long as it is not carried out too late.

Points of attention

- Dry and healed tubers
- Sufficiently airtight storage
- Pay attention to the varieties used for processing market
- Monitor the CO_2 evolution

Indicative cost

4 to 5€/t for 7 at 8 months of storage between 4°C and 8°C.

The essential oils Commercial products:

Peper mint oil (BIOX M)
Orange oil (ARGOS)

Active ingredient

The essential oils, registrated in organic farming and biocontrol, have the ability to necrotize sprouts. Both can be applied by hotfogging. Mint oil can also be applied by continuous evaporation via a Xedavap. Orange oil can be applied by a coldfogging.

Application advices

Apply at the white bud stage or on very small sprouts to obtain their complete necrosis.

Adapt the dose to the size of the sprouts present, preferring higher doses especially when there is a strong sprouting pressure to ensure a good necrotize and avoid a quick restart.

Benefits of use

Their curative action is very interesting for necrosing young sprouts. It is interesting to combine their use with preventive products which allow to:

- Slow down the sprouts developpment to make necrosis easier
- In the case of maleic hydrazide:
- Possibility of delaying the first treatment in storage ➔ limits the risks of lack of selectivity
- Less applications and lower cost

BIOX M

Registrated dose

<u>Hotfogging</u>: Adjustable until 90ml/t , max 390ml/t/season

<u>Continuously</u> : 1 at 2 ml/t/d max 360ml/t/season

Xedavap hotfogger

ARGOS

Registrated dose

900ml/t on the season

9*100ml/t

coldfogging hotfogger

Points of attention

- Dry and healed tubers
- Sufficiently airtight storage
- Do not let the sprouts grow too much with the risk of traces of necrotic sprouts or difficulty in controlling the sprouting
- Caution with coldfogging, risk of burning tubers

Indicative cost

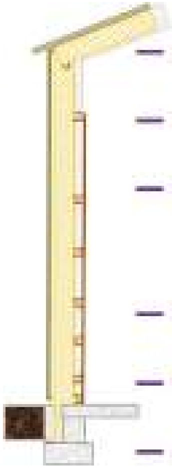
For 7 at 8 months of storage between 4°C and 8°C:

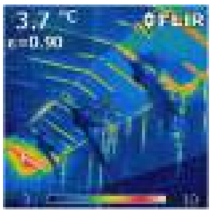
Mint : 13 at 20 €/t

Orange : 10 at 18€/t

Proposed actions for more energetic sobriety in storage

- **Strategic investments**



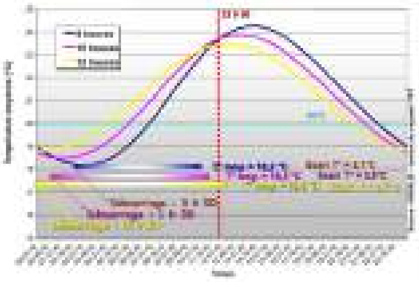


  - High-performance insulation without thermal bridges
  - Variable speed fans with inverters
  - Chiller with high COP with consideration of the GWP of the refrigerant

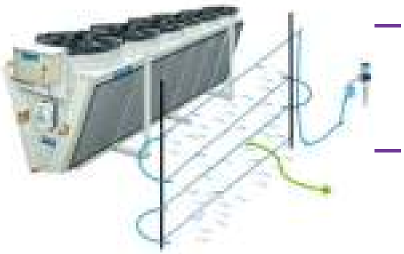
  - Favor cooling units with floating HP and LP
  - Adopt specific CO_2 extractors
  - Ensure local electricity production (solar, wind) for on-site self-consumption

  - Switch to LED for building lighting and limit greening
  - Valuing the calories recovered in the building (heat recovery)

- **Tactical approaches and settings**



  - Harvest in the cooler hours of the day during summer harvests
  - Adapt the setpoint temperature and the choice of the differential according to the possibilities



  - Improve the COP of the chiller at the hottest hours
  - Keep clean the surfaces of the cold unit heat exchangers

  - Run installations as much as possible during off-peak hours

Considering the non-exhaustive list of levers above may reduce the energy cost of storage by more than 20%

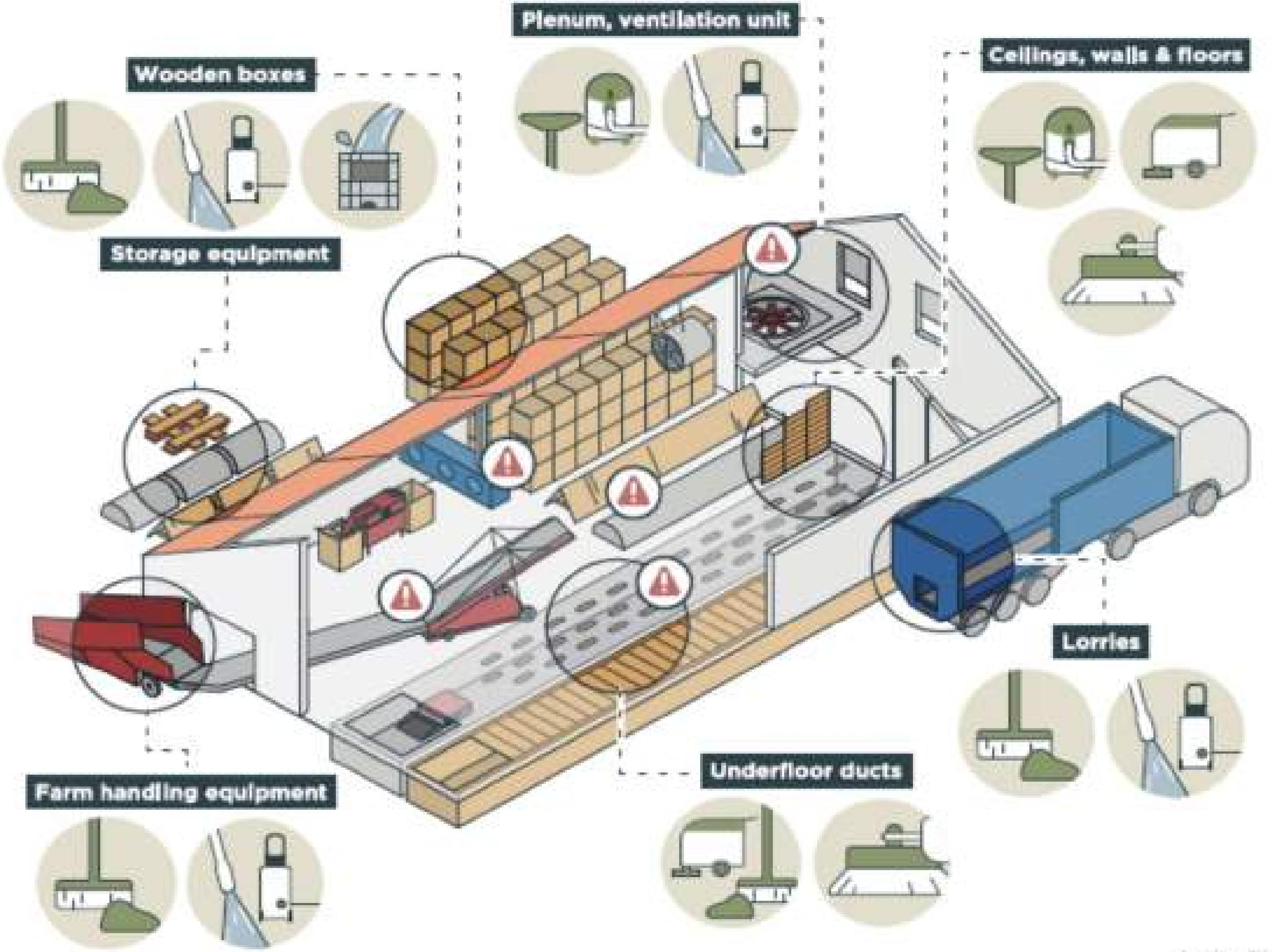
Cleaning guidelines for reducing CIPC residues from stores and equipments

Key principles

- Stores must be cleaned as soon as 2019 crop has been unloaded
- Always use personal protection and pay attention to safety
- Keep written records and/or pictures of what has been cleaned, how and when
- Clean from top to bottom (i.e. from roof to floor)
- Hotspots: pay greater attention to areas of higher contamination

Cleaning methods

- Use dry cleaning methods first (broom + vacuum)
- Use mechanical (industrial) brush
- Complete with water cleaning only if dry cleaning not sufficient - take care on waste water management
- Collect waste water in the tank or pit
- Clean boxes and storage equipment first dry and possibly wet. Keep them outside as much as possible
- Refresh air of the store continuously by leaving hatches and doors open during the empty period

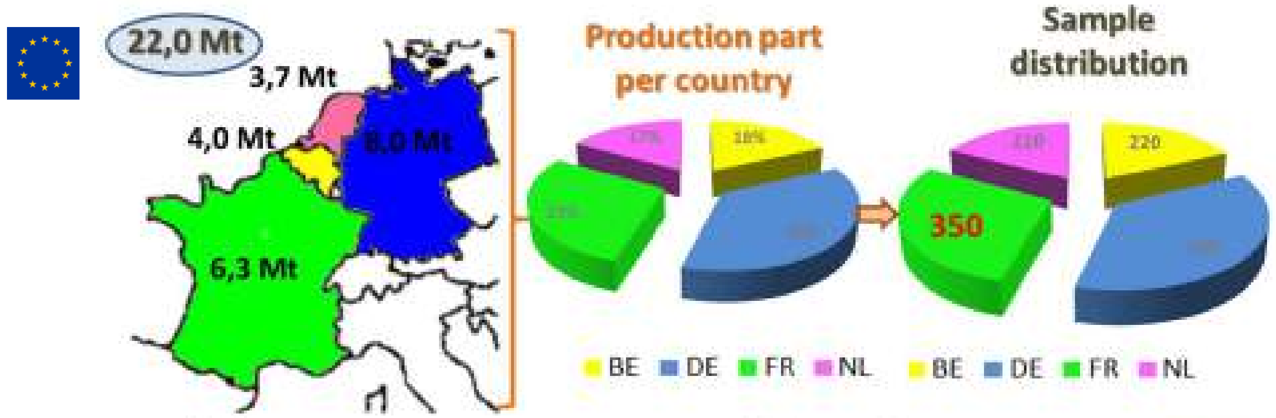


This is a best practice based on the current knowledge, Spring 2020

Avec la collaboration de

A monitoring plan on CIPC for a progressive reasoned decline of the tMRL

- A temporary Maximum Residue Limit for CIPC adopted by the European Commission subject to an annual European monitoring plan since 2020 with a French participation



Production 2019

350 samples

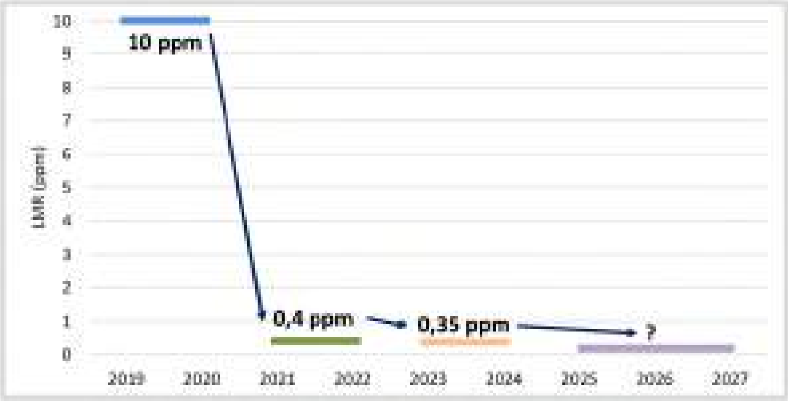
Processing

GIPT → 150 samples
- 145 Consumption
- 5 / 10 Starch

Fresh

CNIPT → 200 samples
- 140 Indoor market
  - 110 trading
  - 30 ind. producers
- 60 export market
  - 30 trading
  - 30 ind. producers

- A first decrease of the tMRL expected September 4 2023



- Identified risk factors

- ▪ Hotfogging
- ▪ Box storage
- ▪ Cleaning defect
- ▪ No fresh air ventilation of boxes and buildings

Necessity to keep high attention on buildings with risk factors to avoid any exceeding of the tMRL at present time and for future.

Maleic hydrazide Commercial products:

FAZOR STAR (Catapult star/Himalaya/Delete), ITCAN SL 270 (Magna SL/ Crown MH)

Active ingredient

This systemic molecule is applied in the field in solid or liquid form. It migrates from the foliage to the tubers. Dormancy is maintained during two to three months of storage depending on the variety and the set temperature.

Application advices

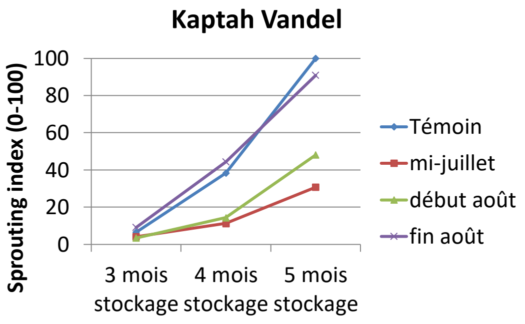
- 80% of tubers larger than 25/35mm (depending on the market)
- Delay of 2 at 3 semaines before haulmkilling to ensure good migration of the product
- Mild temperatures (<25°C)
- Avoid rain and irrigation for 24h
- Apply in optimal growth conditions (no hydric and thermal stress, no senescence)

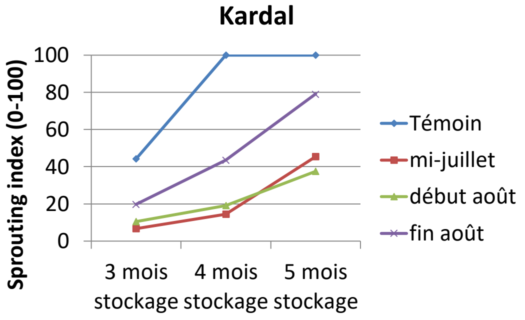
Benefits of use

- Sprouting control for precarious storage
- Delay the first treatment in storage
- Easier sprouting control for long term storage by slowing down sprouts developpment
- Internal sprouting risk is reduced
- Side effect:
    - Limit regrowth in the field in year n+1
    - Physiological regrowth

Registrated doses

- **FAZOR STAR : 5kg/ha max. 2 applications**
- **ITCAN SL270 : 11L/ha non divisible**





Sprouting index (0 at 100) of varieties treated with maleic hydrazide at 3 dates (storage at 7°C – season 2019/2020).
There is flexibility for the application although maximum efficacy is generally observed for the earliest applications and when the application conditions are respected.

Points of attention

- Adapted for short term storage or to be completed with other inhibitors during storage
- Favour early application in field as soon as the crop has reached the stage
- Respect application conditions

Indicative cost

2 to 3€/t

Evaluate the performance of varieties & varietal association with virus inoculation

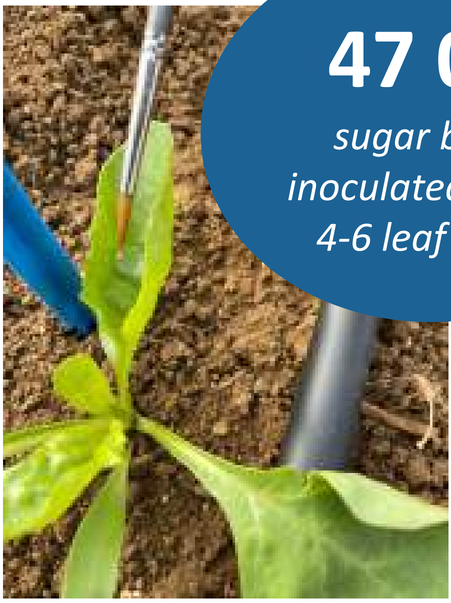
Production of viruliferous aphids at the Griffon (02)

- BYV, severe jaundice

- BMYV, BChV moderate jaundice

500 000

Flightless green aphids *Myzus persicae* produced in 2023



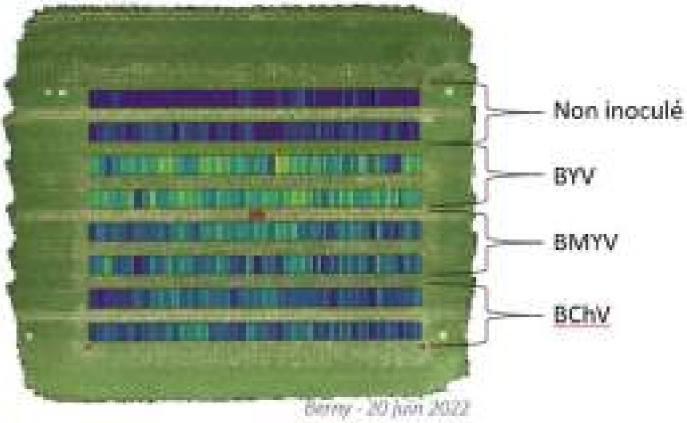
47 000

sugar beets inoculated at the 4-6 leaf stage

Inoculations performed:

- **107 varieties** with the virus cocktail in the ITB SAS severe jaundice network
- **139 varieties in** mono-virus for registration
- **25 Hybrids and intra- and inter-seeder mixtures**

- **Ratings**
- **Drone flights**
- **Harvest**



ITB Institut Technique de la Betterave
Technical Institute of Sugar beet
45 rue de Naples - 75008 Paris
www.itbfr.org - malatesta@itbfr.org

PNRI PLAN NATIONAL DE RECHERCHE ET D'INNOVATION

DIGIFERMES®

The place to scale-up agtech innovations

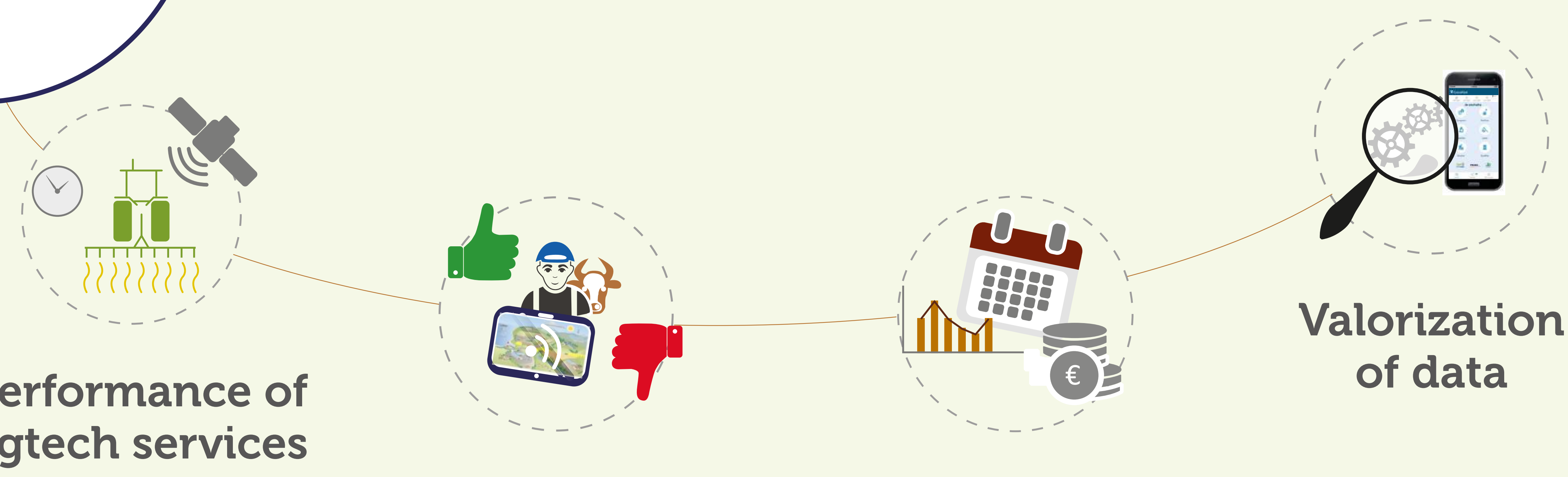
https://digifermes.com/

In collaboration with technical experts

A network of experimental agricultural infrastructures

to evaluate and improve digital innovations in real conditions

4 strategic orientations

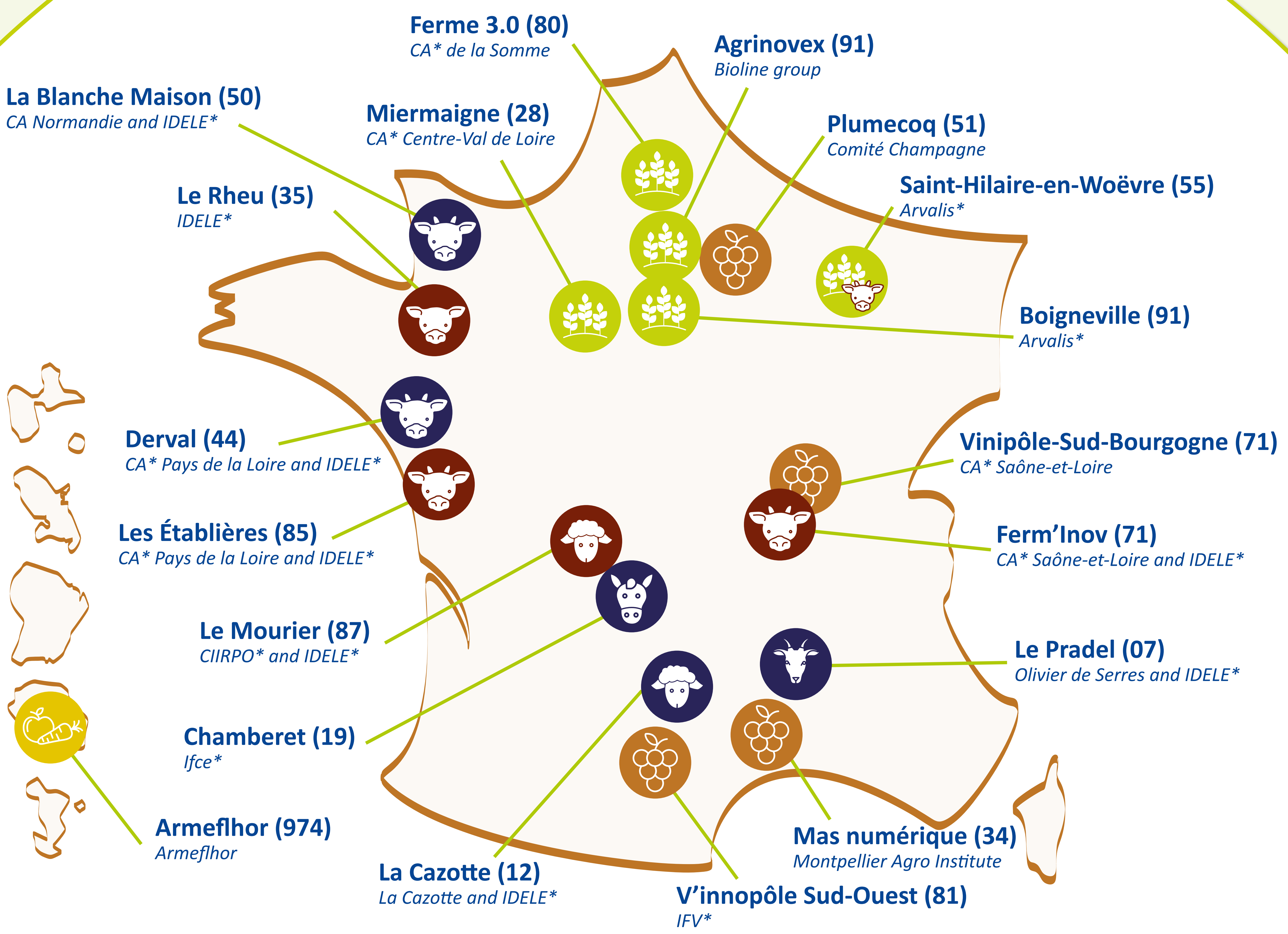


Performance of agtech services

Functionality of digital tools

Integration of digital solutions to farm management

Valorization of data



* CA: Agricultural Chamber ; IDELE: French Livestock Institute ; IFCE: French Institute of the Horse and Horse-riding ; IFV: French Wine and Vine Institute ; CIIRPO:Interregional Center for Information and Research in sheep ; Arvalis: French arable crops R&D institute.

Suckler cattle
Dairy cattle
Nursing sheep
Dairy sheep
Goat
Equine
Beef calf
Crops
Polyculture livestock
Vines
Fruits, vegetables & horticulture

A network of 19 agtech experimental infrastructures specialized in animal and plant productions

Le réseau des Digifermes in

@digifermes

Digifermes f

Space 2 :

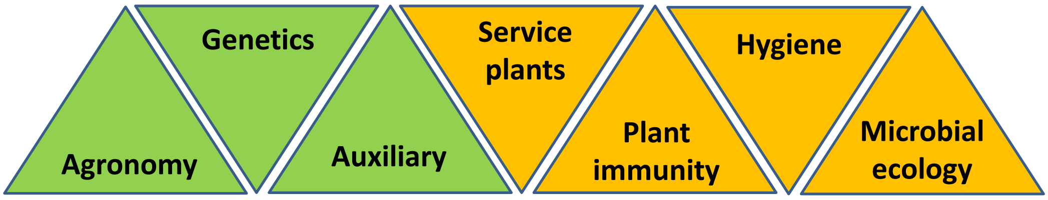
PLANT HEALTH

Les Culturales 2023 14-15 juin

PREVENT: cereal prophylaxis

PROPHYLAXIS
INDIRECT CONTROL

🟩 Current levers
🟧 Research axes

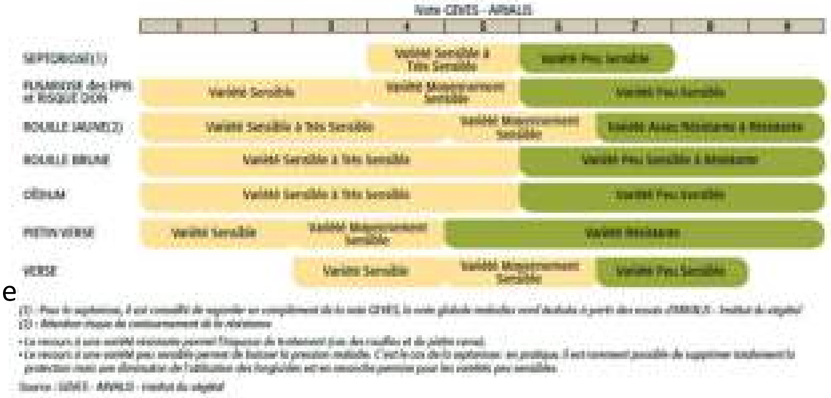


MAIN LEVERS: AGRONOMY and GENETICS

- <u>Varietal choice</u>

Varietal choice remains **the first lever to control the harmfulness of the main fungal diseases on cereal**. Choose a tolerant or resistant variety.

The use of BYDV tolerant variety in barley makes it possible to limit the expression of the virus in the plant and thus to systematize the fight against aphids (= vectors of this virus).



Source : GEVES - ARVALIS - Institut du végétal

- <u>Crop rotations</u>

Appropriate crop succession allows effective weed/disease control
Reduce the return of the same crop in a rotation.

- <u>Tillage and cultural practices</u>

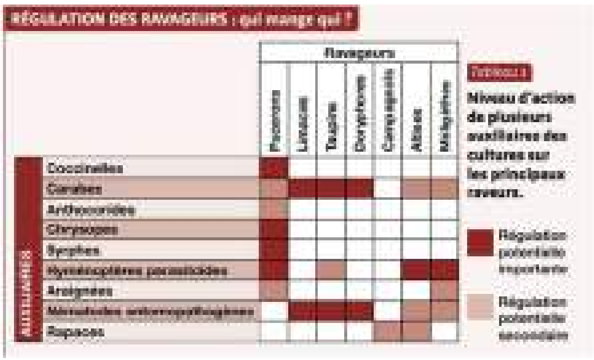
Adapting these agronomic practices makes it possible to limit the pressure of diseases in field:
->Incorporate crop residues and managing crop regrowth (Reduction of ecological relays)
->Practices such as ploughing and false seeding (managing weed pressure)

Adapting the sowing date helps to control diseases and pests on cereal crops. The objective is to delay the cereal cycle to avoid the common period for pest attacks

⇨ The combination of levers optimizes the efficiency of prophylactic control

Biological control

It is the action of crop auxiliaries who will come to control and regulate pest populations. There are two types of auxiliaries:
<u>Predatory auxiliaries:</u> direct consumers of pests (ladybug, lacewing larva)
<u>Parasitoid auxiliaries:</u> that will parasitize the pest that will eventually die (eg small wasps)



RÉGULATION DES RAVAGEURS : qui mange qui ?

		Ravageurs						
		Pucerons	Limaces	Taupins	Doryphores	Campagnols	Altises	Méligèthes
AUXILIAIRES	Coccinelles	■						
	Carabes	▨	■	■	■		▨	▨
	Anthocorides	▨						
	Chrysopes	■						
	Syrphes	■						
	Hyménoptères parasitoïdes	■		▨			■	■
	Araignées	▨						▨
	Nématodes entomopathogènes		■	■	■		▨	▨
	Rapaces					▨	▨	

Tableau 1
Niveau d'action de plusieurs auxiliaires des cultures sur les principaux ravageurs.

■ Régulation potentielle importante
▨ Régulation potentielle secondaire

Source: ARVALIS, 2020

Promising research directions

Microbial ecology

Plant immunity

Service plants

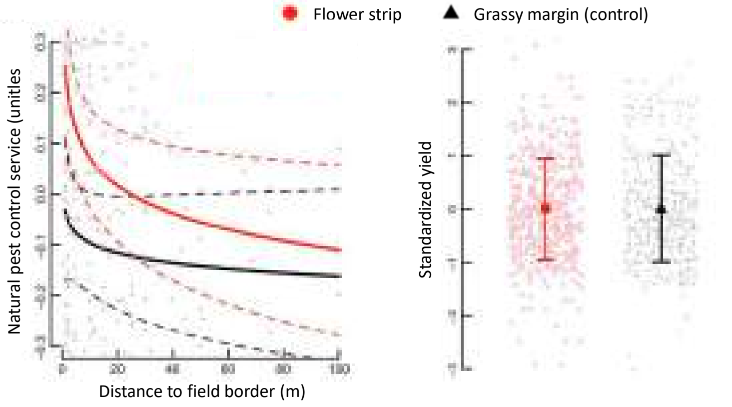
Hygiene

ARVALIS

Flower strips to improve natural pest control in field crops?

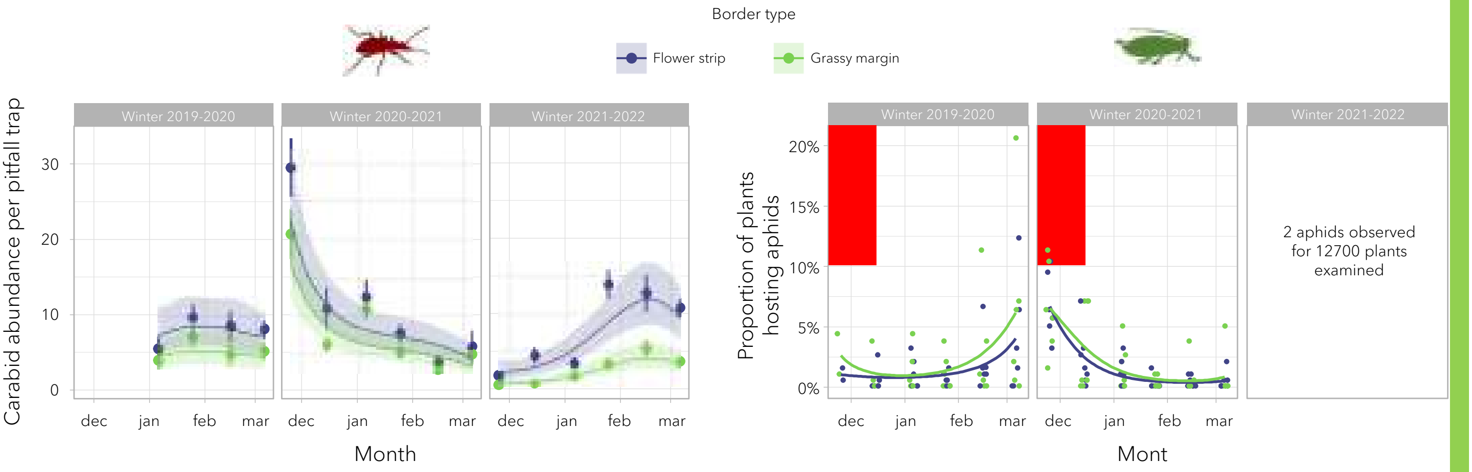
A little bit of context

- Flower strips generally favor natural pest control
- No significant consequences on yield



Albrecht et al. (2020), synthesizing 18 studies on natural pest control and 11 studies on yield

- Case study on aphid vectors of the BYDV
  - Can we improve the control of aphid vectors of the BYDV with flowering intercrops?
  - 34 plots – 3 years – Brittany & Pays de la Loire



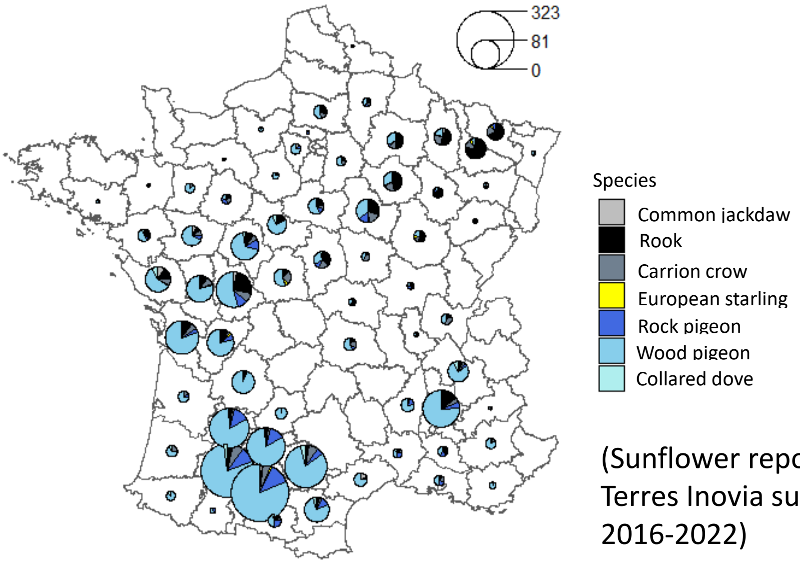
Flowering intercrops improved carabid abundance nearby but did not allow for a better control of aphids and did not lower the incidence of BYDV symptoms

Albrecht *et al.* (2020). The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. *Ecol. Lett.*

Bird damage on sunflower
What impact?

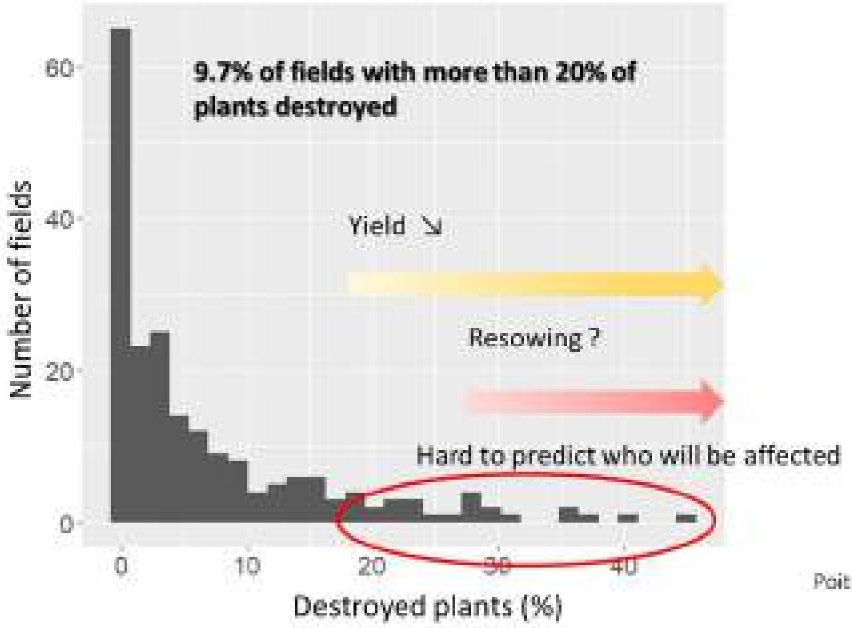
Wood pigeons can cause significant damage during emergence

Stage	%
Sowing	**19**
Seedling	**69**
Vegetation	9
Maturity	3



(Sunflower reports, Terres Inovia survey 2016-2022)

Severe damage in some fields, but difficult to predict



Poitou Charente and Gers survey 2018-2020 (206 plots)

Order of magnitude of production losses 2020-2022

- 777 000 ha
- 10% of plots with harm, half of which are reseeded
- Losses of 220 €/ha (without reseeding) or 330 €/ha (with)

→ €20 million

+ losses for the downstream and upstream sectors

Terres Inovia
l'agronomie en mouvement

Contact: Christophe SAUSSE
c.sausse@terresinovia.fr

Bird damage on sunflower
What solutions?

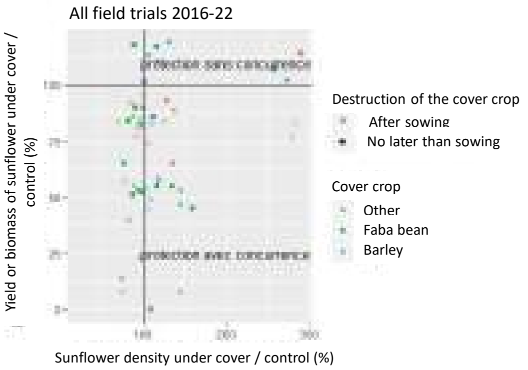
Les Culturales 2023 14-15 juin

Common advice

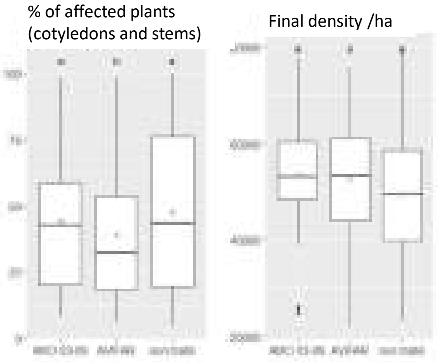
- Respect the fundamentals of successful sowing
- Avoid historically exposed fields
- Be attentive to the activity of birds before sowing and if necessary, use the possibilities of destruction
- If possible, coordinate sowings with neighbours
- Protecting plots with a reasonable use of scarers
- Reseed only on the basis of a diagnosis of stems destruction (and not cotyledons)
- Pooling experiences and reporting damage

Field protection: unsatisfactory results, for the moment

Sowing under cover crops: low success (Terres Inovia and FranceAgriMer PREVOT results)



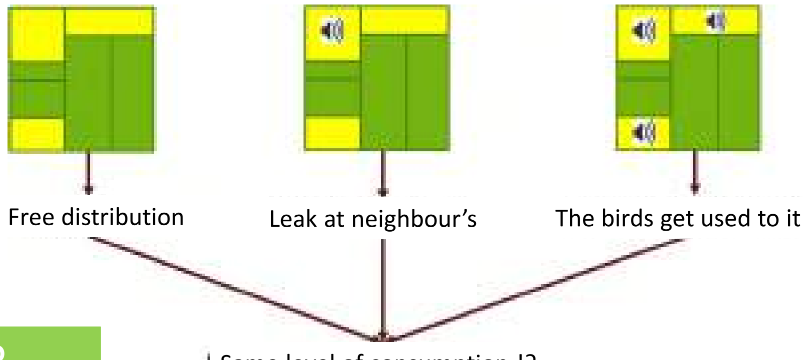
Repellents: very random results (e.g. repellent tests 2016; 31 plots)



Dissuasive seeding: disappointing and difficult to assess (FranceAgriMer PREVOT)

Scaring 2.0: under study

What complicates protection: birds do not think at the field level



Free distribution

Leak at neighbour’s

The birds get used to it

¡ Same level of consumption !?

Towards a territorial approach?

- Combining levers (push/pull)
- Sow at the "right time", at the same time
- ANR Bird Damage Limitation Project 2022-24 (Terres Inovia, Inrae, ANAMSO)

Terres Inovia
l'agronomie en mouvement

Contact: Christophe SAUSSE
c.sausse@terresinovia.fr

Les Culturales 2023 14-15 juin

FNAMS

RYE GRASS SEED PRODUCTION : estimating the black grass risk in a field

- Eliminating black grass (Alopecurus myosuroides) in a ryegrass seed production field is more and more difficult and expensive :
  - Few efficient and approved herbicides available
  - Appearance of herbicide resistance
- The regulation of this weed must absolutely begin with an eradication in the crop rotation (choice of cultures and cultural practices).
- Here is a grid to estimate the risk index in a field :

Black grass in a field of ryegrass seed production

	1 - How many spring crops did you have in the last five years in this field ?	Number of points
a)	At least 3 spring crops	4
b)	2 spring crops	8
c)	1 spring crop	12
d)	None	16
	2- How many yearly stubble management have you made in the crop rotation in this field ?	
a)	More than 2 per year	3
b)	2 per year	6
c)	1 per year	9
d)	None	12
	3- How many times in the last five years have you NOT plouwed or made false sowing (chimical or mechanical) in this field ?	
a)	Plowing or false sowing every year	3
b)	1 year without plowing or false sowing during the last 5 years	6
c)	2 years without plowing or false sowing during the last 5 years	9
d)	At leat 3 years without plowing or false sowing during the last 5 years	12
	4- During the 3 last crops before the sowing of ryegrass seed, what was the quantity of blach grass in this field before weeding ?	
a)	No black grass	5
b)	1 black grass here and there in the field (<1 plant / m²)	10
c)	Distribution by spots in the field (1 to 10 plants / m²)	15
d)	Black grass is present in the whole field (>10 plants / m²)	20
	5- During the last 3 crops, how efficient was the chimical weeding against black grass in this field ?	
a)	No black grass (answer a) at question 4)	5
b)	Really good control - decreasing evolution	10
c)	Average control - variable evolution	15
d)	Insufficient control - growing evolution	20
	Your total (from 20 to 80 points)	

Access to the online tool:

This grid has been developed by FNAMS in collaboration Arvalis, INRAE and ACTA from studies and field observations in Picardie.

To learn more:

- Ray-grass anglais porte-graine : estimer le risque vulpin dans sa parcelle et adapter les conduites culturales pour limiter l'infestation. Note technique NTF145 Juin 2021
- Guide Pratique FNAMS « Protection des fourragères porte-graine » - Liste des produits homologués et leur efficacité par culture - Avril 2023 (à paraitre)
- Note commune inter-instituts pour la gestion des résistances des adventices aux herbicides en grandes cultures/Fiche vulpin (GCHP2E, 2019)
- Ray-grass anglais – Comment mesurer le « risque vulpin » dans ma parcelle ? Bulletin Semences n° 190, 2006

En fonction du **score total obtenu**, le risque est le suivant :

Less than 32 points:
« Black grass risk » LOW
→ Sowing is possible
Black grass should not disadvantage the seed production.

From 32 to 48 points:
« Black grass risk » MODERATE
→ Reconsidering the choice of field
In normal sowing conditions and in the absence of resistance, the black grass should be managed. But the control of this weed is random and the herbicides cost may be quite high.

More than 48 points:
« Black grass risk » HIGH
→ Sowing is not recommended at all !
The control of black grass is not impossible but is becoming realy unpredictable and expensive.

Action funded by

E2_04_1

SEMILONI: a decision-support tool to manage DOWNY MILDEW in onion seed production

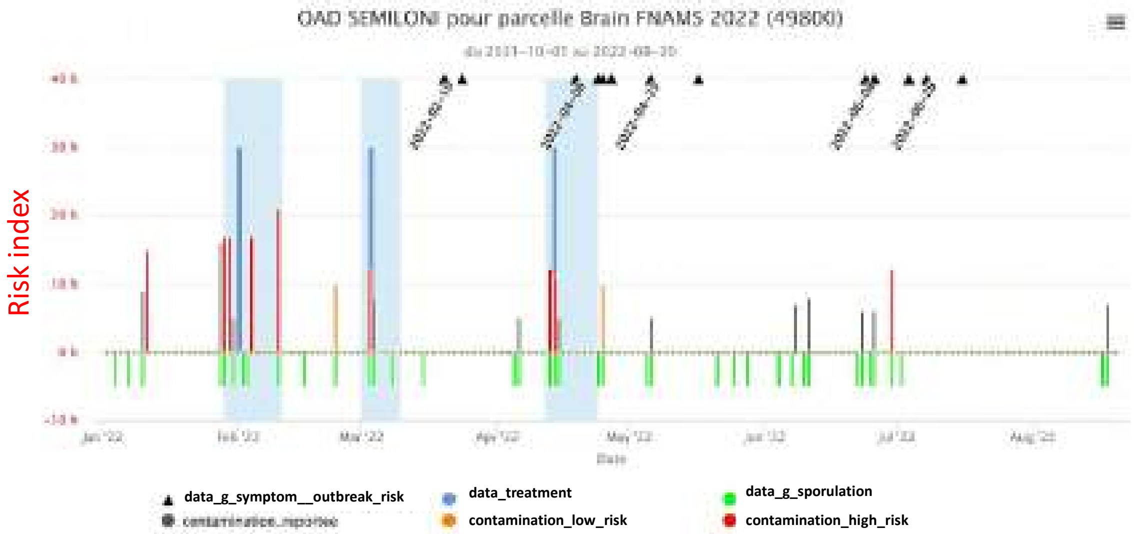
- Downy mildew of onion (*Peronospora destructor*) is **the most penalizing disease** in onion seed production. It develops by spots and its installation can be very early, as soon as autumn.
- Uncontrolled, it can lead to the **complete destruction** of the field, by drying up flower stems and umbels.

Symptoms of downy mildew on a onion flower stem

SEMILONI is a **free** decision-support tool for onion seed growers and seed technicians, which can, based on **hourly wheather datas** (rain, temperature and humidity):

- Determine the **favorable climatic periods** for **sporulation** and **entry of the fungus** in the plant;
- Calculate the **incubation lenght** of the fungus and allow to **anticipate symptoms outbreak**.

Exemple of chart:



Practical modalities: to have access to hourly weather datas and register on http://semiloni.fnams.fr

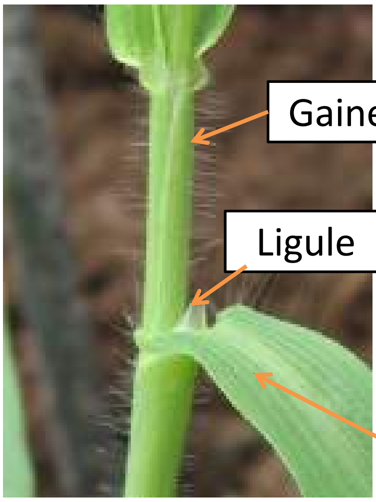
This tool is currently compatible with the following weather stations: SENCROP, WEENAT or METEUS. Users can also access to several free datas from some French airports (Météo-France, SYNOPS network).

CONTACT : semiloni@fnams.fr

With the support of: semae

RECONNAISSANCE DES ADVENTICES

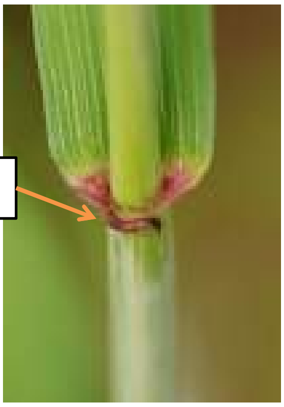
Monocotylédones : Graminées


Gaine

Ligule

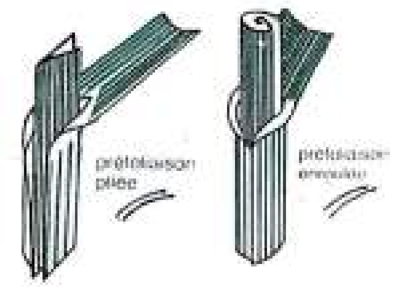
Limbe = feuille

Source: ARVALIS


Oreillettes

Source: ARVALIS

PRÉFOLIAISON
(mode de dégagement des jeunes feuilles)



- Préfoliaison : pliée (ex : pâturin), enroulée (ex : céréales…)
- Ligule : Présence/absence, membraneuse ou ciliée, taille, aspect sommital : tronquée, dentée
- Oreillette : Présence/absence
- Limbe : Pilosité (présence/absence, répartition), nervation
- Gaine : section (ronde, aplatie..), pilosité, coloration (👁base de la tige)

Dicotylédones : Feuilles larges


Source: ARVALIS

Limbe

Tige

Cotylédons

Hypocotyle

Plantule à tige allongée et feuilles verticillées


Source: ARVALIS

Plantule en rosette

- Type de plantule : rosette ou à tige
- Insertion des feuilles : opposée = face à face, alterne, verticillée
- Cotylédons : forme, taille, pilosité
- Forme et découpure des feuilles
- Pilosité : répartition, forme ..
- Odeur, saveur, couleur

MATÉRIEL EXPÉRIMENTAL en CONDITIONS CONTRÔLÉES

- 5 enceintes climatiques

Entre -25 et +30 °C

Jusqu’à 400 µmol/m²/s

Jusqu’à 95 %

Pilotage via automate

De 2 à 8 plages de programmation journalière

Contrôle permanent des paramètres

- 1 banc de pulvérisation

Contrôle de la pression

Hauteur du traitement

Vitesse

Type de buses

Imite le pulvérisateur agricole

Source photos : ARVALIS

LES ESSAIS en CONDITIONS CONTRÔLÉES

Source photos : ARVALIS

LES PRINCIPALES CATÉGORIES D'ESSAIS

- **MALADIES**
- **ADVENTICES**
- **RAVAGEURS AUXILIAIRES**

Pour une éventuelle inscription au catalogue…

Sensibilité variétale aux herbicides

Efficacité insecticides et molluscicides

Pucerons verts (*Myzus persicae*)

Limace grise (*Deroceras reticulatum*)

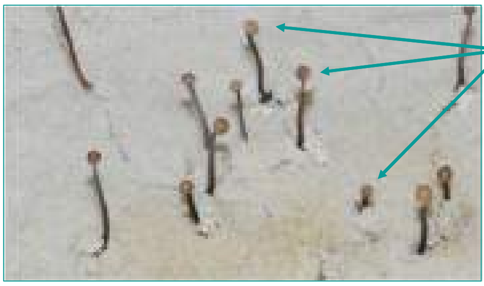
Biologie des adventices

Rumex crépu (*Rumex crispus*)

Datura stramoine (*Datura stramonium*)

Folle avoine (*Avena fuata*)

Maladie des céréales

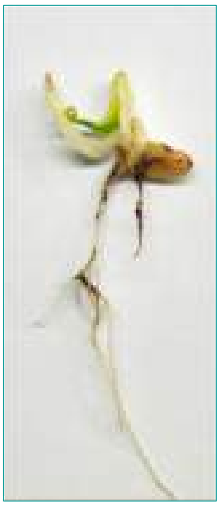


Ergot du seigle (*Claviceps purpurea*)

Traitement de semences

Conditions différentes selon la contamination

🍄	🌡
Fusarium graminearum	17°C
Microdochium sp.	7°C



Blé dur et tendre

Résistance des adventices

Résistante

Sensible

Atelier 1: Epidémiosurveillance

Qu'est-ce que l'épidémiosurveillance ?

Surveiller l'émergence et la présence de bioagresseurs

Prévenir → **Diagnostiquer** → Intervenir

MALADIES
Atelier 2

RAVAGEURS et AUXILLIAIRES
Atelier 3

ADVENTICES
Atelier 4

Que m'apporte l'épidémiosurveillance ?

Le BSV

À quoi me sert-il ?

- Connaître **l'état sanitaire** des cultures de ma région
- Accéder à une **analyse** de qualité du **risque phytosanitaire**
- Être au courant des **actualités réglementaires**

Pourquoi le lire ?

- Un conseil **gratuit**
- Adapter son ITK au risque réel
- Des connaissances en agroécologie et sur la biodiversité*

Pourquoi être observateur ?

- Des formations au diagnostic
- Des points HVE*

Comment être acteur de l'épidémiosurveillance?

Suivre le BSV

À retrouver sur :
- Le site de votre chambre
- Le site de votre DRAAF
- Le site d'ARVALIS

Demandez votre BSV ici !

Être observateur

Je suis technicien(ne)	Je suis agriculteur(trice)
Via le portail de collecte des données d'observations Vigicultures	Via des applications collaboratives*

Demandez votre démo ici !

QR CODE

*Nouveautés liées à l'arrivée du BSV 2.0 courant 2023

ARVALIS

Biodiversité fonctionnelle en grandes cultures, de quoi parle-t-on ?

• Biodiversité en grandes cultures

Biodiversité planifiée	**Biodiversité associée**		
	Biodiversité para-agricole		Biodiversité extra-agricole
	Biodiversité fonctionnelle / auxiliaires de culture	Bioagresseurs	
			

Bockstaller *et al.* (2019)

• Plusieurs types de services assurés

Pollinisation des plantes cultivées

Stabilité et contrôle de l'érosion

Recyclage de la matière organique

Qualité des sols

Structuration

Production agricole

Adventices

Régulation des bioagresseurs

Ravageurs

Maladies

Capacité des écosystèmes à stocker et restituer de l'eau

Dégradation de molécules polluantes (nitrate, PPP…)

Régulation des flux hydriques

Qualité des eaux de consommation

Services culturels et esthétiques

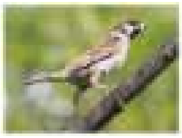
MEA (2005)

• Zoom sur la régulation des ravageurs

Prédateurs généralistes

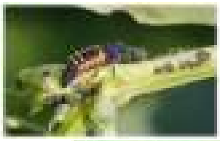
Carabe

Araignée



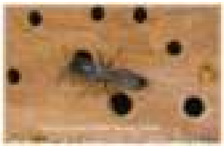
Oiseau

Prédateurs spécialistes



Larve de coccinelle

Larve de syrphe



Guêpe prédatrice

Parasitoïdes (spécialistes)

Guêpes parasitoïdes

Références :
- Bockstaller, C. *et al.* Les indicateurs de biodiversité pour accompagner les agriculteurs : embarras du choix ou pénurie ? *Innovations Agronomiques* 73–86 (2019).
- Millenium Ecosystem Assessment. Ecosystems and human well-being: synthesis. 137 (2005).

E2_05_5

Les techniques de DIAGNOSTIC : du CHAMP au GENE

Réaliser **un diagnostic** pour un accident des cultures est un exercice pouvant être complexe, qui se fait en **plusieurs étapes** et qui peut nécessiter des analyses spécifiques réalisables seulement dans des laboratoires. Néanmoins, c'est un exercice **indispensable** afin d'obtenir une réponse précise et juste, d'adapter les moyens de lutte efficace et d'éviter des traitements inutiles. 3 grands types d'analyses sont réalisables.

1. Le diagnostic visuel

La majorité des accidents de culture causés par des maladies peut être élucidée par le diagnostic visuel. A la manière d'un détective, des étapes clés sont nécessaires :

1. Analyser tous les éléments en votre possession sur la parcelle et recouper les informations :

Symptômes déjà observés sur cette parcelle ?

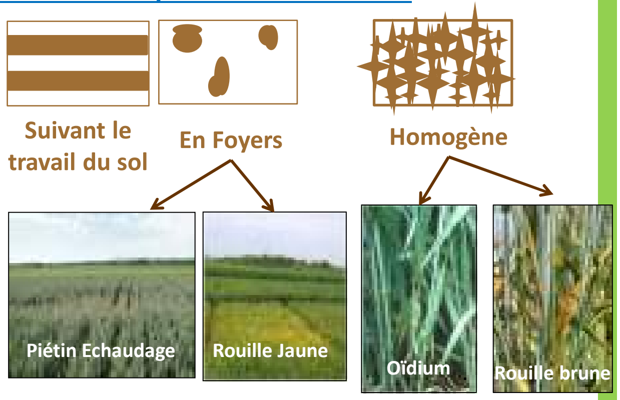
Région ? Type de sol ? Climat ?

Répartition du symptôme dans la parcelle ? Homogène ? En ronds ? …

Variété ?

Stade de croissance de la plante ?

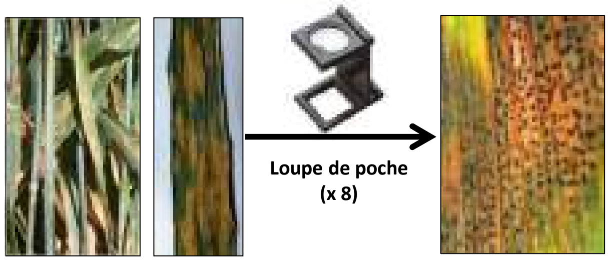
Des traitements ont-ils été réalisés sur cette culture ? Si oui, contre quelle maladie ?



→ éliminer des hypothèses (selon la variété semée, l'application de traitements fongicides, précédents…)

2. Observer les symptômes sur la plante à la loupe

De l'aspect général au détail : toujours progresser de la plante entière à l'observation à la loupe.
Exemple de la Septoriose du blé tendre :



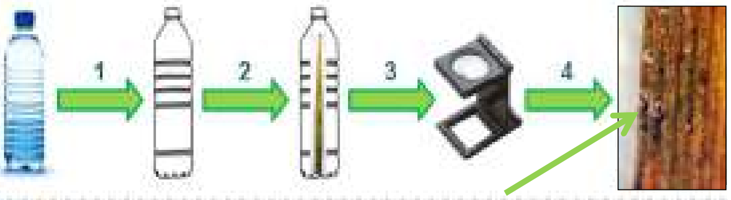
Nécroses brunes progressant du bas de la pante vers le haut

Pycnides → Septoriose

3. Réaliser une chambre humide… et observer encore !

Selon les conditions climatiques, les structures des champignons peuvent ne pas être observables directement au champ. Il existe un moyen très simple pour les faire apparaitre:

LA CHAMBRE HUMIDE



1 = Videz une bouteille d'eau en laissant quelques gouttes.
2 = Placez l'échantillon à diagnostiquer dans la bouteille et fermez.
3 = Laissez 24 à 48 heures à 20°C (dans votre bureau par exemple).
4 = Observez les structures des pathogènes et assurez votre diagnostic

2. Le diagnostic microbiologique

La chambre humide ne permet pas toujours au champignon de sporuler et donc faire un diagnostic précis. **La microbiologie** est l'étape suivante pour réaliser un diagnostic . La technique consiste à **isoler et cultiver « artificiellement »** le champignon responsable des symptômes. L'observation du mycélium et des spores permet d'identifier l'espèce.

Exemple: La fusariose des épis est causée par de nombreuses espèces différentes mais lesquelles dans mon champ?

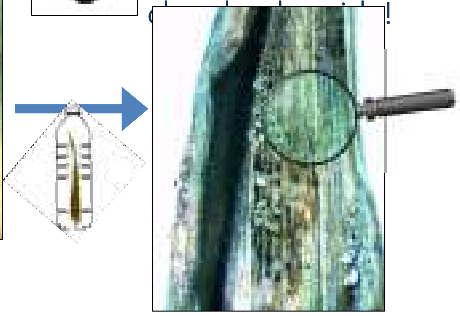
3. Le diagnostic moléculaire

Dans certains cas plus rares, le diagnostic nécessite des **techniques moléculaires**. Ces techniques sont basées sur l'**ADN** ou l'**ARN** des bioagresseurs. Elles sont très utiles dans des activités de recherche, de sélection, quand plusieurs maladies sont présentes et pour confirmer la présence de viroses. Elles permettent même de détecter l'agent pathogène **avant l'expression** des symptômes et peuvent être **disponibles au champ!**

La Septoriose du blé tendre

La septoriose du blé tendre est causée principalement par le champignon *Zymoseptoria tritici.* Elle se reconnaît grâce aux nécroses présentes sur le feuillage. Elles peuvent être blanches et allongées ou brunes, de formes ovales ou rectangulaires. Au sein de ces taches, **des pycnides noires** (petits points noirs très visibles) sont présents et caractéristiques de la maladie. Les pycnides contiennent les spores du champignon qui vont être dispersées par les pluies du bat vers le haut de la plante.

Les pycnides noires peuvent être absentes des nécroses. Pour les faire apparaitre et valider son diagnostic → **La loupe et la**
!



Gelée blanche (cirrhes) contenant les spores sortant des pycnides

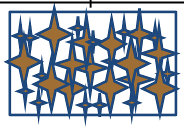
Carte d'identité

Nom :
Forme asexuée :
Zymoseptoria tritici
Forme sexuée :
Mycosphaerella graminicola

Météo favorable :

2°C<T°<37°C
T° optimale 22°C
+ 80% d'humidité

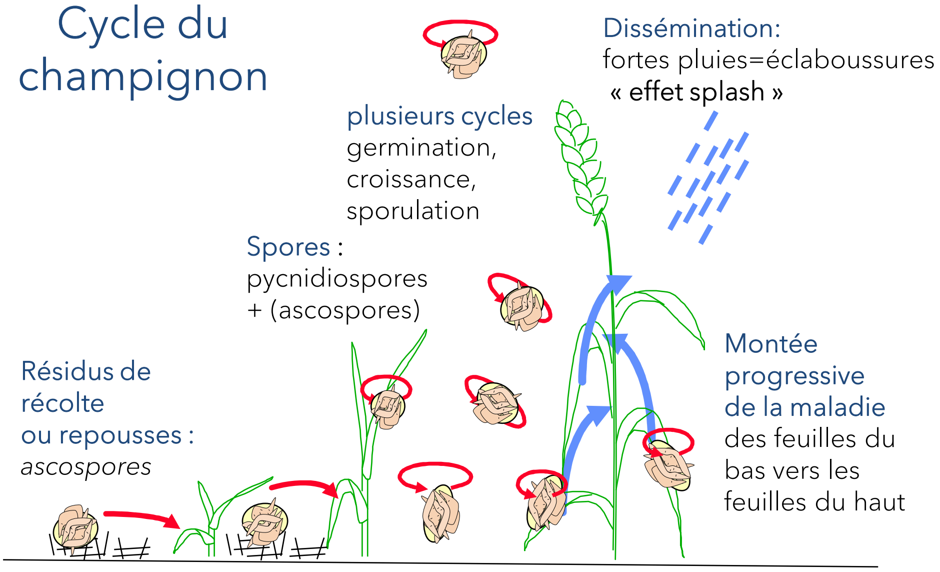
Répartition dans la parcelle:
Homogène



Dégâts :
Pertes de rendement jusqu'à 40% pour une forte attaque

Cultures attaquées :
Blé tendre, Blé dur, Triticale, Seigle

Cycle du champignon



plusieurs cycles
germination,
croissance,
sporulation

Dissémination:
fortes pluies=éclaboussures
« effet splash »

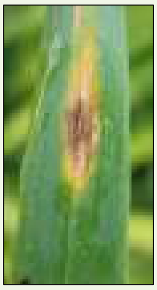
Spores :
pycnidiospores
+ (ascospores)

Résidus de récolte
ou repousses :
ascospores

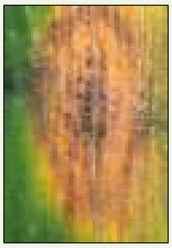
Montée progressive de la maladie
des feuilles du bas vers les feuilles du haut

automne
hiver
printemps

Les « autres Septoriose »



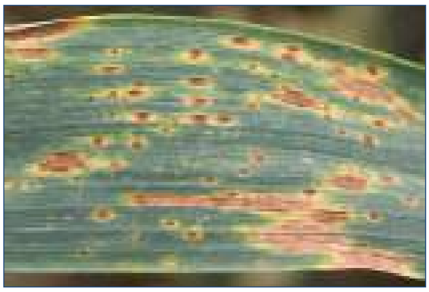
Parastagonospora nodorum
(Phaeosphaeria nodorum)
Principalement sur Triticale, Blé dur, Orge (photo) et rarement sur blé tendre.
Les pycnides sont généralement moins nombreuses et plus discrètes.



Parastagonospora avenae
(Phaeosphaeria avenae)
Potentiellement sur toutes les céréales à paille (2 formes spéciales différentes) mais assez rare.

Ne pas confondre avec

Taches physiologiques



Helminthosporiose

Microdochium

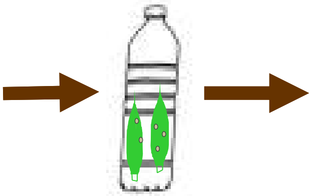
Focus sur 3 maladies fongiques foliaires de l'orge : Symptômes et Diagnostics

L'Helminthosporiose (*Pyrenophora teres*)

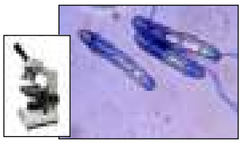
- Principale maladie foliaire de l'orge
- Inoculum primaire sur les résidus de culture
- 2 formes spéciales du champignon *Pyrenophora teres* (syn: *Drechslera teres*) engendrant des symptômes différents :
  - *P. teres* f. sp. *teres* → **Symptômes typiques en forme de réseau:** nécroses marron-noire longitudinales de tailles très variables et qui se rejoignent entre elles par de fines nécroses brunes donnant un effet « **maille de filet** ».
  - *P. teres* f. sp. *maculata* → **Taches brun-noir ovales à elliptiques de 3 mm *6 mm** souvent entourées de chloroses

Diagnostic: Observer la sporulation du champignon → « poils noirs » sur les nécroses qui correspondent aux conidiophores et conidies de *P. teres* .


Symptômes d'Helminthosporiose


Chambre humide 24h à 48h

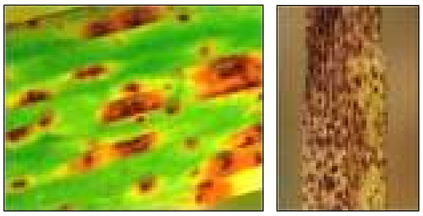

Sporulation de *P. teres*

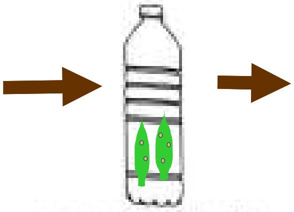

Spores de *P. teres* (*400)

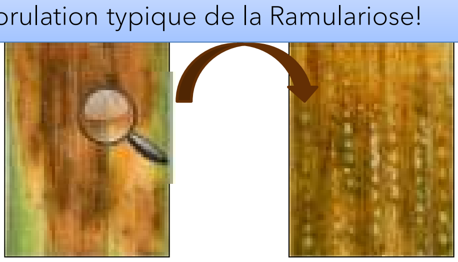
La Ramulariose (*Ramularia collo-cygni*)

- **Maladie « récente » en France** (première observation officielle en 2002)
- Agent pathogène: *Ramularia collo-cygni*.
- **La principale source d'inoculum: la semence** →transmission **verticale** dans la plante d'abord de manière **asymptomatique.**
- **Les symptômes** sont généralement observables, **à partir de la floraison**, sur les dernières feuilles (Remarque: ils peuvent apparaître avant)
- **L'expression** des symptômes serait principalement liée à **un stress de la plante** (floraison, grillures…).
- Les symptômes foliaires caractéristiques de la maladie **sont des nécroses rectangulaires marron-noir de 2mm x 0.5mm qui sont généralement bien délimitées par les nervures de la feuille**, qui présentent un centre plus foncé, et des halos chlorotiques.

Diagnostic: Les symptômes peuvent être facilement **confondus avec ceux de l'Helminthosporiose ou des symptômes physiologiques.** Un moyen simple de faire **le diagnostic** est d'observer **la face inférieure** où vous observerez **les spores blanches alignées sortant des stomates,** sporulation typique de la Ramulariose!


Symptômes de Ramulariose sur feuilles

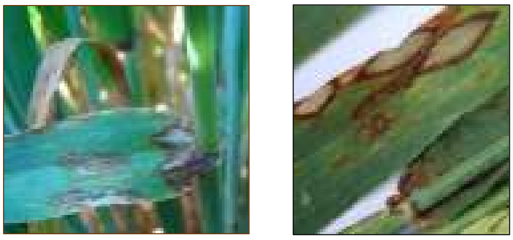

Chambre humide 24h à 48h


Sporulation à la face inférieure sortant des stomates

La Rhynchosporiose (*Rhynchosporium commune*)

- **Agent pathogène :** ***Rhynchosporium commune*** (espèce différente de celle sur triticale: *R. secalis*)
- Partout en France.
- **Symptômes : taches verdâtres ovales** qui évoluent ensuite vers une teinte **gris-blanchâtre à partir du centre**. Les taches sont **délimitées par un contour brun foncé**. Elles finissent par se rejoindre et s'imbriquer les unes dans les autres.

Diagnostic: Peu de confusions possibles avec d'autres maladies. La **sporulation** du champignon se fait **directement sur la cuticule de la feuille** et n'est **pas visible à l'œil ou à la loupe.** Ainsi, dans le cas de la rhynchosporiose, vous n'observerez pas de pycnides ou des « poils noirs » après une chambre humide.


Symptômes de Rhynchosporiose sur feuilles

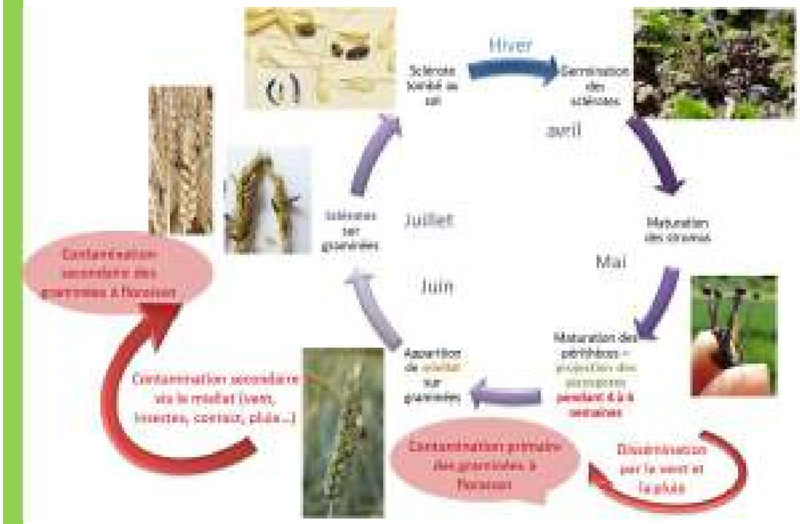
Ne pas les confondre avec des grillures ou des taches physiologiques

→ Vous n'observerez **rien sur les taches même après une chambre humide!**

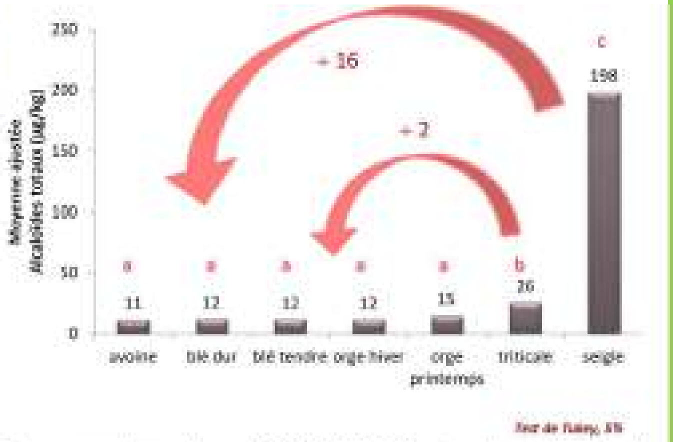
L'ergot des céréales

La recrudescence de l'ergot des céréales en fait de nouveau un enjeu sanitaire important en France. En effet, *Claviceps purpurea*, champignon phytopathogène responsable de la maladie, produit **des sclérotes contenant des alcaloïdes toxiques** pour l'homme et l'animal. Ce champignon contamine à la fois les céréales à paille et les graminées adventices.

Cycle biologique de *Claviceps purpurea* :



Une sensibilité des céréales liée à l'allogamie



Source : enquêtes au champ ARVALIS 2012-2014 toutes cultures, 2060 parcelles

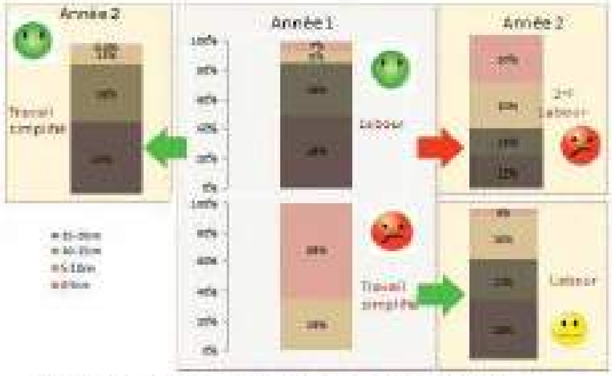
Savoir gérer les adventices

Les graminées adventices jouent un rôle majeur dans le maintien et la dispersion de de l'inoculum de *C. purpurea*.

Elles peuvent être contaminées directement par l'inoculum primaire et ainsi faire relais en devenant une source d'inoculum secondaire pouvant contaminer les céréales cultivées. Elles produiront des sclérotes qui en tombant au sol pourront aussi être la source d'un inoculum primaire l'année suivante.

→ 1er facteur explicatif des teneurs en ergot et alcaloïdes dans les parcelles

Maitriser l'inoculum dans le sol



Source : ARVALIS - Institut du végétal, 2014, avec le soutien financier de FranceAgriMer. Essai travail du sol à l'échelle de 2 rotations.

→ Adapter le travail du sol à la parcelle

Le saviez-vous ?

Le climat joue un rôle très important dans le développement du champignon :

Les sclérotes présents aux sols ont besoin de vernalisation pour germer (<10°C).

Des pluies régulières entre mars et mai vont permettre la germination des sclérotes, puis la libération des ascospores.

Des conditions défavorables à la fécondation (ex: froid à la méiose) vont diminuer le taux de fécondité des épis et favoriser la maladie: chaque fleur non fécondée est réceptive à la maladie!

Le miellat est produit par la plante en réponse à la colonisation de l'ovaire par le champignon. C'est une substance sucrée et visqueuse contenant les conidies de *C. purpurea*. **Les insectes vont être attirés par le miellat et ainsi participer à la dispersion du champignon!**

La forme du sclérotes est en grande partie déterminée par les contraintes que lui imposent les glumelles de la plante hôte et par la précocité de l'infection.

Limiting bird damage to crops

Michel BERTRAND (INRAE)- Christophe SAUSSE (Terres Inovia)- Lucie ZGAINSKI (INRAE)

Target & crop system

Spring crops (sunflower, pulses, maize) can be damaged by pigeons and/or corvids during their sowing-emergence phase. These attacks, sometimes resulting in massive yield losses or costly reseeding, limit the available options for crop diversification.

Initial results

Damage to spring crops during emergence are caused by pigeons, while corvids can attack crops as soon as they are sown. Plot-based solutions are not very effective, as they come up against the birds' ability to adapt their behaviour. It is therefore necessary to consider other strategies on a landscape scale.

Project works

Barriers to be removed

There are a lot of difficulties in preventing bird damages :

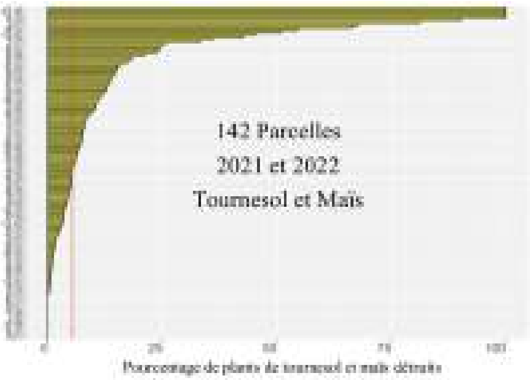
- Predicting the risk of attacks in space and time ;
- Limited knowledge of the behaviour of predatory birds in an agricultural context ;
- Heterogeneous stakeholders (agriculture, hunting, bird protection) ;
- Information (damage, birds, practices) is scattered and difficult to collect ;
- Strategies that need to be tested on a large scale in different areas, as plot-based approaches are inadequate.

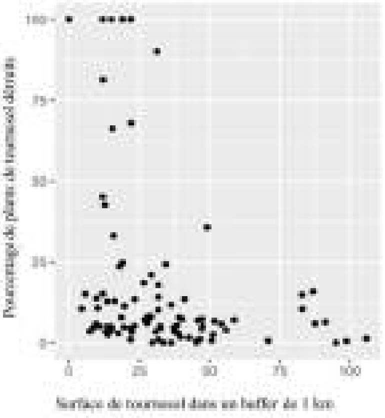
To overcome these obstacles, LIDO defines a territorial approach to diagnosis and design, backed up by a tool for collecting and managing information.

Transfer

Work on 3 pilot arable farming areas in France (Beauce Gatinais, Yonne, Drome) with the involvement of stakeholders.

Creation of a management tool and design of local strategies to limit the impact of predatory birds on the crops.





Tests in a real environment

Once the design results have been obtained, a number of partial-effect levers will be tested alone or in combination, for example :

- Synchronising sowing to exceed the birds daily consumption capacity during the sensitive phase ;
- Synchronising scare tactics to limit bird habituation ;
- Choose the sowing date according to the needs and activity of the birds ;
- Hide the sowing lines.

End users

These are farmers, advisory structures, industries (cooperatives and seed production establishments), as well as those involved in hunting and environmental protection.

Valuation

At the end of the project, dissemination outside the pilot areas will concern :

- The prevention strategies evaluated as part of the project ;
- The management tool used to pool information from different sources and support individual and collective decision-making.

Keys to identify stored grain pests

Observe their morphological characteristics

Primary insect pests

head with a snout

hidden head under thorax

uniformly brown body

grain weevil

4 colored spots on the elytra

rice weevil or maize weevil

lesser grain borer

Secondary insect pests

head visible dorsally, no snout

tooth-like projections on the thorax

regular thorax

size > 3 mm

size < 2 mm

sawtoothed grain beetle

red or confused flour beetle

rusty grain beetle

Dare to change!
One treatment may be enough

- Avoiding diseases by combining integrated pest management levers

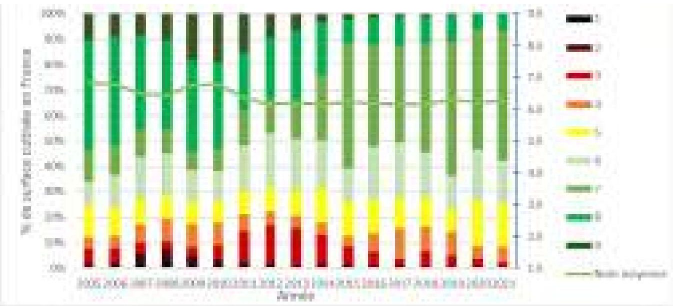
Direct control (preventive, curative)
Treat in optimal conditions

Risk characterization
Avoid systematic treatments

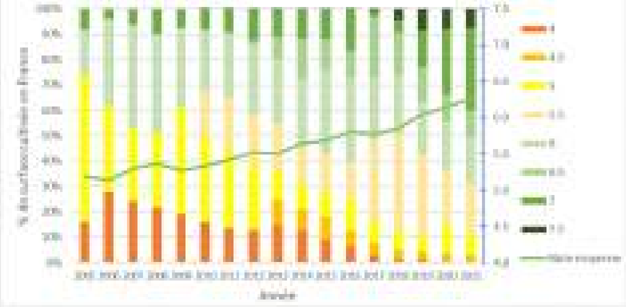
Prophylaxis (indirect control)
Reduce pressure

- The range of resistant varieties is strengthened: daring to change fungicidal protection

Evolution of the level of resistance to yellow rust of wheat varieties grown in France over the period 2005-2021

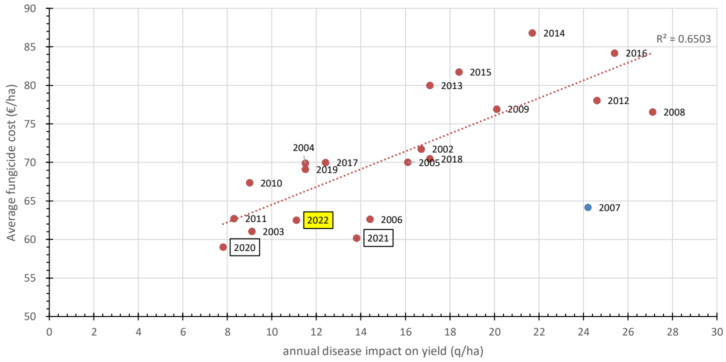


Evolution of the level of resistance to septoria disease (Z. tritici) of wheat varieties grown in France over the period 2005-2021

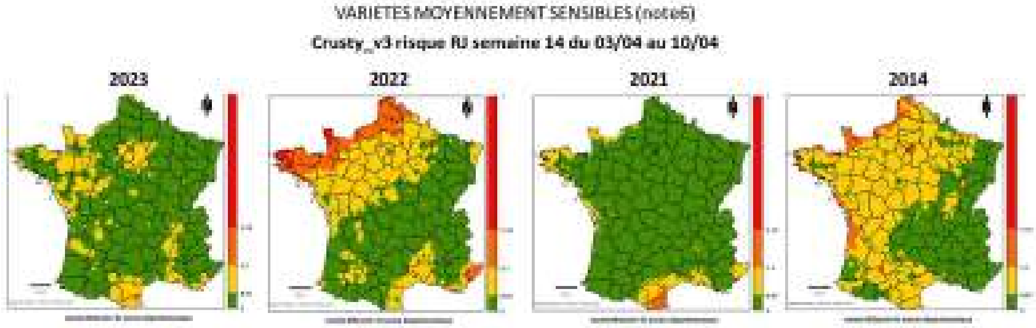


Sources: ARVALIS, FranceAgriMer, CTPS/GEVES

- The disease pressure varies depending on the year:
Take advantage of potential savings



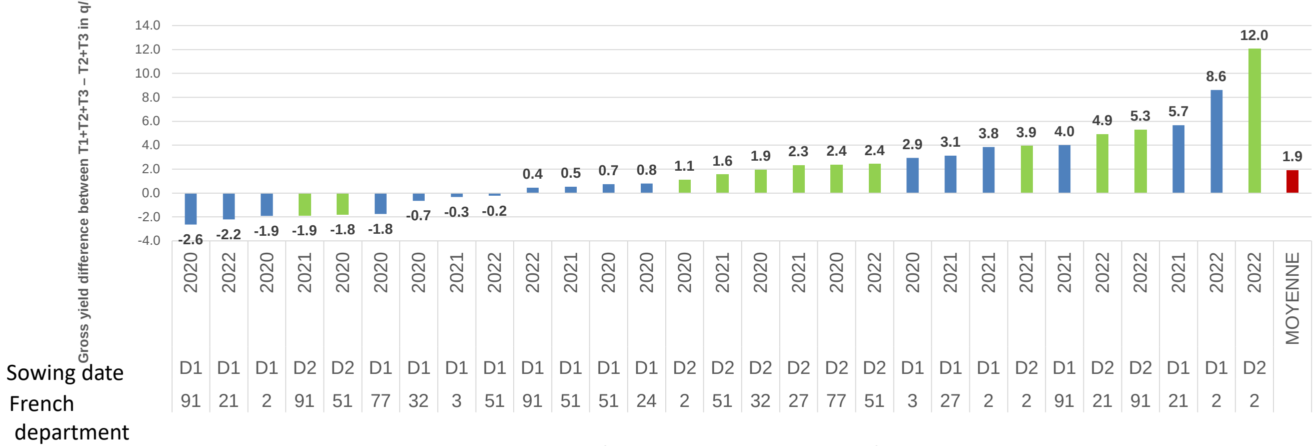
- Each year its disease context: decision support tools are there to secure your choices.



Each disease context has its optimum fungicidal protection

- T1 impasse: an economy to dare in many situations

Variability of T1 gain in q/ha on sensitive varieties
Average gain + 1.9 q/ha

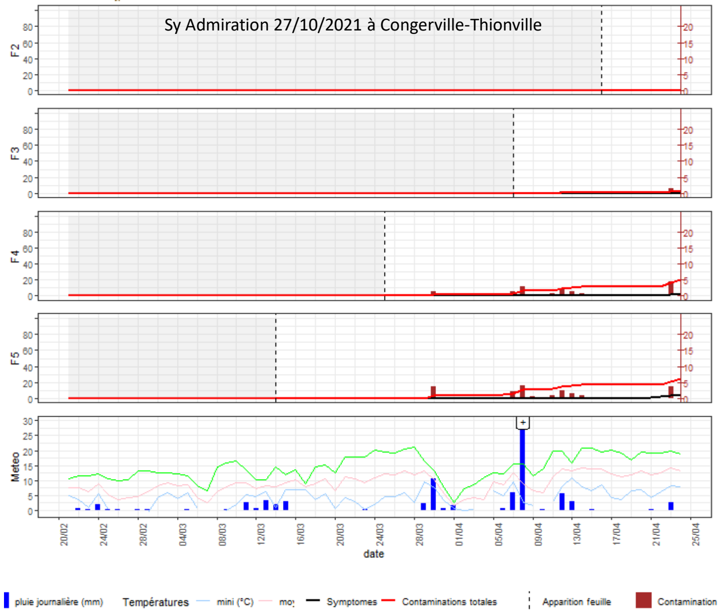


Source: Summary of 29 trials combinations of levers 2020-2022

D1 common sowing date (October 14), D2 sowing date delayed by 22 days (November 3)

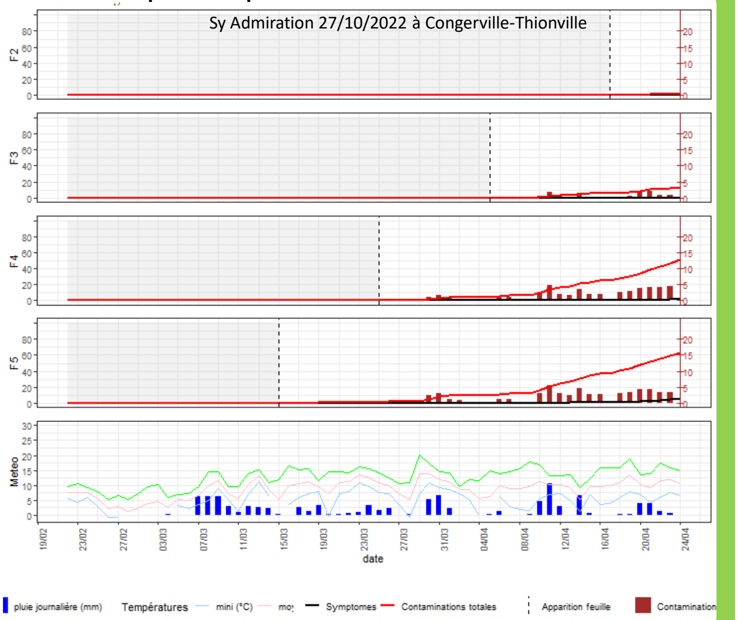
- Septo-LIS : The right decision in every context

2022: Septoria pressure is late



Septo-LIS does not trigger T1.
The T1 fungicide cost is saved while preserving yield.
Gross margin is improved.

2023: Septoria pressure is earlier



Septo-LIS advises T1 protection
when it will be most effective.
Yield and income are preserved.

- The T1 impasse: the rule for low-sensitive varieties to Septoria (score >=6.5), and excluding yellow rust risk

Septo-LIS	Septoriose Tardive		Septoriose Précoce	
	Note S > ou = 6.5	Note S < 6.5	Note S > ou = 6.5	Note S < 6.5
Pas de Rouille jaune ou Note RJ > = 7	Pas de T1		Pas de T1	(T1)
Rouille jaune présente avant DFE et Note RJ < 7	T1 (avec IDM ou QoI)			

ARVALIS

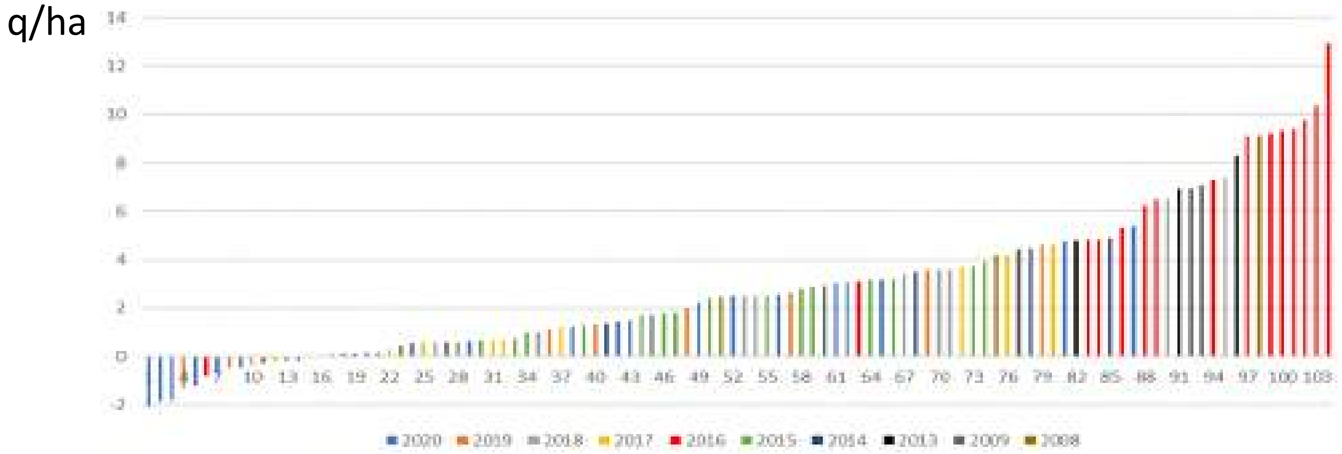
Each disease context has its optimum fungicidal protection

T3: Treatment applied early heading and beyond

- To prolong the leaf activity of T2 in case of septoria risk or brown rust and sensitive varieties
- If fusarium risk (estimated mycotoxin risk with decision support tool + significant rains during flowering)

- T3 protection relay:
  Its gain is not systematic!

Variability of T3 gain applied to flowering in q/ha
Average gain + 2.9 q/ha (104 trials – 2008 to 2020)
median + 2.5 q/ha



Unnecessary treatment costs as much as a wrong no-treatment decision

- And not to take risks with mycotoxins:
  Use the decision support grid

Gestion des résidus*		Sensibilité variétale		Pluie (mm) autour de la floraison (+/-7 jours) <10	10-40	>40
Céréales à paille, colza, lin, pois, féverole, tournesol	Labour ou résidus enfouis	Peu sensibles	1			
		Moyennement sensibles				
		Sensibles	3			T
	Techniques sans labour ou résidus en surface	Peu sensibles	2			
		Moyennement sensibles				
		Sensibles	3			T
Betteraves, pomme de terre, soja, autres	Labour ou résidus enfouis	Peu sensibles	2			
		Moyennement sensibles				
		Sensibles	3			T
	Techniques sans labour ou résidus en surface	Peu sensibles	2			
		Moyennement sensibles				
		Sensibles	4		T	T
Maïs et sorgho fourrages	Labour ou résidus enfouis	Peu sensibles	2			
		Moyennement sensibles				
		Sensibles	4		T	T
	Techniques sans labour ou résidus en surface	Peu sensibles			T	T
		Moyennement sensibles	5		T	T
		Sensibles	6	T	T	T
Maïs et sorgho grains	Labour ou résidus enfouis	Peu sensibles	2			
		Moyennement sensibles	3			T
		Sensibles	4		T	T
	Techniques sans labour ou résidus en surface	Peu sensibles	5		T	T
		Moyennement sensibles	6	T	T	T
		Sensibles	7	T	T	T

ARVALIS-Institut du végétal 2021

Weeding strategies in cereals

• An increasingly difficult context for weeding cereals

Expanding weeds

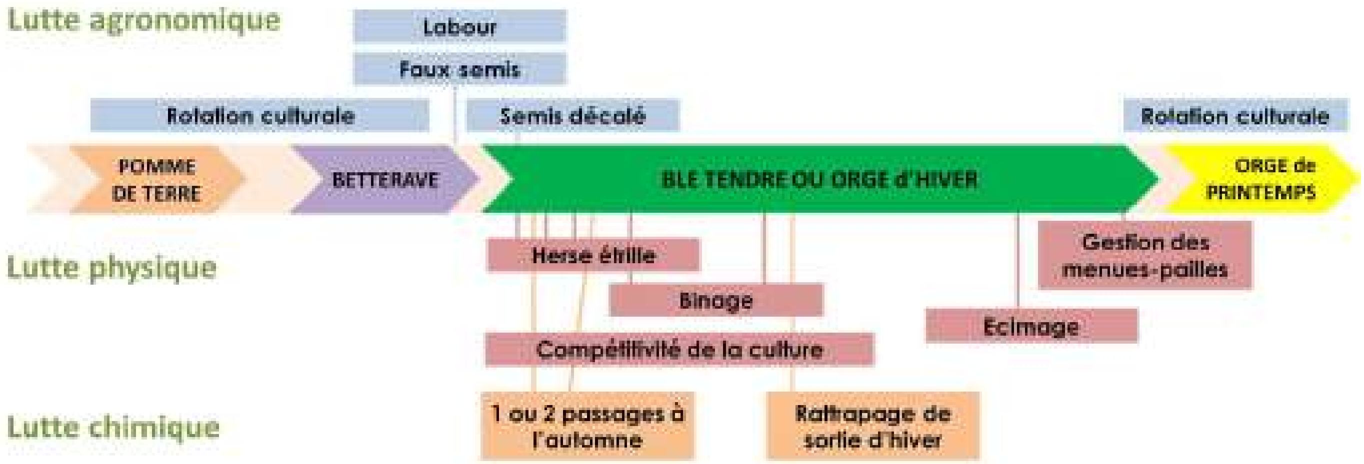
Regulation and impacts

- Restriction of use of certain herbicides: use once every 2 years,
Permanent vegetated strip of 20 m, prohibition on drained soils
- No solution on some target weeds➔ Simplifications of rotations and practices

Herbicide resistance

• In this context, DIVERSIFICATION is the key word

All levers must be activated with agronomic management, physical and chemical control. The equipments or levers to activate depend on the conditions (soil, stage, weeds...)



• The different levers to activate

Costs excluding labour, equivalent 250 ha			Cost of a passage	Herbicide cost	Price of new equipment	Efficiency	Gross margin issue
Agronomic control	Crop rotation		/	/	/	▨ 🟥	+/--
	Ploughing (6 bodies carried, vari-wide)		48 €/ha	/	34 k€	🟩 🟨	++
	False sowing (independent disc stubble 4 m)		29 €/ha	/	27.5 k€	▨ 🟥	+/0
	Delayed sowing		/	11 €/ha	/	🟩 🟨	++/-
Mechanic control	Shrill (12 m)		10.6 €/ha	/	15.4 k€	🟨 🟥	+/0
	Crop competitiveness	Variety	/	=	/	🟥	0
		Density	/	25 €/ha	/	🟥	0
		Under-covered crop (disc seeder 4 m)	45.4 €/ha	40 €/ha	67 k€	🟥	0/--
	Hoeing (4 m, IR 15-20 cm, camera guidance)		21 €/ha	/	42.9 k€	▨ 🟥	+/0
	Ecimage (9 m) per 100 ha		26.7 €/ha	/	21.6 k€	🟥	+/-
	Small straws (recuperator 10 m3) 200 ha		28 €/ha	/	52 k€	🟨 🟥	+/-
Chemical control (ramp 24 m)	1 or 2 interventions during autumn		7.3 €/ha	30 à 100 €/ha	34.3 k€	🟩 🟥	++/0
	Catching up at the end of winter		7.3 €/ha	3 à 55 €/ha		🟩 🟥	+/0

🟩 Résultats satisfaisants (>95%)
▨ Résultats moyens (entre 85 et 95%)
🟨 Résultats irréguliers (entre 70 et 85%)
🟥 Résultats insuffisants (<70%)

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Delay the sowing date

Why delay the sowing date and on which crops?

- To sow after emergence and destruction of weedy grasses, and outside the preferential period = **avoidance strategy.**
- This strategy is mainly put into practice on winter cereals but it can also be effective on maize or soybeans in spring – Beware, however, of drying out the seedbed.
- A practice to reserve for "dirty" fields!

The effect of the delay of the sowing date in pictures

Sowing of 1/10

280 pl/m²

Sowing of 21/10

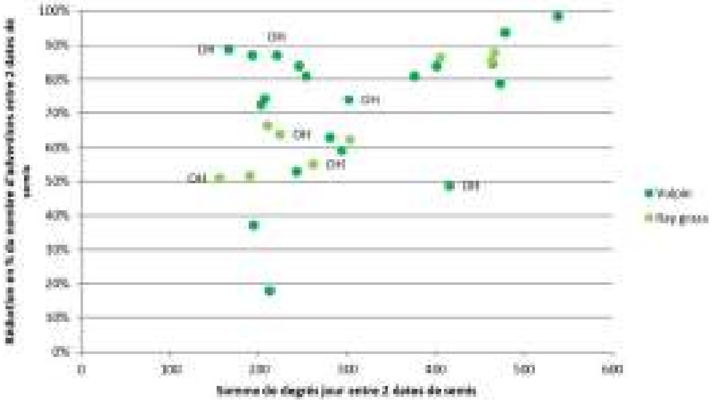
94 pl/m²

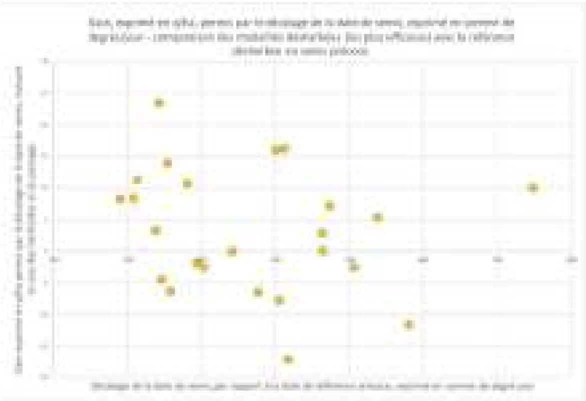
Sowing of 10/11

34 pl/m²

This is possible thanks to the **preferential emergence period** for weedy grasses, which is preferably in October.

What efficiency on grasses?

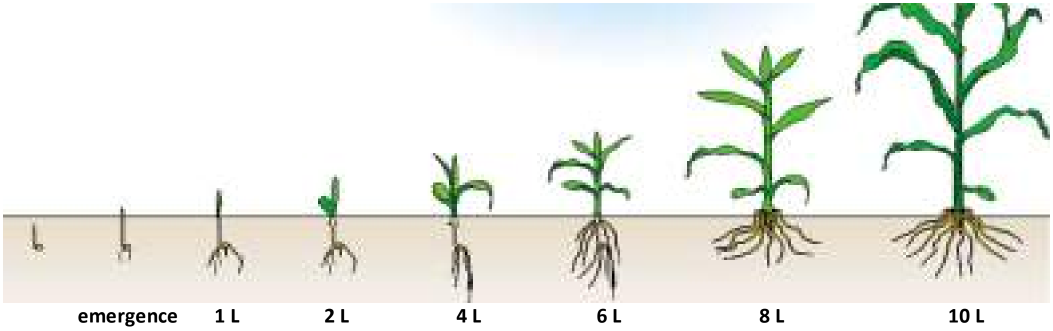




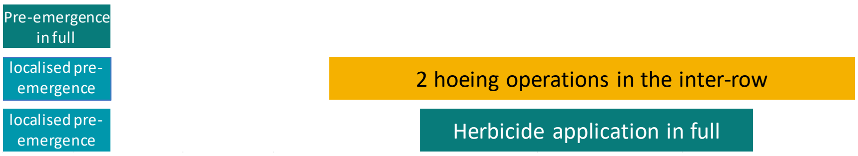
⇒ The delay of the sowing date makes it possible to reduce grass populations by 20 to 95%, depending on the delay. The greater the delay, the greater the reduction of weeds;

⇒ By integrating weeding costs and the possible loss of potential, the best strategy is between 200 and 350°d lag – or 2 to 3 weeks.

Locate pre-emergence weeding on the maize row



Results of 15 trials conducted by Arvalis between 2020 and 2022 with the support of BASF, Bayer and Syngenta


Pre-emergence in full

localised pre-emergence — 2 hoeing operations in the inter-row

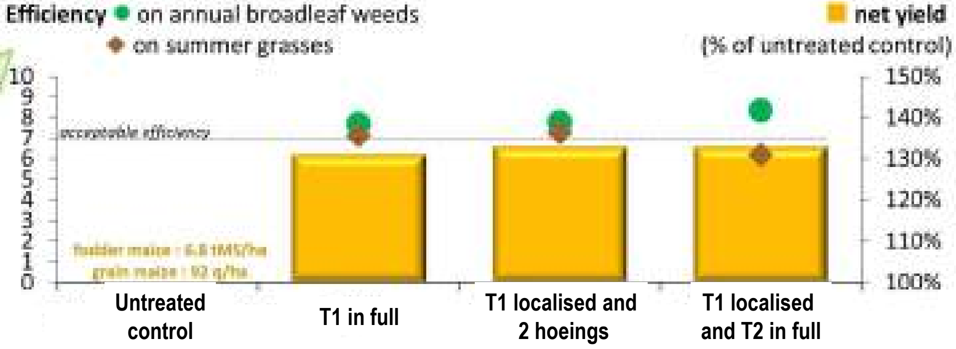
localised pre-emergence — Herbicide application in full

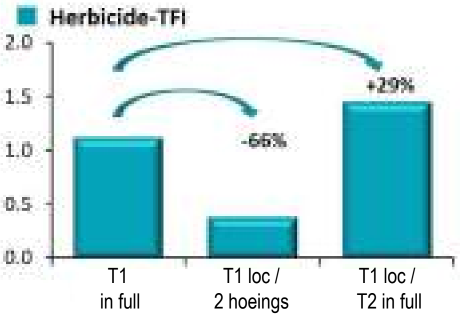
Strategy :

- **T1 in full** : conventional chemistry in full
- **T1loc / 2Hoeing** : localised herbicide / hoeing
- **T1loc / T2 in full** : herbicide localised then in full

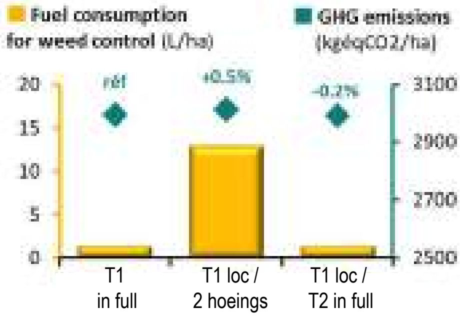
Maize is very sensitive to weed competition, especially at the beginning of the cycle. This is why it is difficult to completely ignore the pre-emergence. However, the pharmacopoeia is reduced and the constraints of use are hardening. This is why trials have been conducted in recent years with the aim of reducing the use of root herbicides by limiting their application where they are essential, i.e. as close as possible to the young crop row. The technical results are supplemented by multi-criteria evaluations carried out with the Systerre® software.

When the right pedoclimatic conditions are met for both chemical interventions and hoeing, efficiencies are satisfactory and net yield is preserved. Conversely, without weeding the potential is strongly compromised.





Locating the pre-emergence on the row, and / or replacing the chemical catch-up by 2 hoeings, reduces the treatment frequency index (TFI). Although hoeing increases fuel consumption, the effects on GHG emissions are almost neutral.



The simulations show that even with an RNG at 2 €/l, the localized pre-emergence strategy +2 hoeings remains competitive. However, work times are strongly impacted, even if it is possible to reduce them with an HD guidance camera.

Conclusion of these 15 trials: it can be retained that locating the pre-emergence on the maize row and replacing a chemical catch-up by 2 hoes is possible provided that:

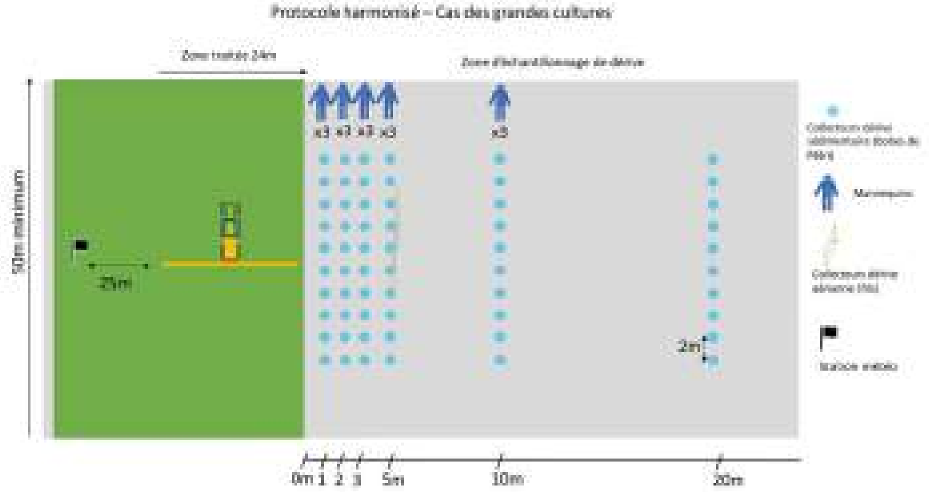
- the necessary available labor is ok
- the right conditions of efficiency are gathered knowing that their frequency is not satisfactory everywhere (soil type, climate ...)

SYSTERRE
Valérie BIBARD v.bibard@arvalis.fr
Emilie NOUGUÉ, e.nougue@arvalis.fr
ARVALIS

Les Culturales 2023 14-15 juin

CAPRIV: Conciliate pesticide application and protection of local residents

A harmonized protocol to test 4 types of nozzles without hedge (2021) and in the presence of hedges (2022)



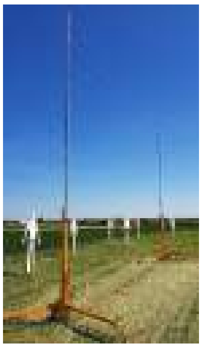
XR, Teejet
Reference

CVI, Albuz
66%

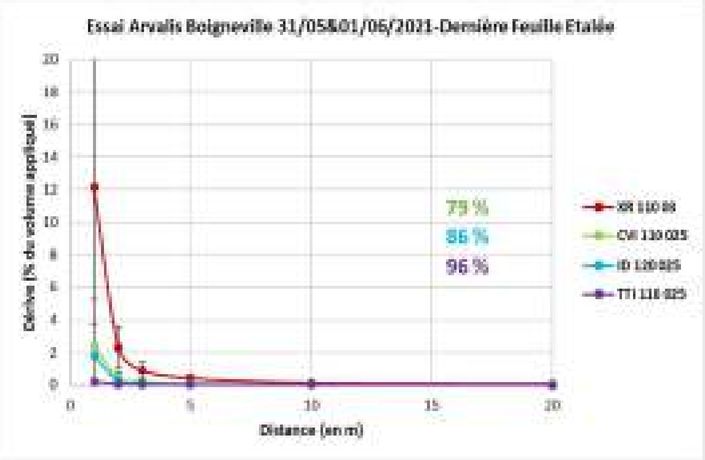
ID, Lechler
75%

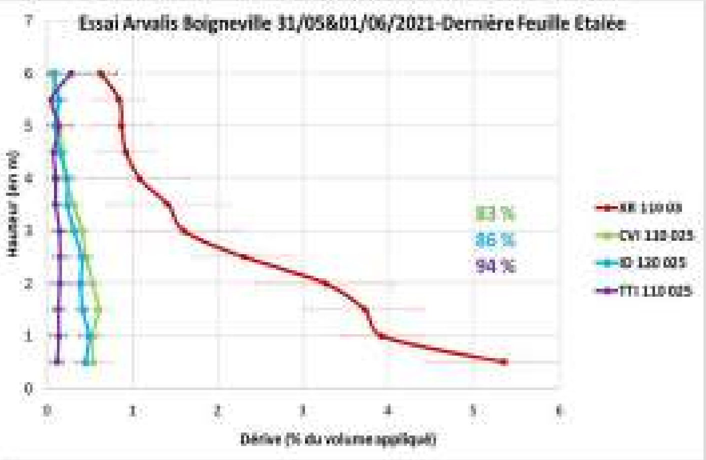
TTI, Teejet
90%

3 types of manifolds for 3 types of drift



Sedimentary and aerial drift: encouraging results





What's next?

- ✓ EFSA and ANSES take data into account in registration models
- ✓ Implementation of risk mitigation measures

acta LES INSTITUTS TECHNIQUES AGRICOLES

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IFV

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Technologies to modulate with a sprayer

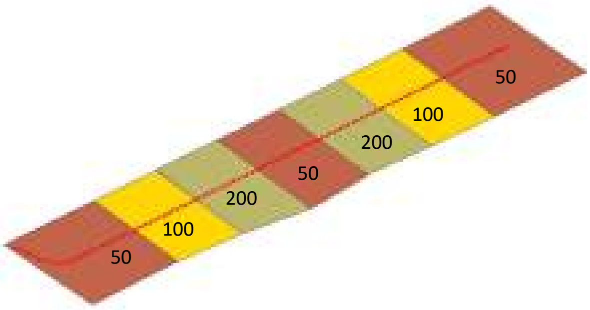
Les Culturales 2023 14-15 juin

PWM nozzles (Pulse Width Modulation)
« Pulsating nozzle »
The flow rate is adjusted by modification the opening time of the nozzle.

Self-selecting nozzle holders:
4 nozzles/2 nozzles
Electric or pneumatic selection
The software chooses the nozzle(s) adapted to the desired flow rate

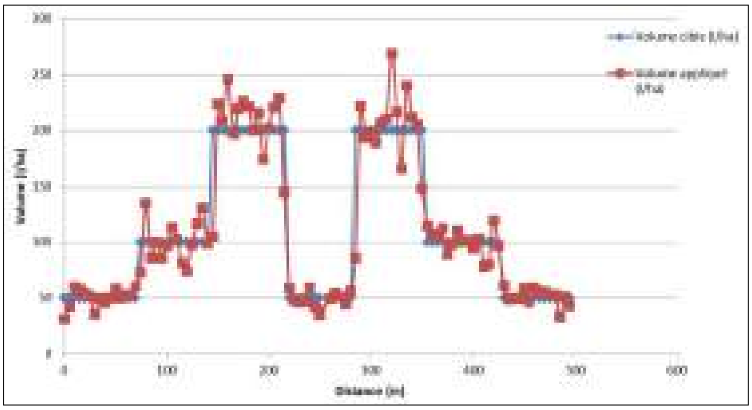
Objectives:

-Maintain volume/ha and drop size constant regardless of the speed of advancement
-Allow the modulation of the volume/ha
-Regulate the flow under the ramp in curves



Modulate the volume of spray mixture by using PWM nozzles

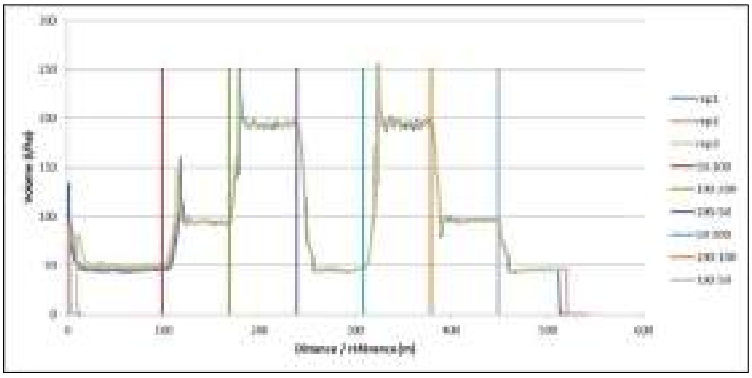
Good match with GPS
Average volume applied equal to target volume at ±5% → OK
Near-instantaneous delay



Expérimentation Hawkeye-Raven, 2016

Modulate the volume of spray mixture with the nozzle holders

Good match with GPS
Average volume applied equal to target volume at ±5% → OK
Average delay of 4 to 6 seconds



Expérimentation Amaselect-Amazone, 2016

ARVALIS

E2_10_2

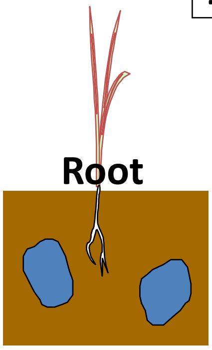
Factors to consider depend on the pesticide used

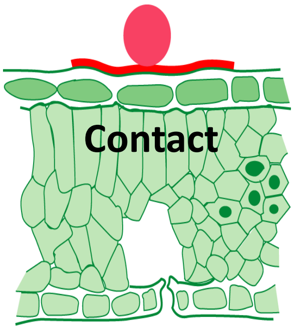
Soil - Roots

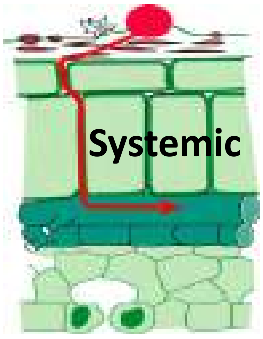
Where is the pesticide applied?

Leaves

- influence of climatic conditions +

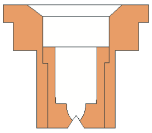
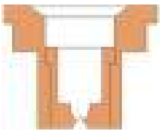
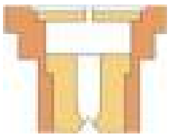
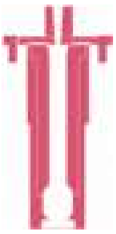
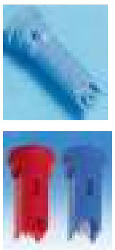






WATER in the Soil % CLAY % ORGANIC MATTER	ACCESSIBILITY OF THE TARGET AND PLANT STAGE	TEMPERATURE HYGROMETRY + FAVORABLE WEATHER FOR PLANT GROWTH
INDIFFERENT TO TYPE OF NOZZLE AND VOLUME/HA	SPRAY QUALITY ATTENTION TO LOW VOLUMES (<80 l/ha) WITH AIR INJECTION NOZZLES	NOZZLES AIR INJECTION OK for volumes > 50 l/ha

The different types of nozzles

Classic slot Standard			Angle formed from 2 bar Operating pressure: 2-3 bar
Low pressure			Angle formed from 1.5 bar Operating pressure: 1.5-3 bar
A calibration pad			Presence of a calibration pad Formation of large drops Operating pressure: 2-3 bar
Air injection			Air suction by VENTURI effect IA Nozzles Classic: 3-6 bar IA nozzles Low pressure: 2-5 bar

To learn more... **Decision support tool "Choice of ARVALIS nozzles" (*in French*):**

ARVALIS

E2_10_3

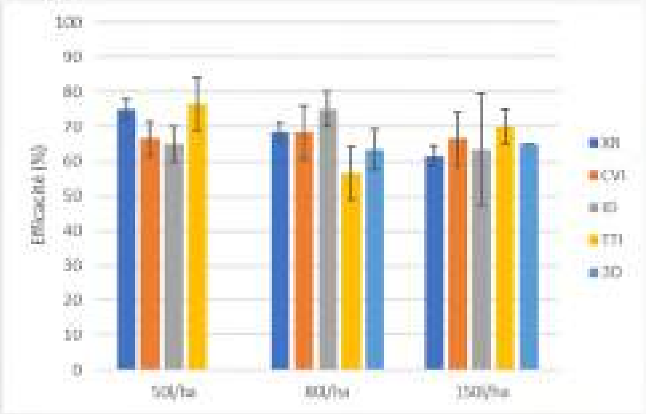
Adapting the volume of spray mixture to the mode of action of pesticides

Root pesticide: independent volume and type of nozzle

- **Prosulfocarb- 2021**

✓ Coudray (45) Ray-Grass 78/m²

✓ 3 volumes and 4 nozzles tested



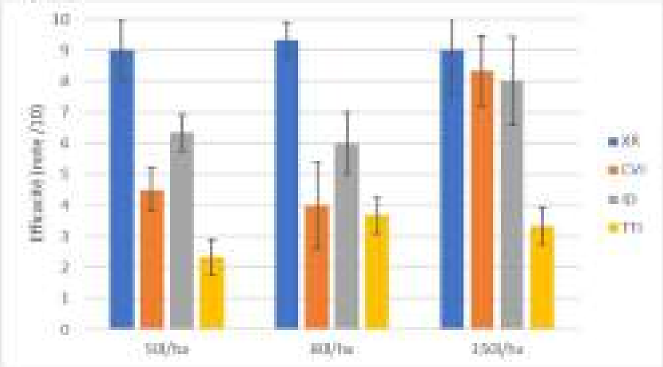
Anova NS at 45%

Contact pesticide

- **Bétanal- ITB- 2022**

✓ Buno-Bonnevaux (91)

✓ 3 volumes and 4 nozzles tested



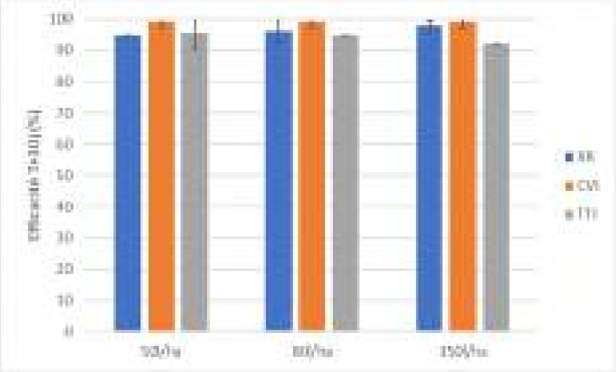
Anova S à 5%

Systemic pesticide

- **Glyphosate- 2022**

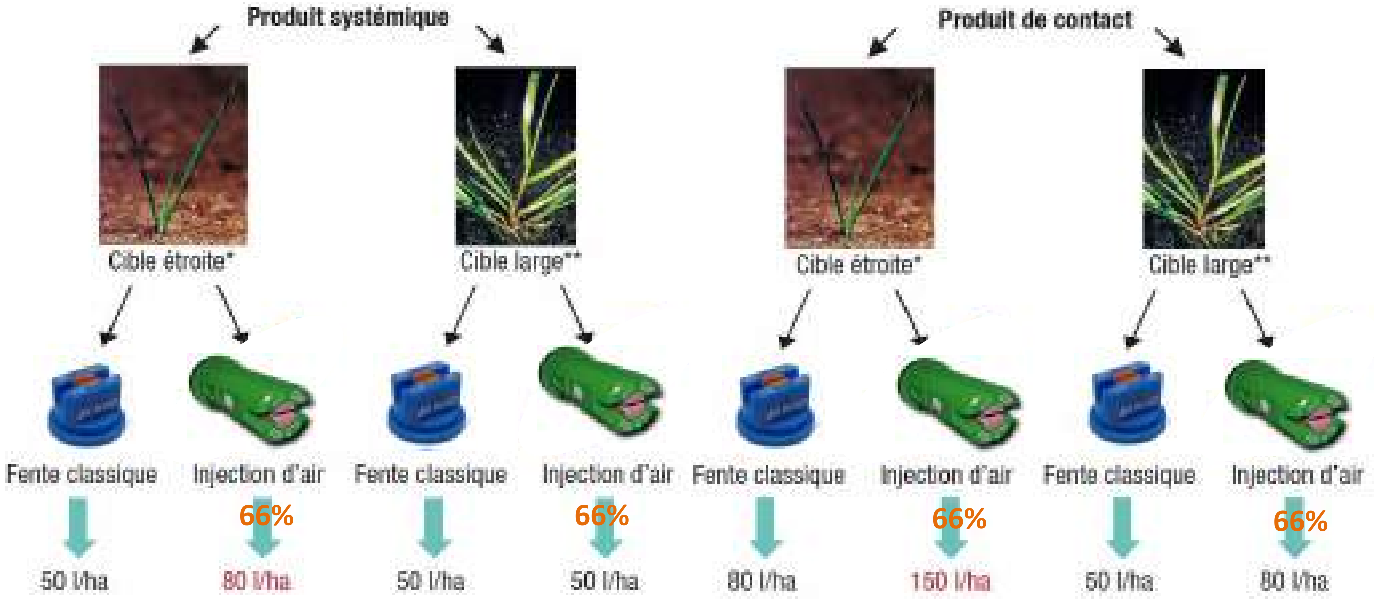
✓ Boigneville (91) rapeseed regrowth

✓ 3 volumes and 3 nozzles tested



Anova NS à 5%

Nozzles and volume: what to choose?



Currently being updated for 75% and 90% approved nozzles

Targeted weeding

Targeted weeding locates weeds and only sprays weeds with the right herbicide. Depending on weed density of the field, the % of herbicide saved varies from 80 to 99% in our trials.

The location of weeds

Location thanks to on-board sensors
Detection of a weed or "all plants except crop"

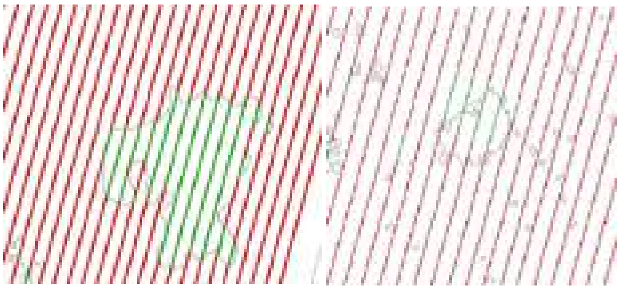
	Adventice détectée par capteur	Pas d'adventice détectée par capteurs
Adventice sur le terrain	29%	0.5%
Pas d'adventice terrain	21%	49.5%

Source: Boigneville, 2022

Example of thistle on maize: 80% good detections and 1 weed forgotten

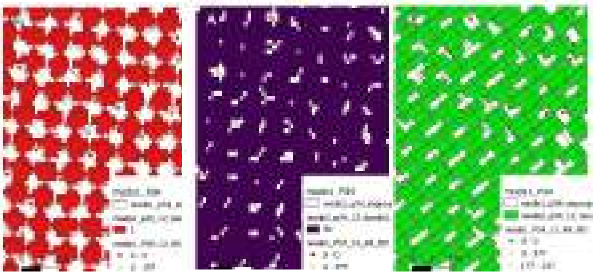
Delayed time application

The weight of the board (number of nodes and polygons) influences the ability of the electronics to respect the recommendation card.



Real-time application

Good detection (red map) of weeds but the application card is not perfect (green card) on small polygons



Scénarii	Automoteur 36m 175000€ (taux de propriété 13%)	=> Idem + option pulvérisation + caméra 84000€	=> Idem 85% surface pulvérisée	=> Idem 50% surface pulvérisée	=> Idem 15% surface pulvérisée
Temps de travail (h/Ha)	4.79	4.79	4.8	4.8	4.8
IFT herbicides	1.32	1.32	1.23	1.03	0.83
Charges herbicides €/Ha	46	46	44	42	39
Marge brute avec aides €/Ha	1038	1038	1039	1042	1044
Charges méca €/Ha	243	248	248	248	248
Marge nette avec aides €/Ha	434	425	430	432	435

Source: Phloème, 2022

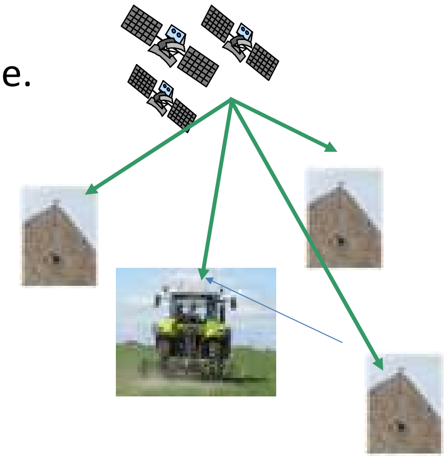
St Hilaire Farm (55)

130Ha 0.8UTH- Meadow/Fodder maize/ Rapeseed/Wheat/Barley

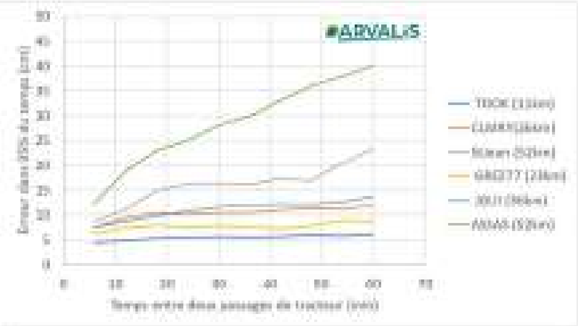
Rumex detection on grassland: Profitability from 50% of surface treated in the plots concerned despite an additional cost of 84000 € HT

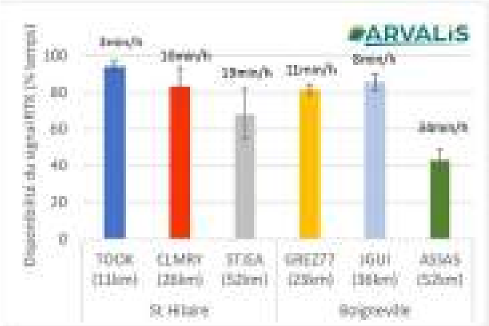
The single-base RTK in telephone transmission - Centipède

Network initiated by INRAE since 2019.
The correction comes from a single RTK Centipede base.
Can be used on a "home" or commercial receiver (Trimble, John Deere ,...)



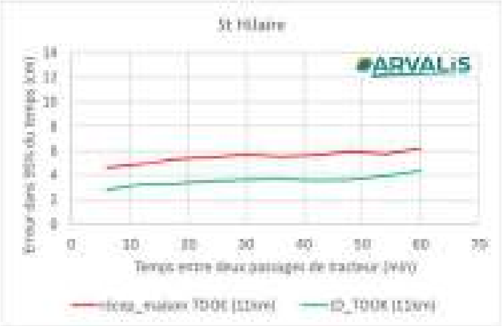
Influence of baseline on homemade receptors

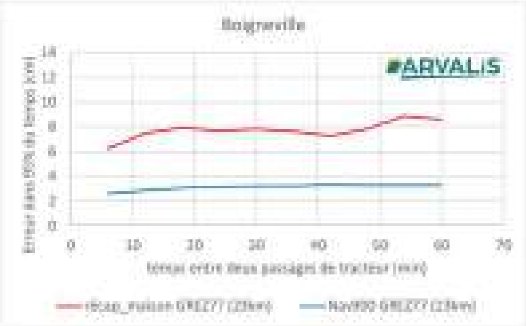




The farther away the Centipede base, the more accuracy and availability degrade

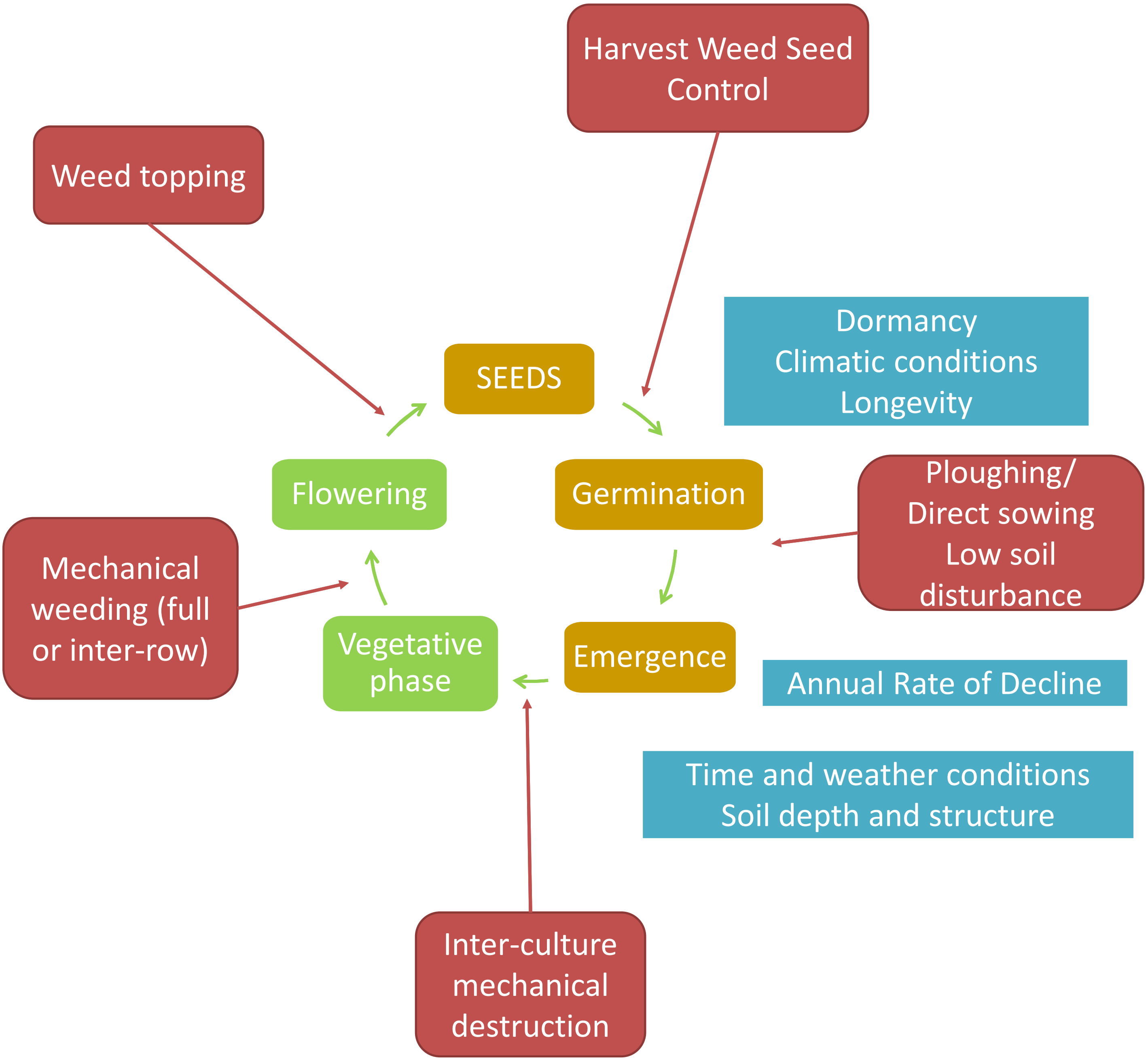
Centipede on a commercial receptor/homemade receptor





A commercial receiver values centipede accuracy better than a "homemade" receiver

Mechanical levers and weed cycling



Harvest Weed Seed Control

Weed topping

SEEDS

Dormancy
Climatic conditions
Longevity

Flowering

Germination

Ploughing/
Direct sowing
Low soil
disturbance

Mechanical weeding (full or inter-row)

Vegetative phase

Emergence

Annual Rate of Decline

Time and weather conditions
Soil depth and structure

Inter-culture mechanical destruction

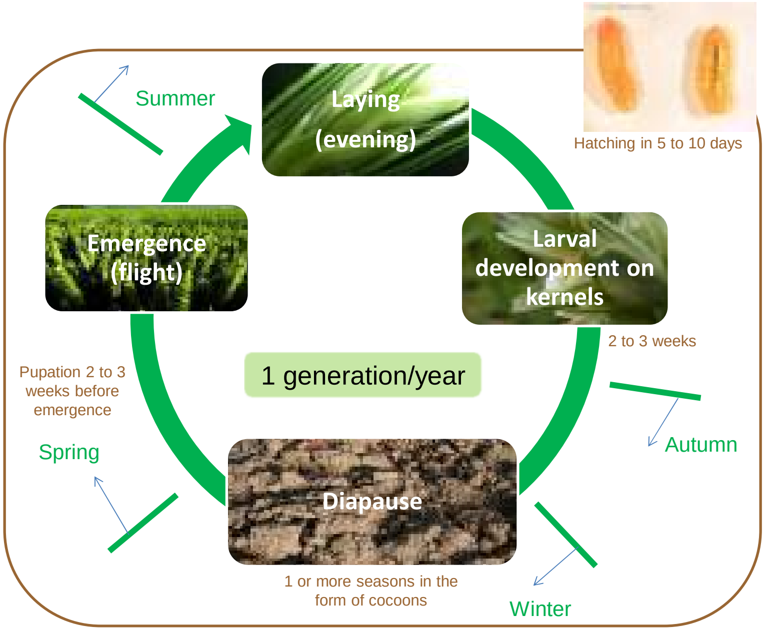
Legend

🟥 Mechanical levers for weed control

🟦 Weed biology

Protection against the orange wheat blossom midge *Sitodiplosis mosellana*

Midge about 3mm long with long and thin legs.
The adult and larva are of a characteristically bright orange.



Laying (evening)

Hatching in 5 to 10 days

Larval development on kernels

2 to 3 weeks

Autumn

Winter

Diapause

1 or more seasons in the form of cocoons

Spring

Pupation 2 to 3 weeks before emergence

Emergence (flight)

Summer

1 generation/year

Damage

- Distorted kernel, poor filling

Infected kernels

distorted healthy

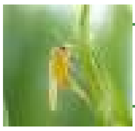
- Poorer baking quality of the flour

➔ **Yield loss of approximately 1q/ha per larva per ear**

Varietal control: the most effective method

Monogenic resistance (Sm1 gene)

- No effect on oviposition of females
- **Inhibition of larval growth through increased production of phenolic acids**
  ➔ **90%** reduction of larvae/ear
  ➔ Yield gain up to **11q**



Ineffective against the lemon wheat blossom midge *Contarinia tritici*

Non-exhaustive list of resistant wheat varieties

Name	Plant breeder	Year of registration	Ear at 1cm precocity	Heading precocity	Quality class
KWS ULTIM	KWM	2020 (FR)	3	7	BPS
PRESTANCE	FD	2021 (FR)	6	7.5	BPS
PROVIDENCE	FD	2019 (FR)	4	7	BPS
SY ADMIRATION	SYN	2021 (FR)	4	6.5	BPS
GARFIELD	SEC	2020 (FR)	2	5.5	BPS
CELEBRITY	FD	2022 (FR)	(4)	7	BPS
RGT TWEETEO	RAG	2020 (FR)	(2)	7	BPS
TENOR	UNI	2018 (FR)	4	7	BPS

Chemical control: only on susceptible varieties

1. Agronomic risk assessment grid

Varietal sensitivity	History of the field	Field rotation	Dominant soil type	RISK
Resistant variety				0
Sensitive variety	History without midge	Rotation without Wheat/Wheat	Sandy	1
			Loamy	1
			Clayey (+ chalk)	2
		Rotation with Wheat/Wheat	Sandy	3
			Loamy	3
			Clayey (+ chalk)	4
	History with midge	Rotation without Wheat/Wheat	Sandy	5
			Loamy	5
			Clayey (+ chalk)	6
		Rotation with Wheat/Wheat	Sandy	7
			Loamy	7
			Clayey (+ chalk)	8

0 : No risk. Do not treat.
1 à 4 : Low risk ➔ Installation of yellow bowls recommended.
5 et 6 : Medium risk ➔ Place 2 yellow bowls per plot.
7 et 8 : High risk ➔ Check the bowls every 48 hours, or even 24 hours.

2. Treatment advices in case of high risk

Limited timeframe to intervene !

Apply insecticide in the evening when the following 4 conditions are met:

☐ **10 midges/yellow bowl caught in 24 hours**
☐ Wheat stage between **heading and late flowering**
☐ **Heavy and stormy weather + lack of wind** (T° > 15°C and wind < to 7 km/h)
☐ Midges **actively laying eggs** ; midges visible on the ears

E2_11_1

Axe 4_30.5

Les Culturales 2023 14-15 juin

The grey slug
Deroceras reticulatum

Dominant species in field crops

- Greyish to yellowish brown colour
- Up to 40mm in extension
- Lifespan of 8 to 12 months
- Possible overlapping of populations in the field

Almost constantly present throughout the crop cycle with main peak in autumn and secondary peak in spring

Seed consumption

Leaves consumption from crop emergence

Severed emergence / Loss of plants & vigor

Risk assessment

Monitoring slug activity

Ideally 4 traps of 0.25m² placed in the middle and at the edge of the plot

- Minimum spacing of 5m
- Weekly observation
- A few weeks before sowing until the end of the susceptible period (3-4 leaves)

Warning: it's difficult to link precisely the number of slugs observed to the severity of the damage → **many other factors to consider.**

Plot factors

Cultural practices (tillage, rotation, etc.), **crop palatability**, **soil type** or even **plot environment** can influence the abundance and activity of slugs.
→ use the document **Fiche Ciblage® ACTA** to assess the risk beforehand.

Climatic factors

Mild temperatures and humidity favor slug activity. The **ACTA climate model** can be used to assess the overall risk of the current year compared to past reference years.

Management strategies

Short term: chemical control

Treat accordingly to the level of risk and the stage of the crop.

2 approved active substances: metaldehyde (conventional) and ferric phosphate (biocontrol)

- Comparable effectiveness at D+8
- 3-days delay of action observed for ferric phosphate
- **Not all ferric phosphate products are equally effective**

Spread carefully (evenly, at the right dosage…) and use, if possible, a specific equipment.

Long term: agronomic control

Adjust practices to **disrupt the living environment and the development of slugs**.

- **Avoid direct sowing :** buried seeds are less accessible
- **Ploughing and stubble ploughing :** eliminate eggs and residues (which provide shelter & food)
- **Lengthen crop rotation / introduce unpalatable crop and plant cover :** mustard, radish, vetch ...

ARVALIS

INTEGRATED PROTECTION TO CONTROL BYDV : Good practices

CHOOSE THE RIGHT VARIETY

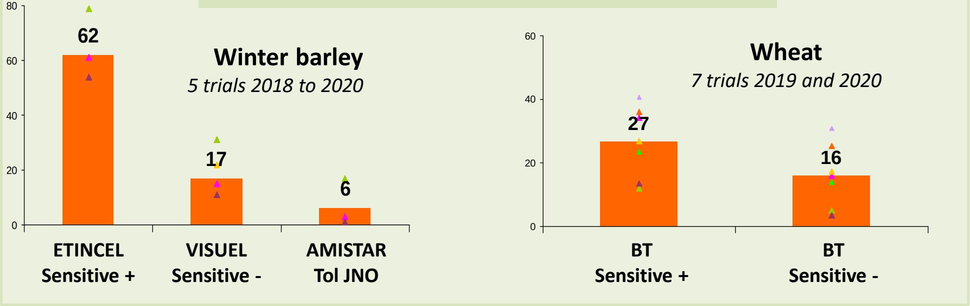
BARLEY

- Depending on the destination of production, favor varieties tolerant to BYDV
  - Efficient protection
  - Some symptoms but very low impact

SOFT WHEAT

- Differences in sensitivity between varieties
- A new partial resistant variety to the test

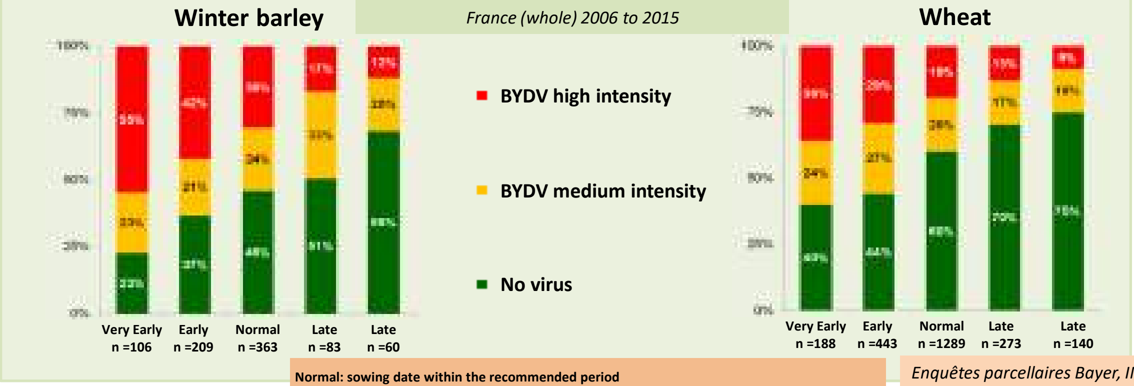
% Yield losses (Early sowing)



DO NOT SOW TOO EARLY

Limits situations favorable to aphid arrivals and high infestations over a long period of time

Frequency and intensity of detection of BYDV
France (whole) 2006 to 2015



Normal: sowing date within the recommended period
Early / late: sowing carried out between 1 and 10 days before / after the recommended period
Very early / Very late: sowing carried out at least 10 days before / after the recommended period

Enquêtes parcellaires Bayer, INRAE, Arvalis

MONITOR CROPS

Search and detect the presence of aphids on plants until the 1st true frosts:

- In good weather, at the hottest hours
- Focus on areas close to hedges, grass strips, fallows, maize...
- Between the leaves, in the cornet, at the base of the tillering tray

Plants are sensitive until the end of tillering

INTERVENE AT THE RIGHT TIME

- ✓ Pyrethroids: Action by contact, limited persistence, effective if well positioned
- ✓ No intervention recommended on barley varieties tolerant to BYDV and without leafhopper pressure

The threshold to trigger an insecticide is >10% of plants with aphids or more than 10 days of presence
Repeat the intervention if new infestations are observed

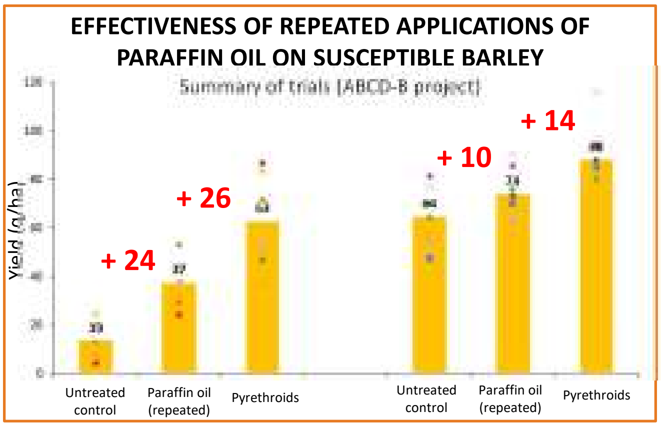
INTEGRATED PROTECTION TO CONTROL BYDV:
Research and development

DIRECT CONTROL

- ➢ Biocontrol insecticides

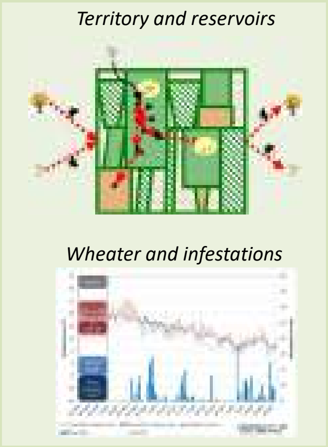
  To combine tomorrow with other levers: sowing date, varietal sensitivity…

- ➢ Alternatives to pyrethroids
- ➢ Participation in pyrethroid resistance monitoring


EFFECTIVENESS OF REPEATED APPLICATIONS OF PARAFFIN OIL ON SUSCEPTIBLE BARLEY

RISK CHARACTERIZATION

- ➢ Identification of aphid species
- ➢ Study of all virus genomes and development of diagnostic tools for viruses with an agronomic interest
- ➢ Field monitoring
- ➢ BYDV Risk Prediction Model



INDIRECT CONTROL

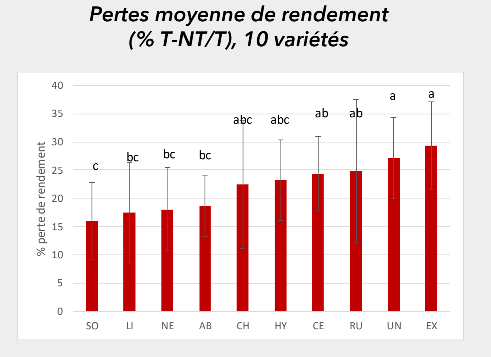
- ➢ Resistant/tolerant varieties

WINTER BARLEY

- Interest of tolerance genes
- Sustainability of these genes
- Differences in sensitivity between varieties without tolerance genes

SOFT WINTER WHEAT

- Interest of the partial resistance gene
- Sustainability of this gene
- Differences in sensitivity between varieties


Pertes moyenne de rendement (% T-NT/T), 10 variétés

- ➢ Regulation by auxiliaries
- ➢ Sowing date shift

INTEGRATED PROTECTION TO CONTROL WHEAT DWARF VIRUS (WDV)

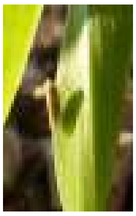
DO NOT SOW TOO EARLY

Limits situations favorable to the arrival of leafhoppers on the field

MONITOR CROPS

Look for the presence of leafhoppers in the plot when the weather is nice, during the hottest hours. Leafhoppers are very mobile insects, They jump when moving around the field.

Sensitive plants up to "1 node" stage



INTERVENE AT THE RIGHT TIME

- ✓ Recommanded threshold to use an insecticide :
  - Regional observations: **30 weekly catches of leafhoppers** *Psammotettix alienus* on a yellow glue trap (A4; 21x29.7 cm). Or depending on the increase in leafhopper activity →difference of about twenty catches between 2 surveys (bi-weekly monitoring).
  - Observation on the plot: if a strong activity is observed on **5 places of the plot making jump in front of you at least 5 leafhoppers for each place** (walk the plot in sunny period, the hottest of the day, operation of a few minutes that can be repeated as many times as necessary).
- ✓ Pyrethroid-based insecticides: Action by contact, limited persistence. In case of early attack, treatment may be necessary as early as the stage of one leaf of the cereal. Some years, It can be renewed in case of prolonged presence of insects during the autumn.

WD symptoms on winter barley
2023 – BRUX (86)

WD symptoms on soft winter wheat
2023 – BRUX (86)

RESEARCH WORKS

- Study of the sensitivity of different wheat and barley genetics to WDV
- Testing of different conventional and biocontrol products

Les Culturales 2023 14-15 juin

Produce wheat in all serenity!

My aim: to have the healthiest possible situation to optimize direct control in culture

I identify the problem or problems of my field to combine the most suitable levers!

STEP 1 : I choose my varieties!

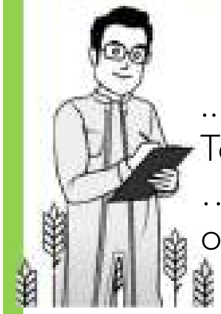
To limit the pressure of foliar and root **diseases** (eyespot, mosaics)	To resist the main **pests**: orange midges and in the future autumn aphids and leafhoppers	To prevent **lodging** without regulating	To compete with **weeds** (by the covering power of plants)

STEP 2 : Sowing: « Why should I sow later?"

- for weed management: the most efficient agronomic lever at the scale of the crop
- to dodge peaks of pest activity: autumn aphids and leafhoppers
- to decrease disease pressure
- to limit the risk of physiological lodging

And I adapt my seeding densities: NOT TOO DENSE

STEP 3 : I will observe to decide my interventions!



Diseases, pests, lodging risk, weed catch-up …

... I identify and analyze my risk with the available Decision Support Tools

… to avoid any unnecessary intervention (e.g. no early intervention on septoria)

I adapt throughout the campaign

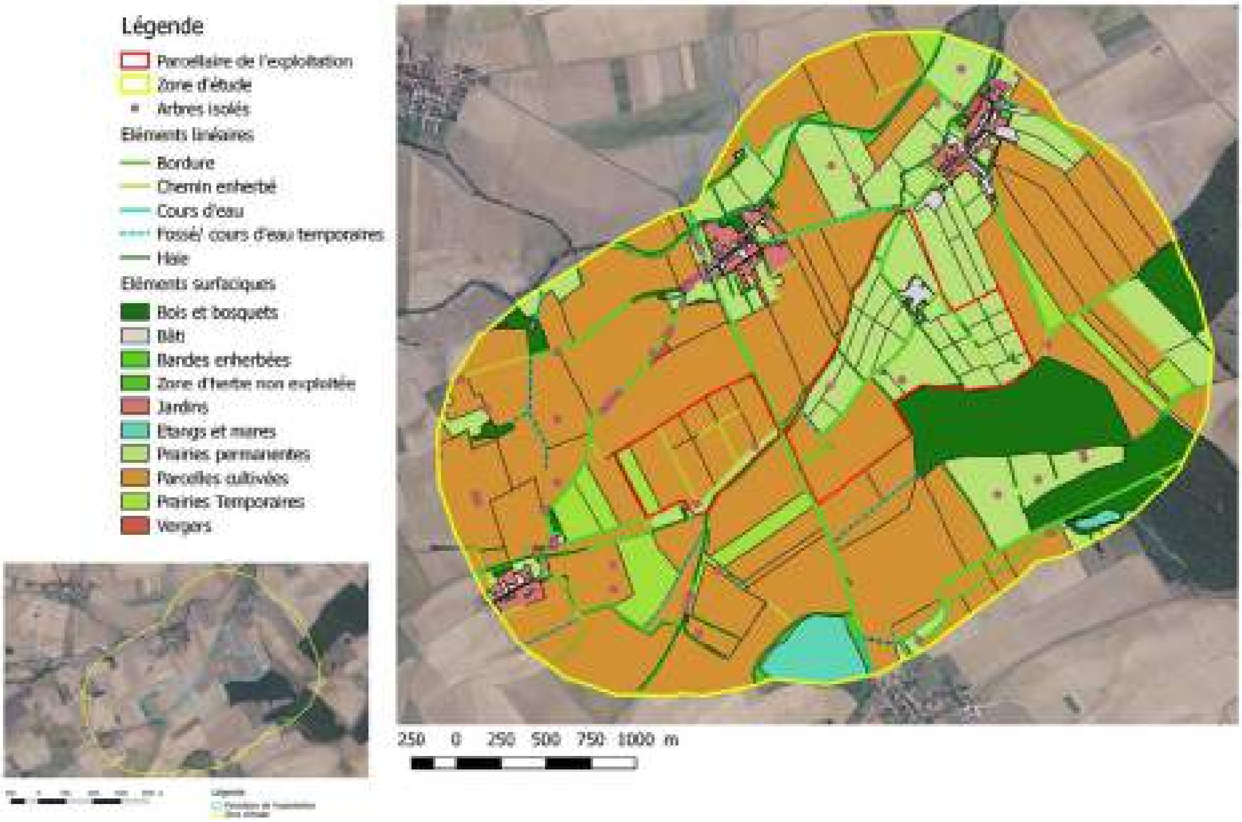
THE COMBINATION OF LEVERS DOESN'T AFFECT MY GAINS

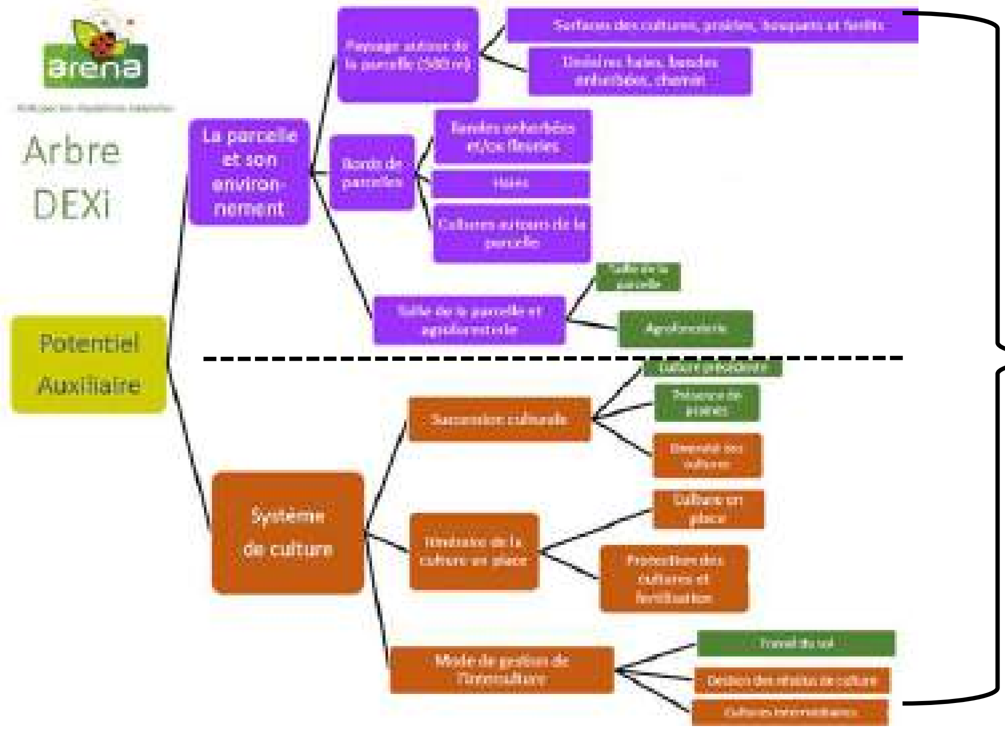
ARVALIS

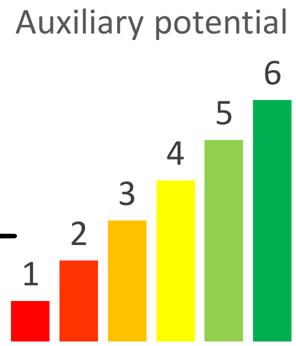
E2_12

Cropping systems and landscapes favourable to natural regulation

Les Culturales 2023 14-15 juin







The fields are generally favorable to the reception of auxiliaries in Saint-Hilaire: score between 4 and 6.

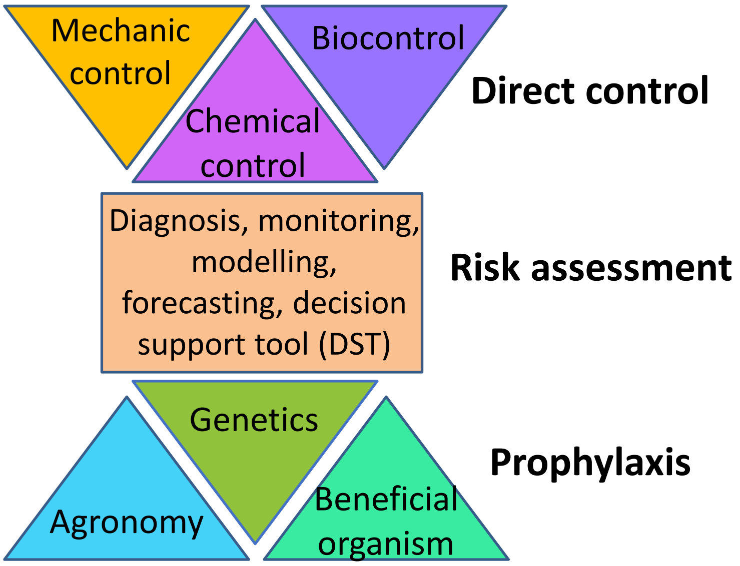
Les Culturales 2023 14-15 juin

Cap du futur: Activate the solutions of integrated plant health

Silt-clay soils on hard limestone
Medium to shallow soils
7 irrigated plots on 47 ha

Objectives of the system experiment:

- Ensuring economic profitability
- Sustainable weed management
- Limiting reliance on pesticides
- Producing high-quality cereals



System-wide levers

Balance rotation:

- Disrupt weed cycle with crops with different planting periods (2 winter / 2 summer)

- Distribute the ploughing (1 ≈ 3 years) to bury the stock of ryegrass seeds then shallow tillage to avoid emergence of a still viable stock.

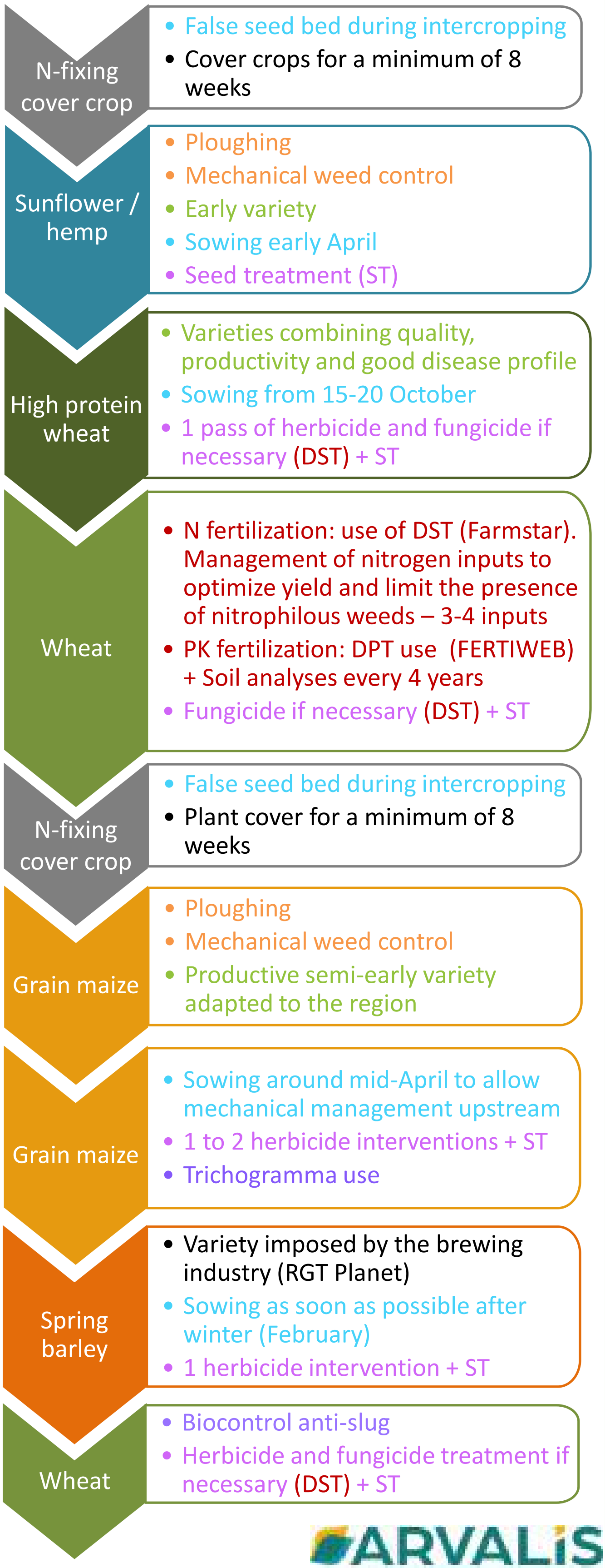
Limit the presence of weeds:

- Multiply false seed bed and destruction of weeds
- Delay sowing dates
- Sowing on "clean" soil
- Use "clean" seeds
- Control nitrogen inputs to limit the presence of nitrophilous weeds (ryegrass)
- Chemical weed destruction when damage thresholds are reached.

Avoid the introduction of new weeds:

- Clean the combine between fields
- Manage the edges of fields

Crop-wide levers



N-fixing cover crop
- False seed bed during intercropping
- Cover crops for a minimum of 8 weeks

Sunflower / hemp
- Ploughing
- Mechanical weed control
- Early variety
- Sowing early April
- Seed treatment (ST)

High protein wheat
- Varieties combining quality, productivity and good disease profile
- Sowing from 15-20 October
- 1 pass of herbicide and fungicide if necessary (DST) + ST

Wheat
- N fertilization: use of DST (Farmstar). Management of nitrogen inputs to optimize yield and limit the presence of nitrophilous weeds – 3-4 inputs
- PK fertilization: DPT use (FERTIWEB) + Soil analyses every 4 years
- Fungicide if necessary (DST) + ST

N-fixing cover crop
- False seed bed during intercropping
- Plant cover for a minimum of 8 weeks

Grain maize
- Ploughing
- Mechanical weed control
- Productive semi-early variety adapted to the region

Grain maize
- Sowing around mid-April to allow mechanical management upstream
- 1 to 2 herbicide interventions + ST
- Trichogramma use

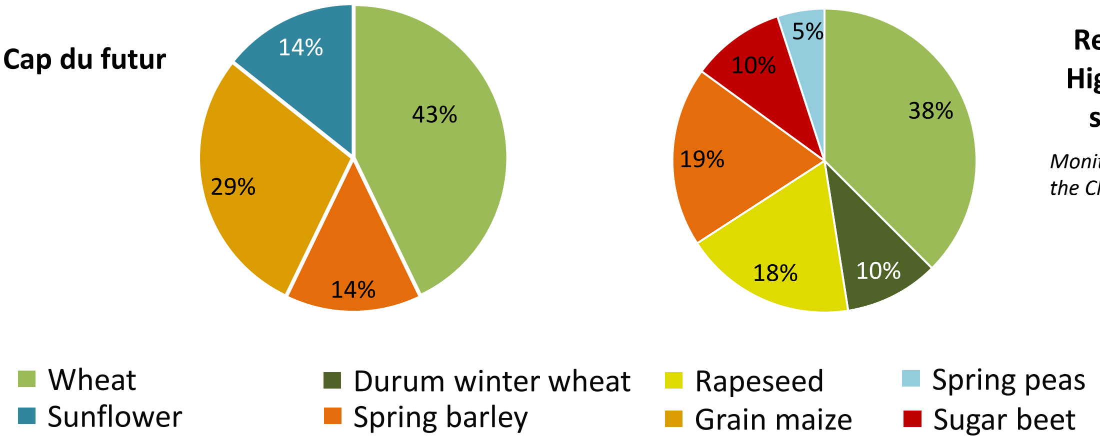
Spring barley
- Variety imposed by the brewing industry (RGT Planet)
- Sowing as soon as possible after winter (February)
- 1 herbicide intervention + ST

Wheat
- Biocontrol anti-slug
- Herbicide and fungicide treatment if necessary (DST) + ST

ARVALIS

Cap du futur: Evaluation of the multiperformance of the system experiment

Extrapolation of results to the farm level
300 ha
→ 1 family annual work unit
→ Employed labour: 1 annual work unit for Cap du futur / 0.5 unit for the reference farm
→ 45% shallow soils + 55% medium soils
→ Dimensioned park of equipment, interventions in field according to workable days
→ Irrigable land: 100% on Cap du futur / 75% on the reference farm



Reference farm = High-performance simulated farm

Monitoring of local practices with the Chamber of Agriculture of the Ile de France region

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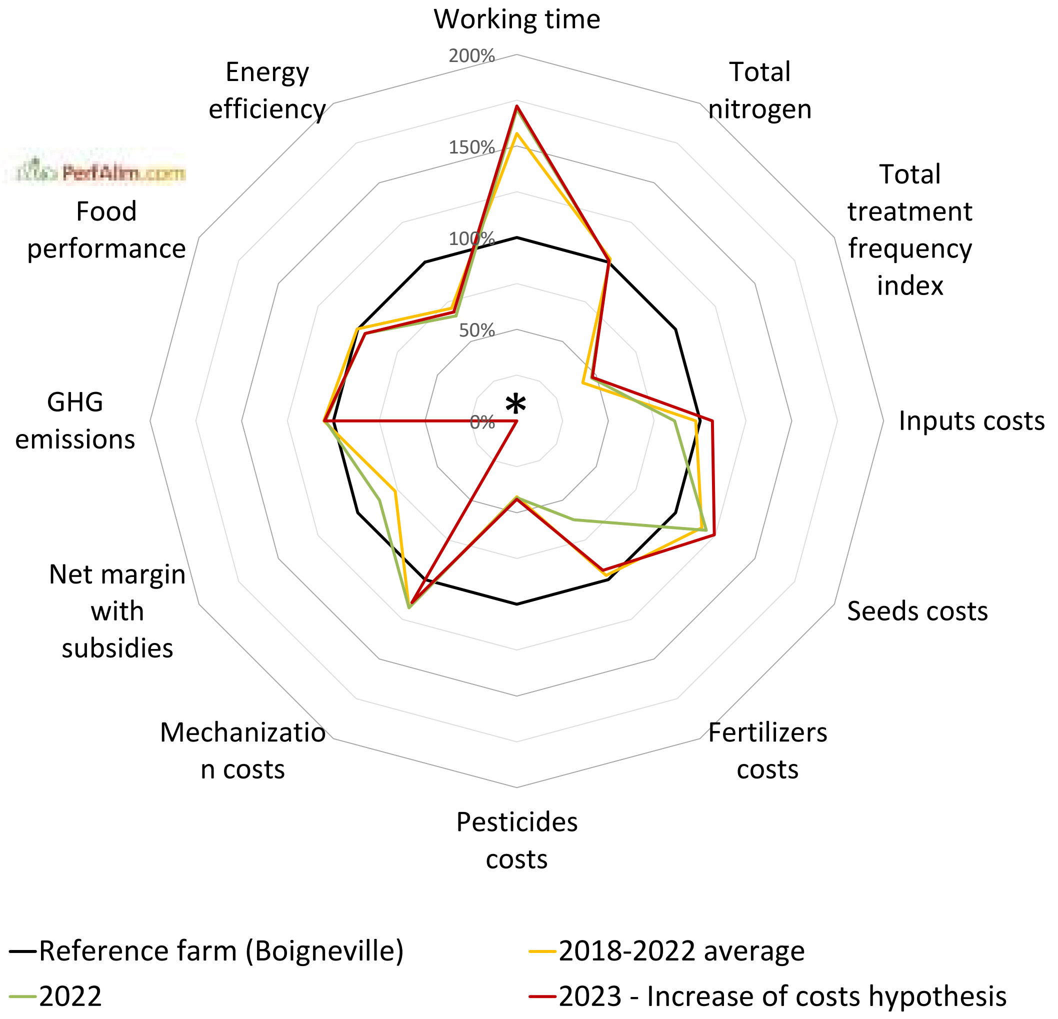
Multicriteria assessment of the testing system "Cap du futur" compared to a high-performance simulated farm ou reference farm



Hypothesis 2023 scenario
Pesticides: +10% / 2022
Seeds : - *Cereals:* +25% / 2022 - *Oilseeds and legumes:* +2% / 2022
Electricity: +10% / 2022
Vehicles maintenance: +10% / 2022
Buildings maintenance: +7% / 2022
Land rent: +3.55% / 2022
Contract work: +15% / 2022
Insurances & interest: +2% / 2022
Taxes: +0% / 2022
Social security contributions: +42% / 2022
Staff remuneration & social charge: +2% / 2022
Machinery depreciation: +6% / 2022
Selling price: moy. 2018-2022

* Negative margin under the 2023's campaign hypothesis

Evaluation conducted with SYSTERRE

Focus on 3 potato blemish diseases: symptoms and diagnosis

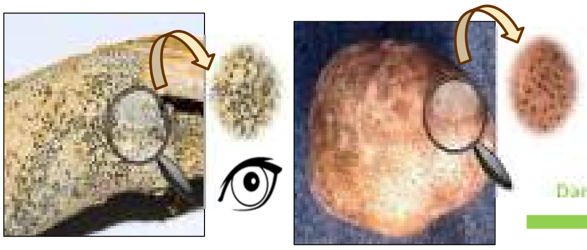
Les Culturales 2023 14-15 juin

English version

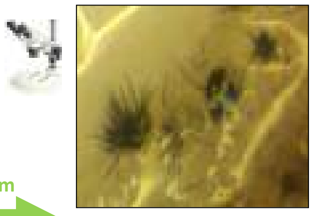
Did you know ?: There are about 160 potato diseases of which about 50 are caused only by fungi.

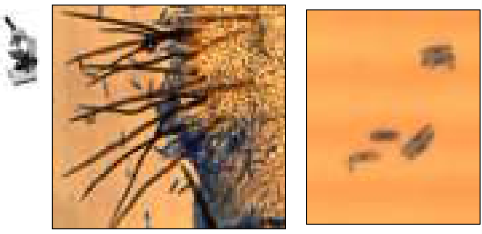
Black dot - *Colletotrichum coccodes*

Black dot is a disease of the aerial parts of the plant and tubers. It is manifested by withering stems and leaves, destruction of roots and the appearance of black spots (sclerotia) on stems and tubers.


Potato stem and tuber with microsclerotics of black dot

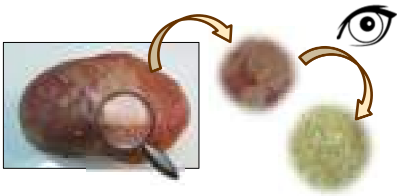
Damp room


Viewing the acervuli with a magnifying glass


Observation of acervuli and conidia (spores) x100 et x400

Silver scurf - *Helminthosporium solani*

Silver scurf is a disease affecting the tubers of the plant and manifests itself in clear, **silvery spots covered with thin black spots**. These black spots correspond to the sporulation of the fungus. Very little visible at harvest, **the symptoms appear more during storage** when the temperature and humidity are favorable**.**


Potato tuber with symptoms of silver scurf

Damp room


Observation of conidiophores (sexual reproduction) (x60 left et x100 right)

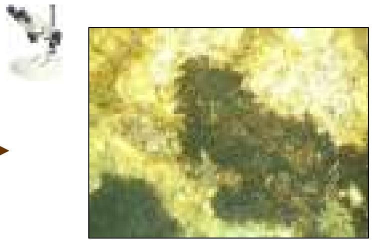

Observation of spores x400

Black scurf or Stem canker - *Rhizoctonia solani*

Black scurf is a disease affecting the aerial parts of the plant and tubers. Symptoms **include irregular or late lifts and brown spots** that are more or less deep. **Sclerotia** are also observable on tubers and persist even after washing.


Potato tuber with symptoms of black scurf

Damp room


Observation of mycelium with magnifying glass


Observation of mycelium x400

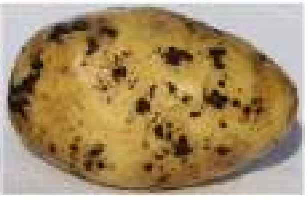
ARVALIS

Control of potato blemish diseases

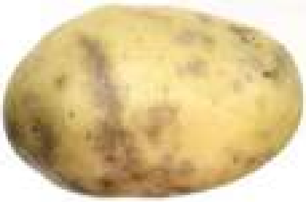
English version

After receiving potato tuber seed

A rigorous examination of each batch to detect the presence black scurf, black dot, silver scurf and de rots (dry, wey) is essential.



Black scurf



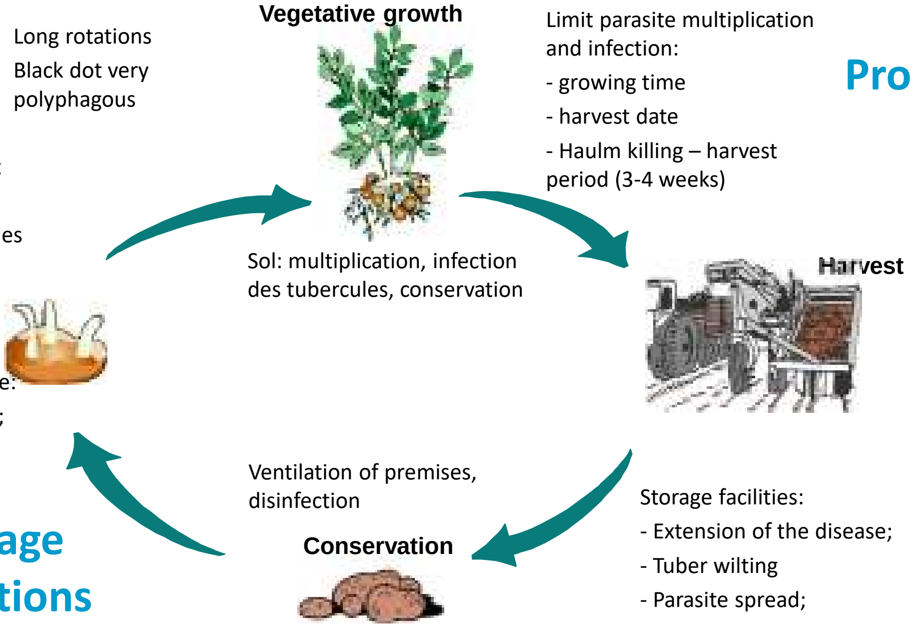
Black dot

Silver scurf

Choose your treatment according to your production

Outlet	Objectives	Targets	Teatment
Processing and starch	✓ Good emergence ✓ Mediocre aesthetic quality permited (no deformed tubers)	➢ Black scurf on stems and stolons at early stages	▪ Anti-black scurf
Consumption Fresh market	✓ Good emergence ✓ Excellent aesthetic quality at harvest and after storage	➢ Black scurf on stems and stolons at early stages ➢ Silver scurf and black dot	▪ Anti-black-scurf, silver scurf and black dot

Regardless of the type of production if the plot presents a risk black-scurf and/or black dot a soil treatment in plantating row is necessary with Amistar 3l/ha.



Vegetative growth

Long rotations

Black dot very polyphagous

Limit parasite multiplication and infection:
- growing time
- harvest date
- Haulm killing – harvest period (3-4 weeks)

Prophylaxis

- Check the health of the plant
- Avoiding early planting
- Use the least sensitive varieties

Sol: multiplication, infection des tubercules, conservation

Harvest

Planting

Limit the expression of the disease:
- Chemical treatment of the plant;
- layout of premises

Ventilation of premises, disinfection

Storage facilities:
- Extension of the disease;
- Tuber wilting
- Parasite spread;

Conservation

Storage conditions

Temperature, humidity

Potato aesthetic aspect

A very good quality of tuber presentation is required by the fresh market: undistorted tubers, well washed, without stains, smooth etc.

Tubers affected by its diseases are consumable in the state, no mycotoxins, peeling is enough to remove the skin with the affected parts (superficial diseases).

If good quality at planting is necessary to avoid loss of vegetation yield, post-harvest and post-storage presentation quality usually only reduces marketable yield…

ARVALIS

Integrated Potato Late Blight Management

Les Culturales 2023 14-15 juin

English version

Context

Ecophyto II+

Societal expectations

Biodiversity conservation

Environmental issues

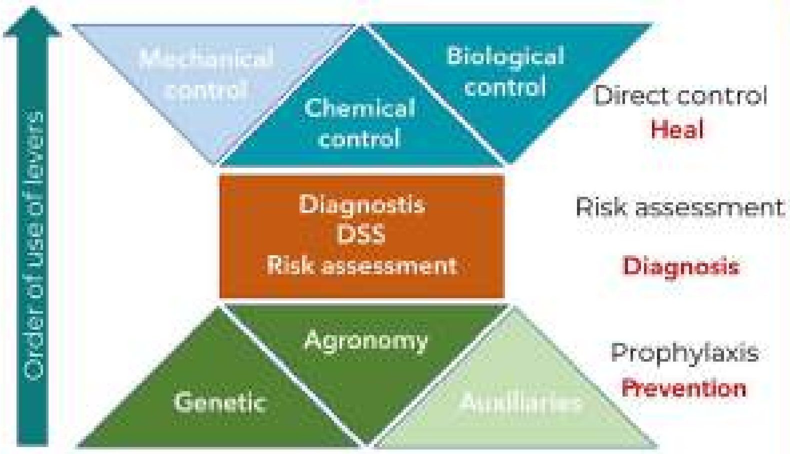
Quality

Active ingredients banned

Health

Significantly reduce potato fungicide TFI (Treatment Frequency Index) with integrated crop protection

Integrated Pest Management (IPM)



Levers used

Assess TFI reduction potential and efficacy of IPM programs

Cultivar

Susceptible (CTPS ≤ 4)
Ex: Bintje

Moderate resistance (CTPS ≥ 5)
Ex: Magnum

DSS

Treatments triggered with Mileos®

Biological control

Potassium phosphonate with adjusted dose of traditional fungicide

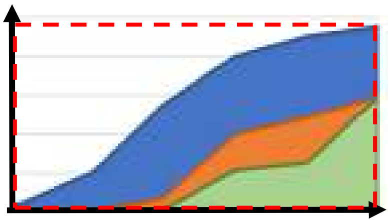
Fungicide

Adjusted dose regarding cultivar, disease pressure

rAUDPC (0-1)

The value of rAUDPC reflects disease pressure during the season

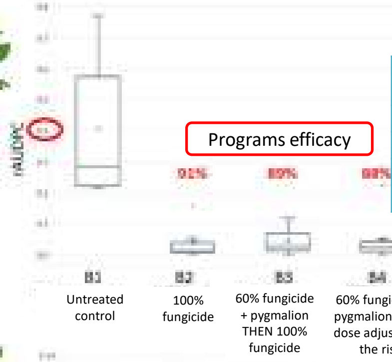
AUDPCmax > AUDPC > AUDPC > AUDPC



Results

2018-2020 : low pressure

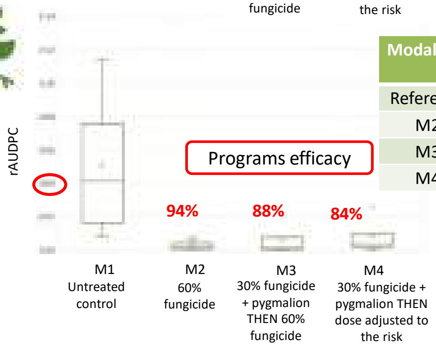
Susceptible cultivar



Programs TFI

Modalities	Global TFI	TFI reduction
Reference	11.3	
B2	7.1	- 37%
B3	6.2	- 45%
B4	4.8	**- 58%**

Moderately resistant cultivar

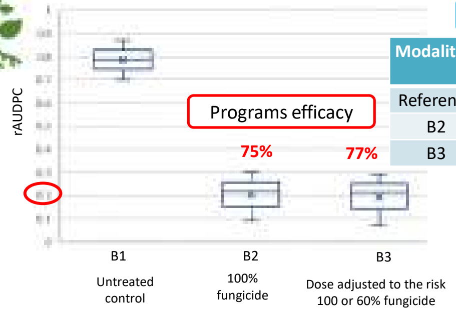


Programs TFI

Modalities	Global TFI	TFI reduction
Reference	11.8	
M2	4.2	- 64%
M3	2.6	**- 78%**
M4	2.4	**- 80%**

2021 : high pressure

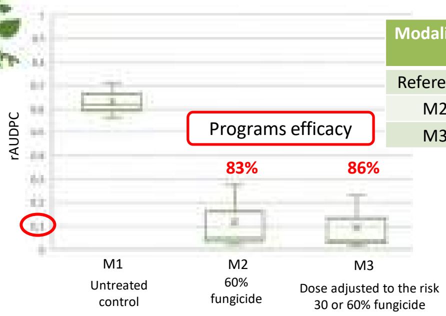
Susceptible cultivar



Programs TFI

Modalities	Global TFI	TFI reduction
Reference	12	
B2	9	- 25%
B3	8.6	- 28%

Moderately resistant cultivar



Programs TFI

Modalities	Global TFI	TFI reduction
Reference	12.6	
M2	6.8	-46%
M3	5	**-60%**

Conclusion

Low/moderate pressure: TFI reduction: **-50% on Bintje** et **-80% on Magnum**.
High pressure: TFI reduction, **-30% on Bintje** et **-60% on Magnum** to preserve good efficacy.

The varietal lever is the corner stone of the IPM: less infestation, reduction in the number of treatments, enhance biocontrol and dose adjustment

Discussion

In light of current and future withdrawals of active ingredients, societal and environmental expectations, how can late blight be managed, in 10-20 years, in a low TFI environment, in a difficult year?

- Substitution of the very majority susceptible varieties today by intermediate varieties or gradually to very little sensitive
- Better management of primary inoculum (dumps, volunteers, gardens, etc.)
- Generalization of the use and respect of the recommendations of DSS Mileos®
- Adaptation of fungicide doses to varietal resistance and late blight risk

ARVALIS

E2_14_3

Potato Early Blight

THE PHANTOM MENACE

Les Culturales 2023 14-15 juin

English version

Prophylaxis

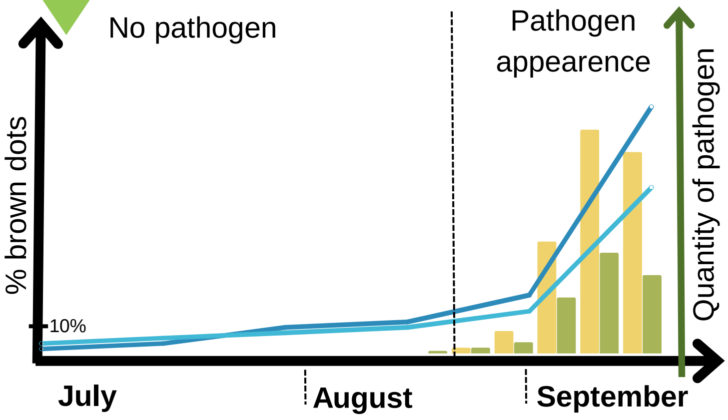
Good management by agronomy

Destroy sources of primary inoculum
Cull piles, volunteers…

Balanced fertilization and irrigation
Watch out for excess!

Avoid any stress of the plant causing early senescence

Weakness disease



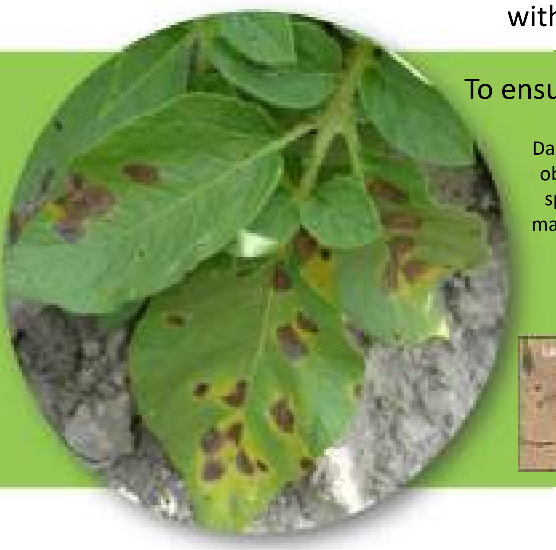
Symptoms of the presence of the pathogen. It appears very late in the season and in connection with senescence.

Misleading symptoms

There is a lot of confusion: deficiencies, lesions, burns, senescence… We are talking about **"supposed" symptoms of early blight**

In 2/3 of the cases, an assumed symptom of early blight is not confirmed by the analysis

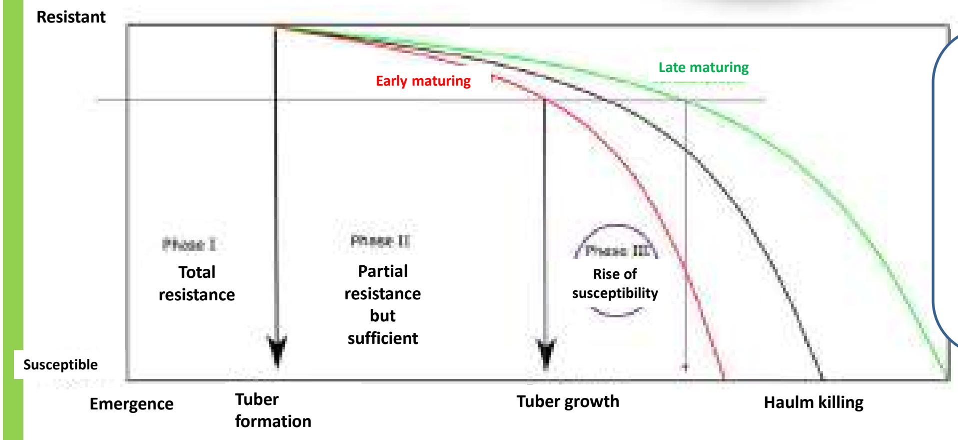
This leads to unnecessary treatment, because too early, sometimes as early as June/July



To ensure the presence of Alternaria

Damp room and observation of spores with a magnifying glass

Laboratory analysis to know the species



Step 1: When does the plant become too sensitive (Phase III)?
Physiological model

Step 2: In phase III, when to start the T1 and renew it if necessary?
Epidemiological model

A new risk model

Highlights:

Rarely injurious weakness disease

Late arrival of pathogen

Frequent confusion of symptoms

Good agronomic management is essential

A physiological and epidemiological model is being validated in the field

ARVALIS

Flax fiber : integrated protection levers

I foresee	I assess	I protect
DAMPING-OFF DISEASES		
▪ Certified seed ▪ Minimum interval of 6 years between 2 flax	▪ Plant loss	▪ THERMOSEM® ▪ Biocontrol ▪ PPP
FLEA BEETLES		
▪ Sow in sufficiently dry, warmed and not cloddy soil	▪ Number of bites on the leaves ▪ Flax stage ▪ Meteorology ▪ ARVALIS risk matrix ▪ BSV	▪ PPP
WEEDS IN GROWING PERIOD		
▪ Rotation lengthening and diversification ▪ False seed-bed	▪ Weed counting and identification	▪ Mechanical weeding ▪ PPP
DISEASES IN GROWING PERIOD		
▪ Tolerant varieties ▪ Minimum interval of 6 years between 2 flax ▪ Seeding rate ▪ Nitrogen fertilization	▪ Symptoms on leaves and stem ▪ BSV	▪ Biocontrol ▪ PPP
STANDABILITY		
▪ Varieties ▪ Seeding rate ▪ Nitrogen fertilization	▪ Meteorology (storm) ▪ Growth rate ▪ ARVALIS risk matrix	▪ PPP

PPP = Phytopharmaceutical products

Flax fiber : Technical and economic impacts of combinations of alternative levers to PPPs*

3 CMS* tested over 3 years

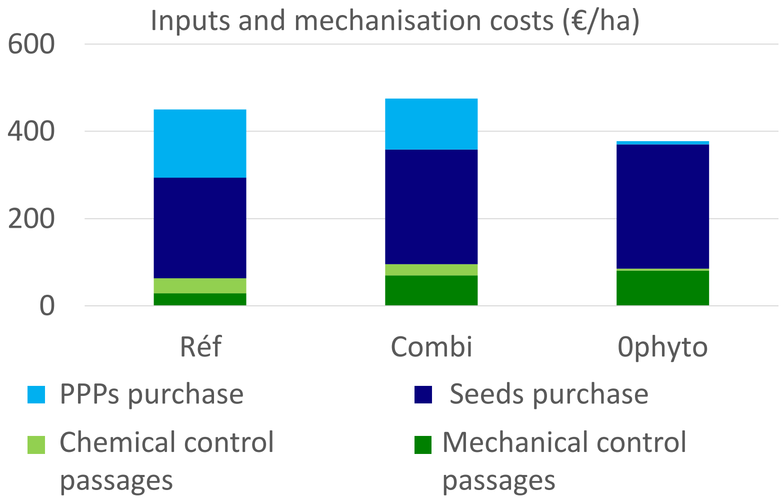
- **Ref CMS :** corresponding to the farmer's practices
- **Combi CMS** : combinations of levers with the possibility of using PPPs
- **0phyto CMS :** combinations of levers without synthetic PPPs

Expenses : the fragile compromise of Combi CMS

+ 30mn/ha for Combi and 0phyto CMS compared to the Ref CMS.

-80€/ha of expenses for the 0phyto CMS against **+20€/ha** for the Combi CMS (excluding workforce)

	Ref CMS	Combi CMS	0phyto CMS
Working time (h/ha)	8.8	9.3	9.3
Nb passages	21	21	18
Included chemical control	5	3.5	0.5
Included mechanical contol	0.5	2	2.5



Satisfactory technical performance

	Ref CMS	Combi CMS	0Phyto CMS
RNB* (T/ha)	6.5	6.3	6.3
LT* (% RNB)	17.2	18.1	18.7
IFT*	4.9	3.5	0.6

Levers allowing an effective fight against bio-aggressors :

- Aiming for **good sowing conditions** (shifting sowing date)
- Using **tolerant varieties**
- Using **sulphur** as a biocontrol

False seed-bed and **mechanical control** (weeding, swath turning and lifting), levers that are not always sufficient to control weeds and highly dependent of **climatic conditions**.

A reflection on the **scale of the cropping system** is necessary (Rotation, intercropping, etc.)

But difficulties in managing weed

PPP = Phytopharmaceutical products
CMS = Crop Management System

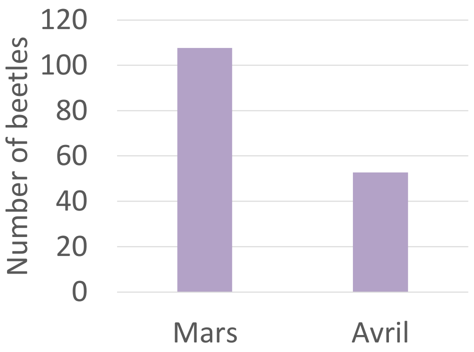
RNB = non-scutched retted flax yield
LT = Scutched flax
IFT = Treatment frequency indicator

ARVALIS

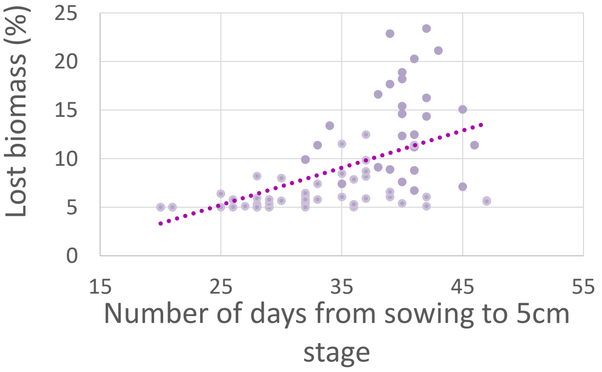
Flax fiber : focus on a few integrated protection levers

FLEA BEETLES : Shifting the sowing date and ensuring rapid emergence

Abundance according to sowing month

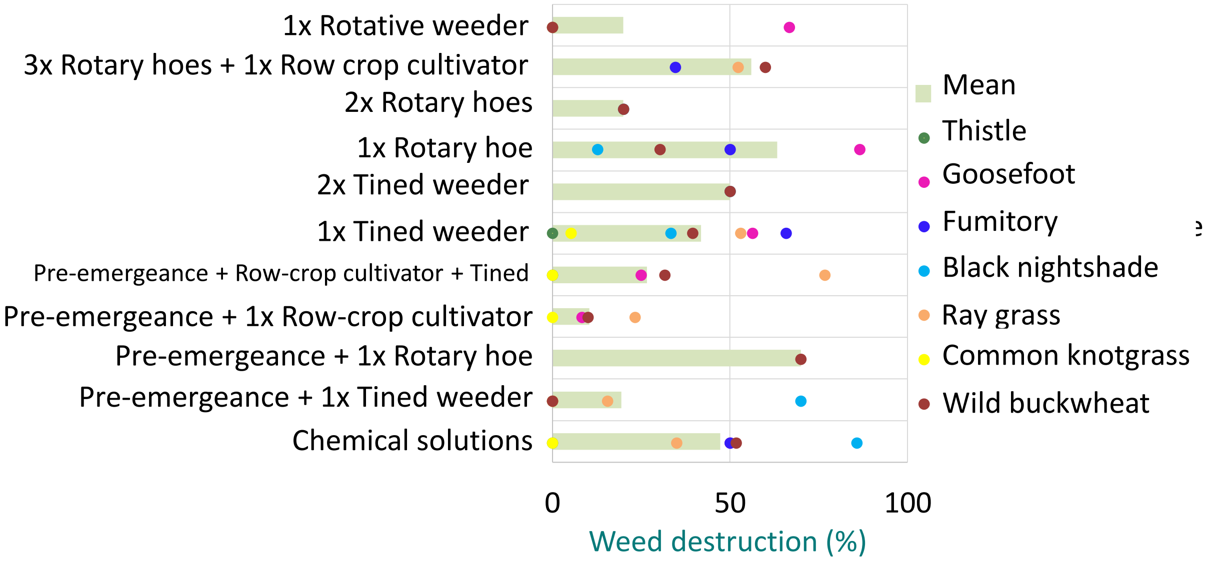


Damage according to growth rate



ARVALIS – Characterization of flea beetles risk - 77 fields (2021-2022)

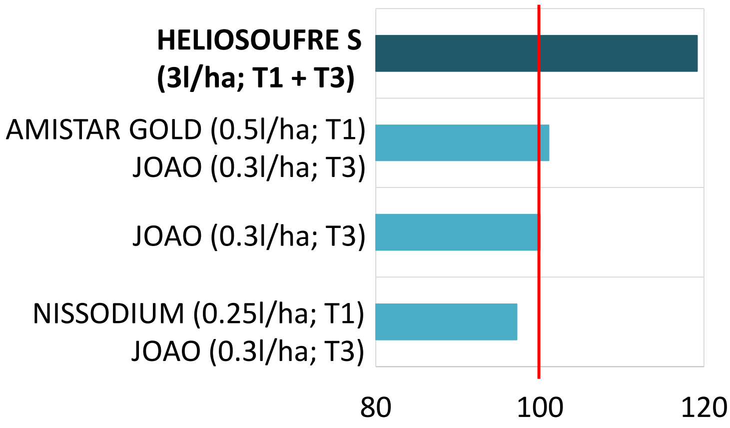
WEEDS: variable effectiveness of mechanical weeding



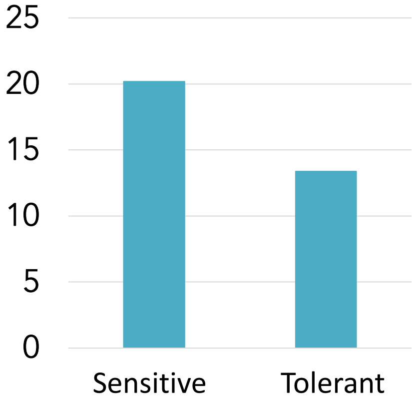
ARVALIS – microplots trials - mechanical weed control (2020, 2021, 2022)

DISEASES : the effect of varietal tolerance and biocontrol

Gain in scutched flax in % of the untreated control



Harmfulness according to the variety



ARVALIS – Microplots trials – Evaluation of fongicides - 2022

Les Culturales 2023 14-15 juin

The toolkit to manage the risk of jaundice in 2023

The technical Institute of sugar beet supports planters with prophylactic advice and treatments, risk forecasting and monitoring, as well as recommendations to volunteer farmers to plant companion plants.

→ Managing viral reservoirs

Before sowing, the technical Institute of sugar beet advises to destroy all beet regrowth (regrowth in the digging cords and in the plots that had sugar beets last year).

→ Predicting risk

The institute offers a forecast of the arrival date of aphids and their abundance to:

- assess the risk/benefit of implementing preventive measures that could have an impact on performance
- Increase vigilance in the fields at the time identified as at risk, and thus best position vegetation treatments*.

→ Assessing daily risk with the Aphid Alert Decision Support Tool

The Decision Support Tool provides real-time information throughout the spring on the presence of green aphids in each geographical area. The interactive map shows the evolution of the jaundice risk around each farm and thus helps to position aphicidal treatments*.

→ Implant companion plants

The efficacy of companion plants as an alternative to neonicotinoids is tested in the PNRI. The first results are promising but the technical itinerary remains to be refined to limit competition with sugar beet. The toolkit provides guidance for volunteer farmers for their implementation.

→ Treating with aphicides

To control the populations of green aphids Myzus persicae, only two active subtances, mixed with oil, are effective: flonicamide, registered product and spirotetramat, produced under exemption for use for 2023. The toolkit specifies the conditions of use of these products and the application tips to maximize their efficiency*.

Consult the toolkit:

ITB
Institut Technique
de la Betterave

*It is imperative to check that the threshold is exceeded in the plots before any intervention.

What are the useful auxiliaries to control sugar beet aphids?

Ladybirds, hoverflies, lacewings and parasitoid Hymenoptera are insects frequently observed on sugar beets in spring. They participate in the regulation of populations of aphids vectors of jaundice. Entomophthorales, fungi that parasitize insects, are also observed on aphids. Other predators can be observed more punctually on sugar beets such as spiders, ground beetles, predatory bugs, cantharides...

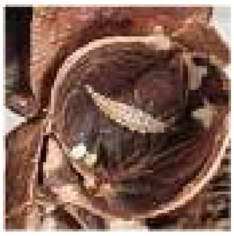
Ladybugs

Regulatory capacity: One larva can consume up to 80 aphids in a day.

Observable stages on sugar beets:
adult, nymph, larvae and eggs

The different stages of development of ladybugs.

Lacuewings and hoverflies



Lacewing larva

Hoverflie larva

Lacewing adult

Regulatory capacity: a larva consumes several hundred aphids in its life
Observable stages on sugar beets:
nymphs, larvae and eggs.
Adults are observable in the environment.

Parasitoid Hymenoptera*

Regulatory capacity: These parasitoids lay eggs in aphids. The larva then develops at the expense of the aphid.

Observable stages on sugar beets: mummies

«Mummy», aphid parasitized by an Aphidius ©Bioline

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*Parasitoid: an organism that grows at the expense of a "host", which it inevitably kills.

PNRI : National Research and Innovation Plan

« Towards operational solutions against jaundice »

4 main axes:

1- Improved understanding of the health situation

2- Identification and demonstration of crop-wide solutions

3- Identification and demonstration of environment-wide regulation solutions for plants, crops and landscapes

4- Transition to a sustainable economic model

The PNRI in figures:

42 Partenaires

3 Années

23 Projets de recherche

4 Axes de recherche

30 Millions d'euros de financement (dont 7 publics)

La responsabilité du ministère ne saurait être engagée

FRANCE RELANCE

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

MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION
Liberté Égalité Fraternité

ITB Institut Technique de la Betterave

Autonomous sowing and weeding of sugar beets with the Farmdroid FD20 robot

With batteries powered by its **solar panels**, the robot has a **working autonomy of 24 hours**.

- Speed: 700 m/h
- Work rate: 4/5 ha/d
- Cost: 100K€

Autonomous sowing

At sowing, the position of each seed is referenced using RTK GPS. The robot sows 6 rows (45 or 50 cm apart). The spacing of the seeds in the row is regular, configurable from the robot console.

Mechanical in-row and inter-row weeding

The position of each seed being recorded during sowing at RTK, the robot can hoe the weeds as close as possible to the crop in the row and inter-row, even before the emergence of the sugar beet. The last hoeing can be carried out at the stage 12-14 leaves of sugar beets.

ITB
Institut Technique de la Betterave

Technical Institute of Sugar beet
45 rue de Naples - 75008 Paris
www.itbfr.org - @ITBetterave
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Companion plants to reduce the symptoms of jaundice on sugar beet

Technical itinerary:

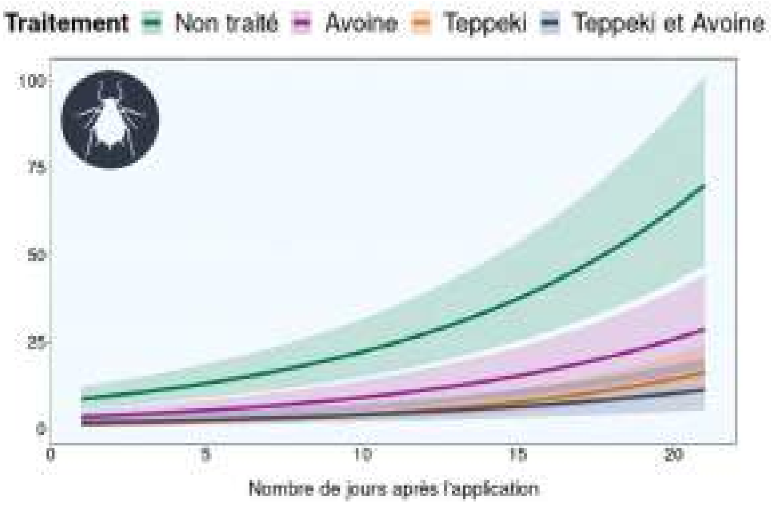
- preferred species: oats / barley

- **sowing at the same time** as sugar beet at a density of 75 grains/m²,

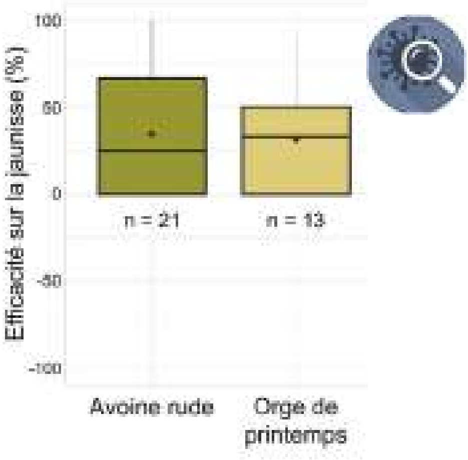
- Chemical destruction **at stage 4-6 leaves of sugar beets.**

Indicative stage of destruction companion plants

Results:



Prediction of the number of green flightless aphids per 10 beets after treatment



Efficiency on jaundice
n: Number of trials

4 leaves: stage of the beet beyond which the companion plant exerts competition which penalizes the yield

Conclusions:

- A technical itinerary to validate
- Efficaciency lower than that of the aphicide Teppeki® based on flonicamide
- An interest to validate, in combination with aphicidal protection in situations of high risk.

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Smart sugar beet technology

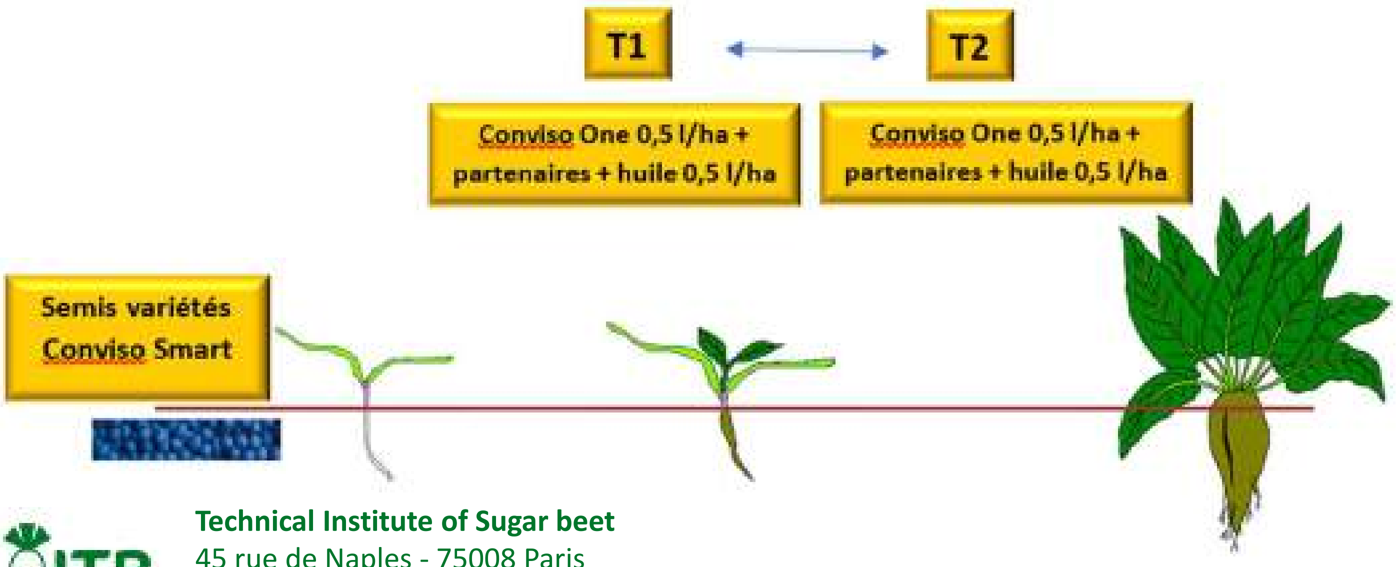
Main recommendations for weeding Smart varieties:

- Carry out **2 weed control** with the herbicide Conviso One based on foramsulfuron and thiencarbazone-methyl at a dose of 0.5 l/ha.Add **0,5 l/ha of oil.**
- Wait for the 2-leaf stage of the first goosefoot. A minimum interval of 10 to 14 days is recommended between the 2 passages.
- **Necessarily add one or two herbicids** with different modes of action (phenmedipham, ethofumesate, metamitron, clomazone, lenacile ,...).
- **Respect the conditions of application:** Early morning, absence of wind and good humidity (greater than 60%).
- Clean all parts of the sprayer after the procedure.
- Avoid this technology if HRAC*2 resistant grasses are present.
- Do a specific treatment based on clopyralid against thistles.

Then, the seed production of the year must be destroyed as soon as possible and taken out of the plot.

*HRAC : Herbicide Resistance Action Committee

Schematic representation of the different operations of Smart technology



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Mechanical weeding strategies in sugar beets

Possible reduction of the Treatment Frequency Index by **up to 60%** with:

Hoe with reels

4 to 12 km/h

Roto-strille

4 to 7 km/h

Cable harrow

4 to 7 km/h

Rotary hoe

15 to 20 km/h

Effeciency and possibility of intervention with these equipments:

Sugar beet stage		Pre ermergence	Emergence / crosse stage	Cotyledons	2 leaves	4 to 12 leaves
Rotary hoe	**Plant loss**	Medium loss	Not recommended	High loss	High loss	Low loss
	Efficiency on weed control	Moderate		Moderate	Moderate	Moderate
Cable harrow	**Plant loss**	Medium loss	Not recommended	High to medium loss	Medium loss	Very low loss
	Efficiency on weed control	Moderate		Good	Good	Good
Roto-strille	**Plant loss**	High loss	Not recommended	High loss	High loss	Low loss
	Efficiency on weed control	Moderate		Good	Good	Good
Hoe	**Plant loss**	Not recommended	Not recommended	Not recommended	Medium loss	Very low loss
	Efficiency on weed control				Very good	Very good
Kress Fingers	**Plant loss**				High loss	Medium to low loss
	Efficiency on weed control				Good	Moderate

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Space 3 :

CLIMATE CHANGE

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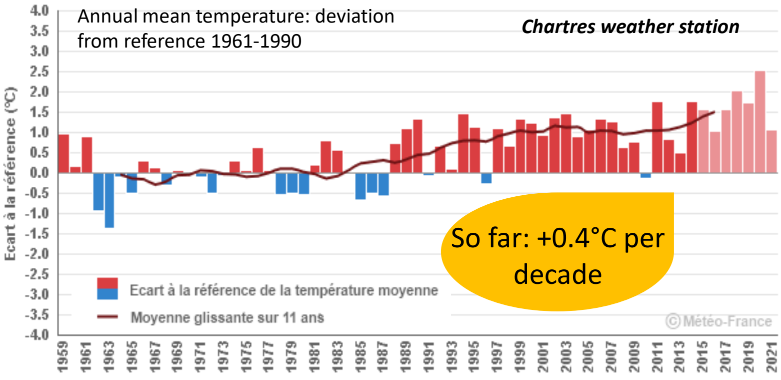
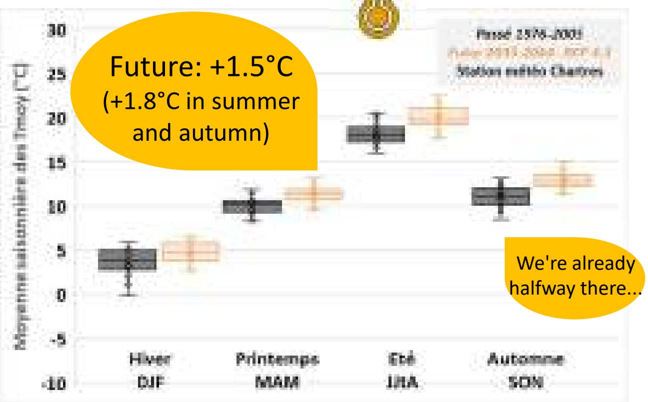
It's and will be warmer

An increase in average temperatures



So far: +0.4°C per decade

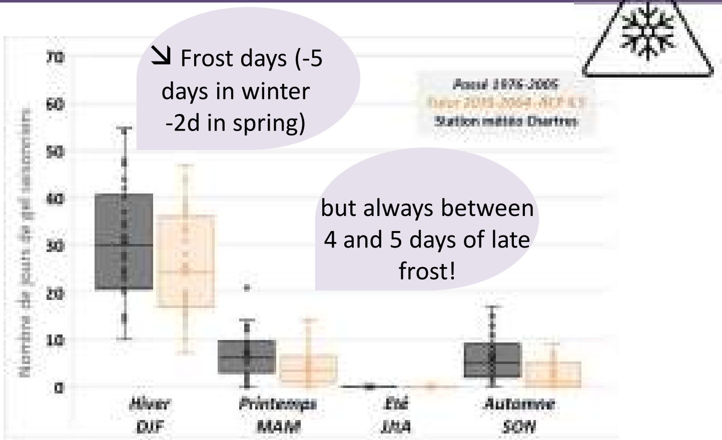


Future: +1.5°C (+1.8°C in summer and autumn)

We're already halfway there...

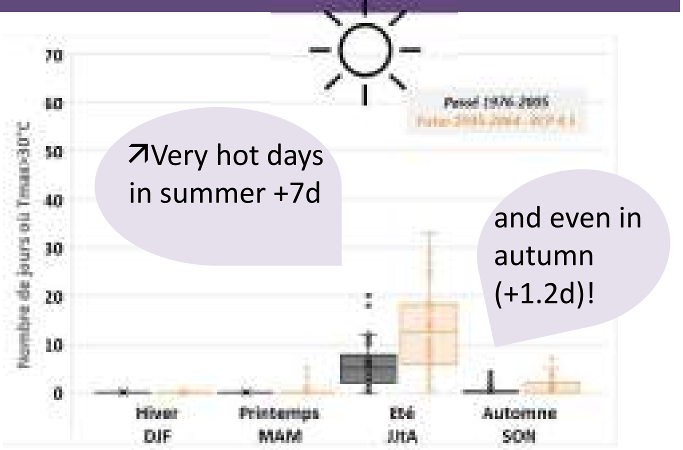
Source: Drias, Météo-France data, CERFACS, IPSL, 2020.
Model ALADIN63_CNRM-CM5

Beware of extremes!



↘ Frost days (-5 days in winter -2d in spring)

but always between 4 and 5 days of late frost!



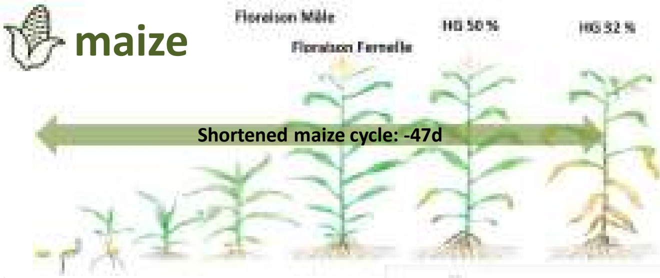
↗Very hot days in summer +7d

and even in autumn (+1.2d)!

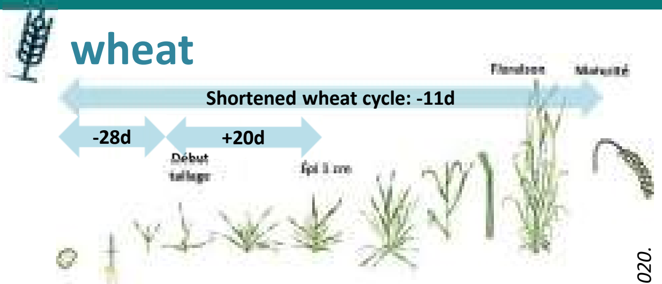
Source: Drias, Météo-France data, CERFACS, IPSL, 2020.
Model ALADIN63_CNRM-CM5

Risks and opportunities for crops

maize

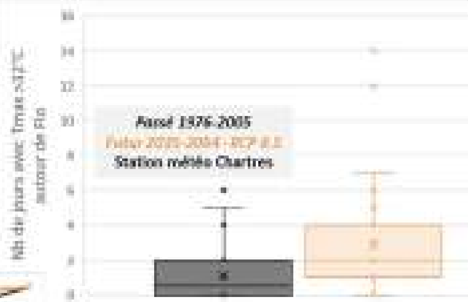


wheat

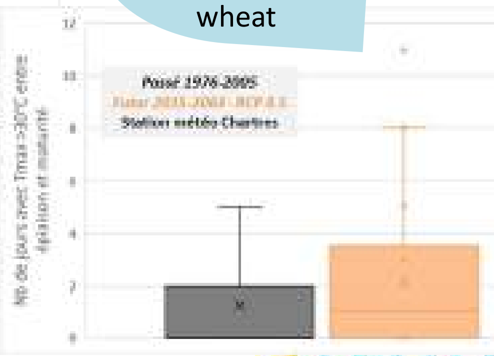


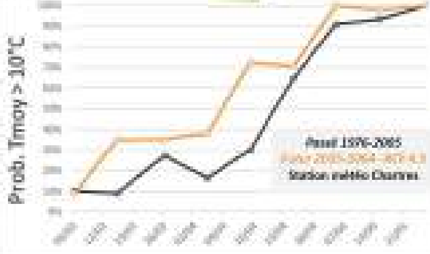
Harvest early Nov. =>end of September!
Or grains + dry
Or 1 range of precocity!

More opportunities for early sowing of maize



↗ **risk of thermal scalding** for wheat





↗ **risk of heat stress** around the flowering of maize

Source: Drias, Météo-France data, CERFACS, IPSL, 2020.
Model ALADIN63_CNRM-CM5

Hypothesis: maize G3 Sowing April 20; wheat Apache Sowing 25 October

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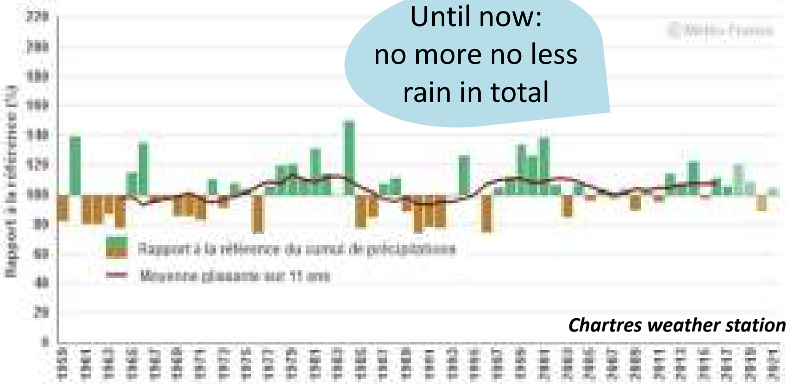
Less water and/or more water stress?

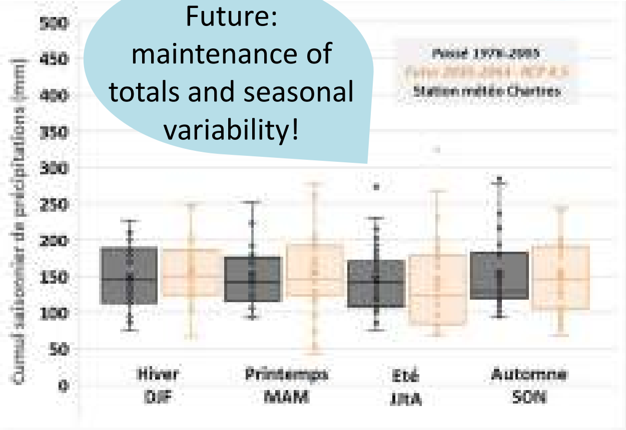
Evolution of rainfall totals over the year: no clear trend

Annual total rainfall: reference ratio (%) 1961-1990



Until now: no more no less rain in total

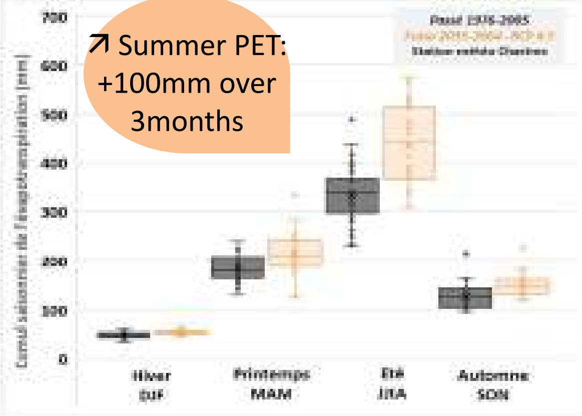
Chartres weather station



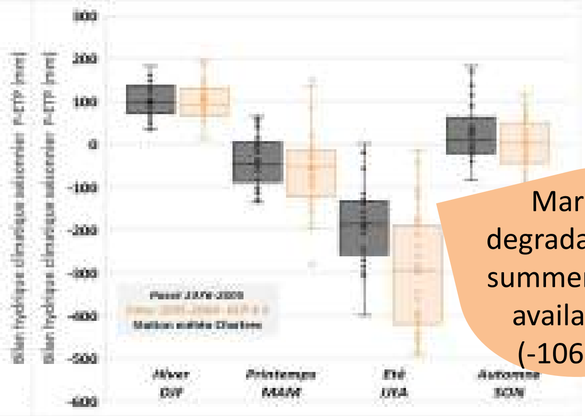
Future: maintenance of totals and seasonal variability!

Source: Drias, Météo-France data, CERFACS, IPSL, 2020. Model ALADIN63_CNRM-CM5

Evaporative demand is exploding!



↗ Summer PET: +100mm over 3months

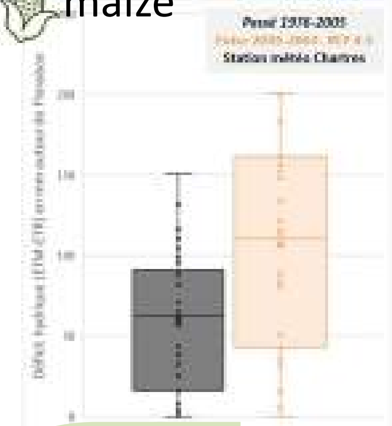


Marked degradation of summer water availability (-106mm)

Source: Drias, Météo-France data, CERFACS, IPSL, 2020. Model ALADIN63_CNRM-CM5

Risks and opportunities for crops

maize

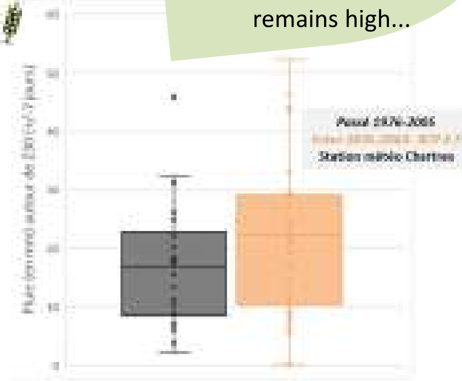


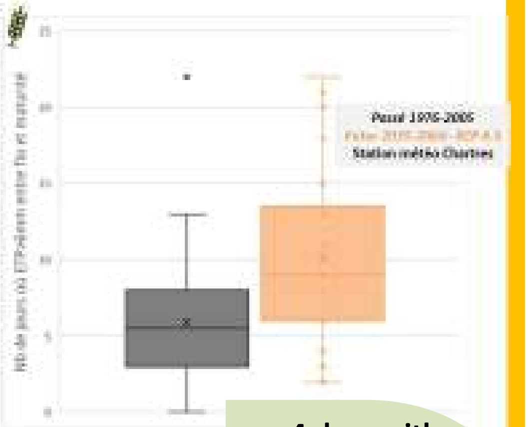
↗ Risk of water stress around sensitive stages

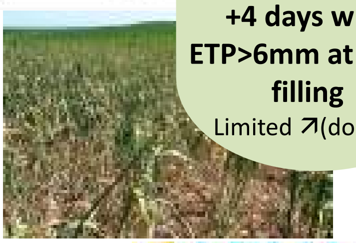
(15 leaves until grain abortion limit stage)

wheat

Less difficulty around ear at 1cm ?
The variability of rainfall remains high...







+4 days with ETP>6mm at grain filling

Limited ↗(dodge)

Hypothèses: maïs G3 semis 20 avril; blé Apache semis 25 octobre
Source: Drias, Météo-France data, CERFACS, IPSL, 2020. Model ALADIN63_CNRM-CM5

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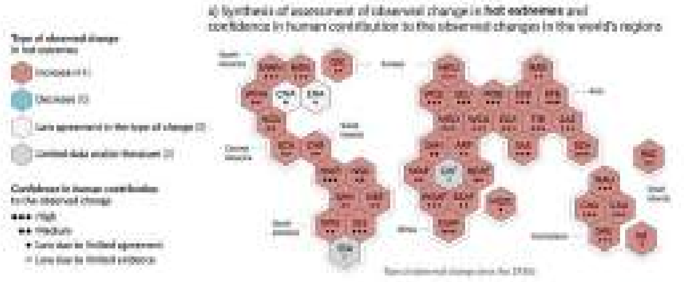
Ever more extreme climate events?

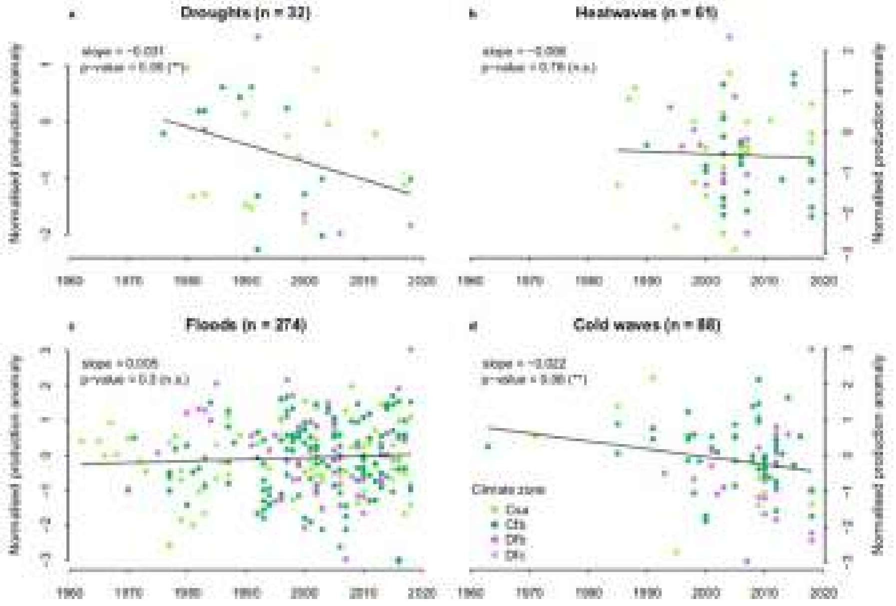
Les Culturales 2023 14-15 juin

True observation : change in the frequency and intensity of extreme events



Europe: Cereal production anomalies during years of reported extreme weather disasters

Source: AR6 WGI SPM, Figure SPM.3



- ✓ The severity of droughts and heat waves has tripled over the last 50 years in Europe
- ✓ Droughts and heatwaves are particularly bad for cereal production
- ✓ Higher average cereal yield losses in Eastern Europe

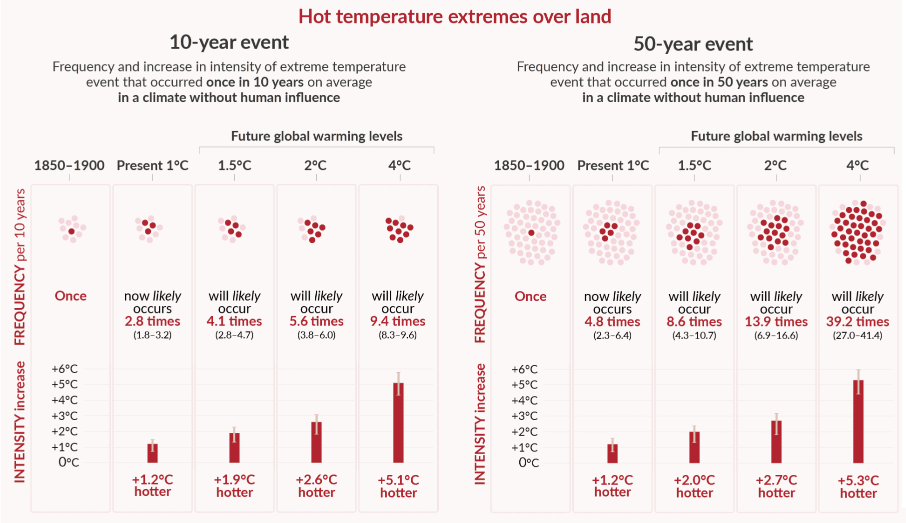
Koeppen–Geiger climate zone
Cfb: temperate oceanic
Csa: Mediterranean
Dfb: warm-summer humid continental
Dfc: subarctic

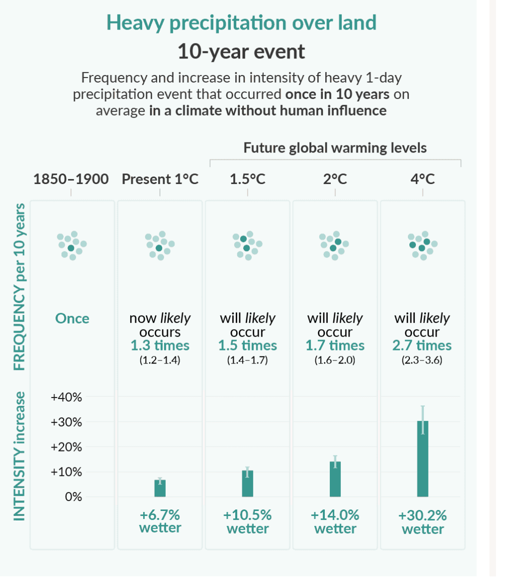
Brás, T. A., Seixas, J., Carvalhais, N., Jägermeyr, J. (2021): Severity of drought and heatwave crop losses tripled over the last five decades in Europe. - Environmental Research Letters, 16, 6, 065012.
https://doi.org/10.1088/1748-9326/abf004

"Increasing warming increases the probability of severe, widespread and irreversible climate incidents"

IPCC 2021

Projected changes in more frequent extreme events and more intense with each additional increase in warming (Source: AR6 WGI SPM, Figure SPM.6)

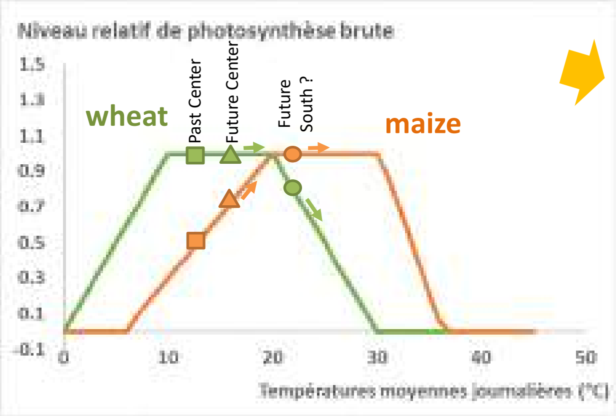




ARVALIS

Impacts of climate change on photosynthesis

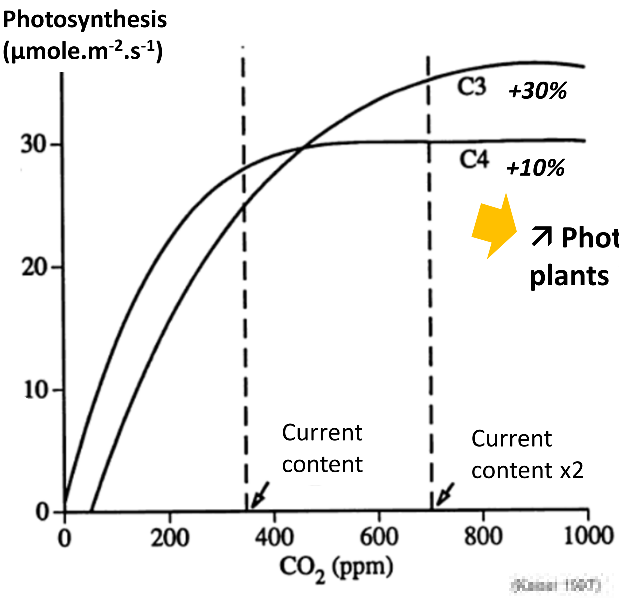
↗ T°C: contrasting effects depending on the type of plant



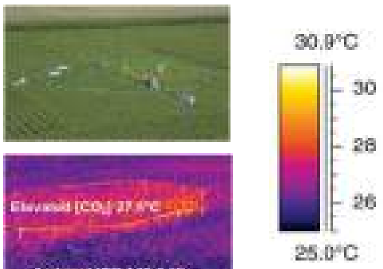
C4 plants (maize): Towards a better photosynthetic yield?

C3 plants (wheat): A photosynthetic yield that stagnates or even decreases in the hottest areas?

↗ [CO_2]: positive and negative impacts on photosynthesis!



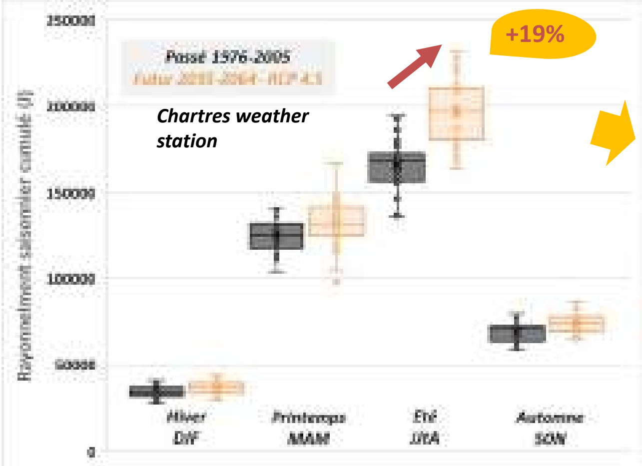
↗ Photosynthesis of plants in C3 (wheat)?



Long et al (2006) *Science*

↘ Transpiration => ↗ T°C & risk of heating, decreased photosynthesis efficiency at certain T°.
Amplified by water stress!

↗ Radiation? = Increase in climate supply?



Increased radiation especially in summer and, to a lesser extent, the rest of the year
Warning: variable very poorly identified in climate projection models!

Source: Drias, Météo-France data, CERFACS, IPSL, 2020.
Model ALADIN63_CNRM-CM5

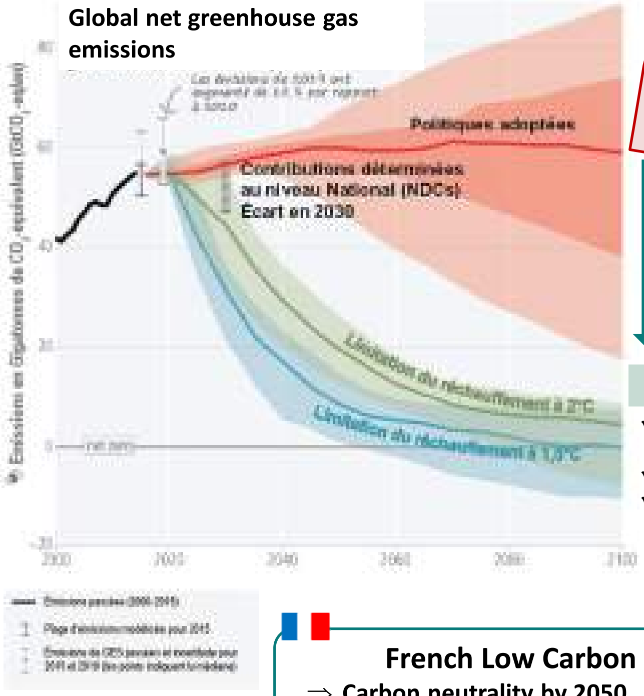
- **⇨T°C x CO2 x water interactions on photosynthesis**
- **⇨Poorly understood radiation trends**
- **⇨Adaptation of plants: what is the result?**

Actions to address climate issues?

Les Culturales 2023 14-15 juin

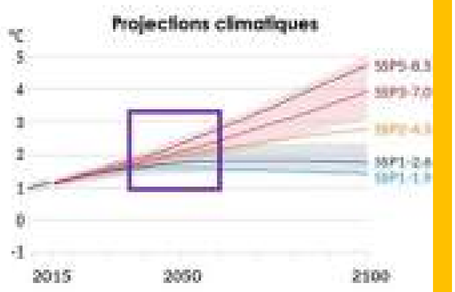
International agreements: commitments and actions

Global net greenhouse gas emissions



Warming of 3.2°C (variation from 2.2 to 3.5°C) = we continue to accumulate greenhouse gases!

To limit warming to 2°C requires more effort!



Objectives of the Paris Agreements (COP21 in 2015)

- ✓ ***Keep the increase in average temperature well below 2 °C and preferably limit to 1.5 °C***
- ✓ ***Reaching net zero in the 2nd half of the twenty-first century***
- ✓ ***Building capacity to adapt to the adverse effects of climate change***

French Low Carbon Strategy

⇒ **Carbon neutrality by 2050**

⇒ **Reduce the carbon footprint of the French**

=

- 4.7% per year over the period 2022-2030!

(against -1.7% of emissions observed since 2010...)

What trajectory for French agriculture?

In France agriculture contributes to the emission of 20% of greenhouse gases:

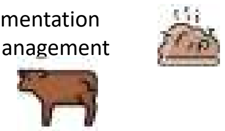
N_2O 1st GHG in agriculture (50%)

Origin:
Direct and indirect emissions from agricultural soils
Animal production
Waste management

1g N_2O= 298g CO_2

CH_4 2nd GHG in agriculture (40%)

Origin:
Enteric fermentation
Effluent Management



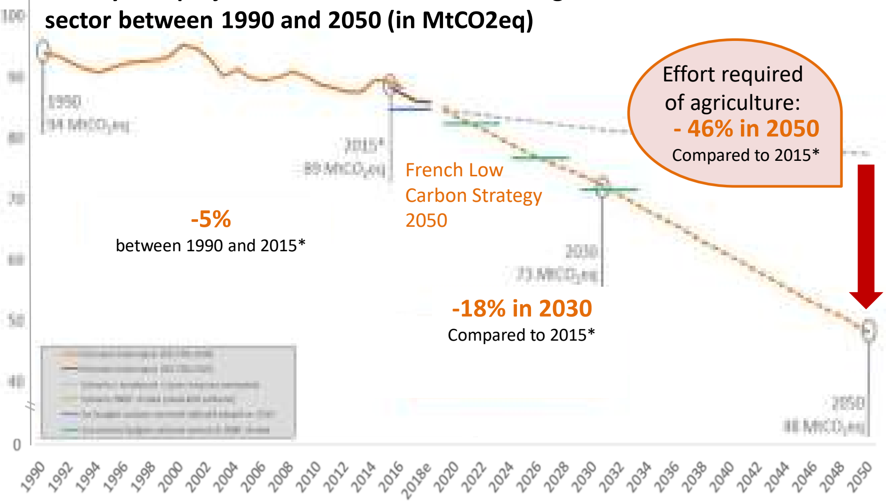
1g CH_4 = 28g CO_2

CO_2 3ᵉ GHGs from agriculture (10%)

Origin:
Combustion of fossil fuels
Imported deforestation

Agricultural emissions:
- mostly of origin non-energy
- controlled by biological processes

History and projection of emissions from the agricultural sector between 1990 and 2050 (in MtCO2eq)



-5% between 1990 and 2015*

French Low Carbon Strategy 2050

-18% in 2030 Compared to 2015*

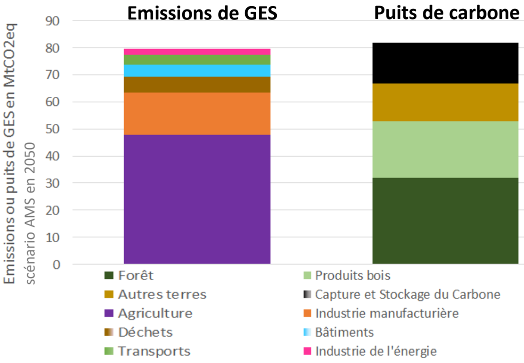
Effort required of agriculture: **- 46% in 2050** Compared to 2015*

Les émissions utilisées pour l'année 2015 sont celles de l'inventaire CITEPA SECTEN 2018

NB 2050 emission reduction targets compared to 2015 for other sectors:

Industry: -81% Transport: -97% Buildings: -95%

Carbon neutrality 2050: the amount of GHG emitted is equal to the amount absorbed by carbon sinks



Emitting agriculture AND carbon storage!

ARVALIS

E3_01_5

Rapeseed and climate change: possible challenges to take up

Temperature increase

Less water at sowing

Increase in hazards and extreme weather events

CO_2 increase

Main impacts on rapeseed

Milder temperatures during autumn at the origin of continued growth

Spring Radiation Performance Interaction

Reduced risk of freezing

High compensation capabilities

Good rooting ability to capture water at depth

Terres Inovia : N. Harel

Implantation difficulty due to drought: absent, irregular or late emergence

Rising temperatures favoring pests (especially in autumn)

Difficulty filling grains due to heat stress (early senescence)

Root anoxia favored by very rainy periods

Adapting to ensure "robust" rapeseed

Take care of planting to promote early emergence, vigorous seedlings, deep rooting

Combining rapeseed with a frost-sensitive legume

Consider irrigation at sowing to ensure successful emergence

Improving genetics for better resistance to spring water stress

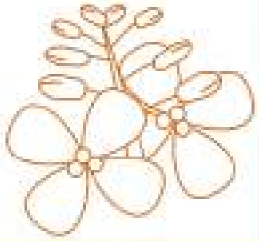
Robustness × **Avoidance**

Use an August rainfall forecasting tool to drive sowing

Choose a variety with early vegetation recovery

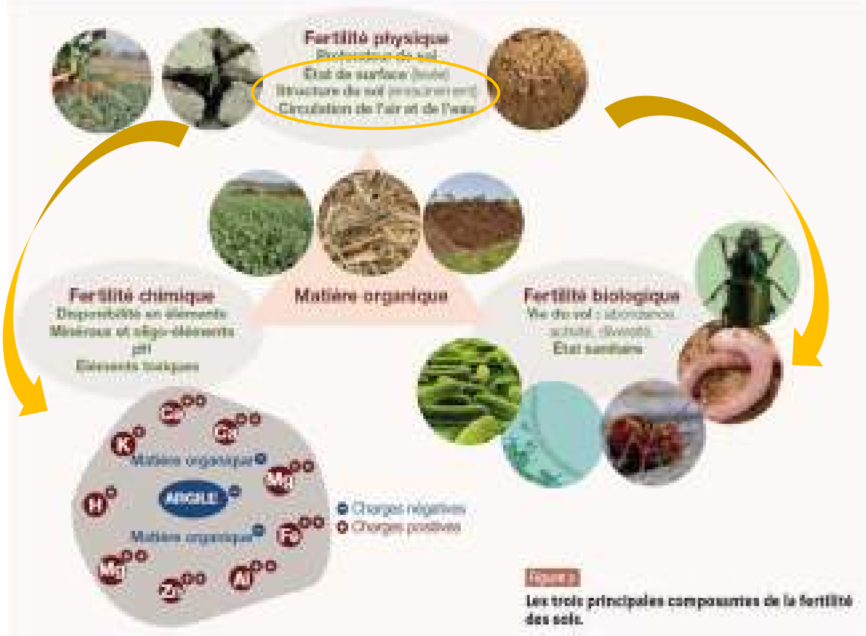
Adaptability × **Impacts**

Vulnerability

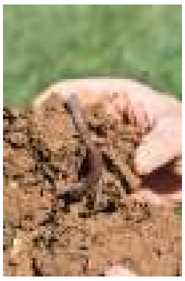


Tillage: observing and acting at the scale of rotation

Soil structure: one of the components of soil fertility



Les trois principales composantes de la fertilité des sols.

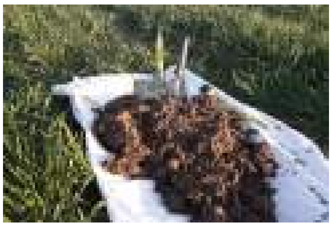


Objectives of observation: diagnose, evaluate, decide

1- Take a block

2- Observe the general state of the block

3- Observe the internal state of the clods



General state Open (O)

General state Block (B)

General state Continuous (C)

Internal state of the clods Porous (Γ)

Internal state of the clods Porous (Γ)

Internal state of the clods Compacted (Δ)

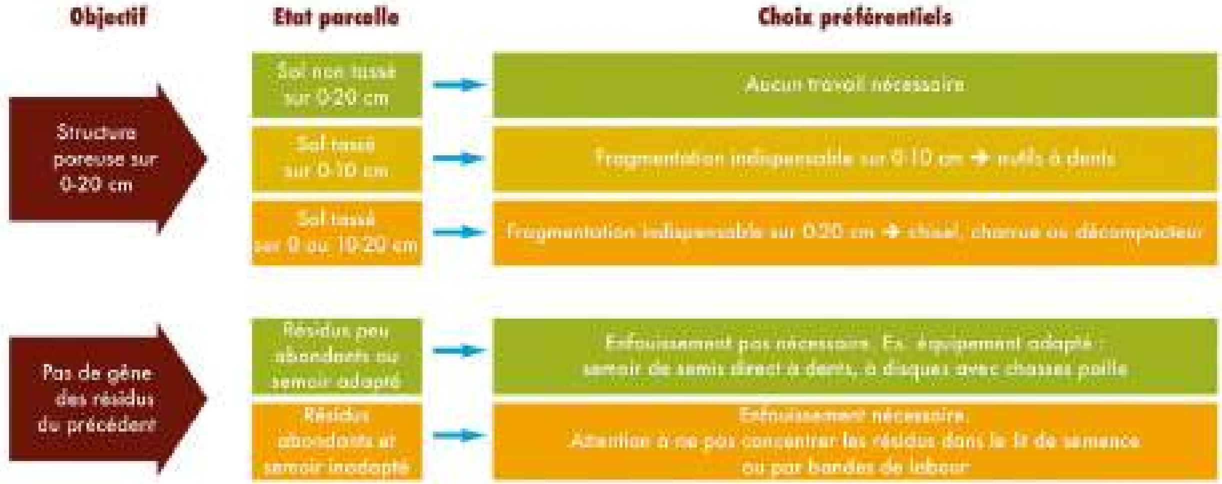
Internal state of the clods Cracked (φ)

Do not forget to look at the activity of earthworms

Tillage: from observation to decision-making

Adapt tillage to observations and objectives:

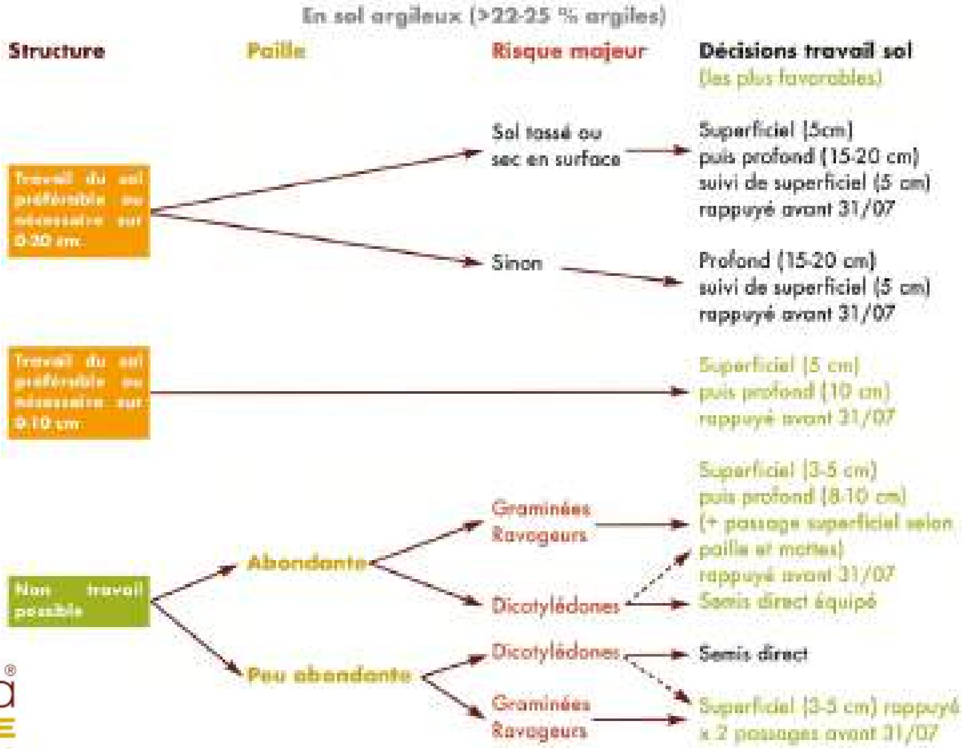
		Etat interne des mottes		
		Poreux (Gamma Γ)	Fissuré (Phy Φ, lamellaire P)	Tassé (Delta Δ)
Etat général du bloc prélevé	Ouvert (terre fine)	Non travail possible	Non travail possible	Peu probable
	Bloc (mottes décimétrique)	Non travail possible	Sur 10-20 cm uniquement Non travail possible	Sur 0-10 cm uniquement Travail du sol préférable sur 0-10 cm
			Sur 0-10 cm Travail du sol préférable sur 0-10 cm	Sur 0-20 cm ou 10-20 cm Travail du sol préférable sur 0-20 cm
	Continu (monobloc)	Situations rares de sol non travaillé depuis de nombreuses années fortement rappuyés mais non tassés	Sur 0-10 cm uniquement Travail du sol préférable sur 0-10 cm Sur 0-20 cm ou 10-20 cm Travail du sol préférable sur 0-20 cm	Sur 0-10 cm uniquement Travail du sol nécessaire sur 0-10 cm Sur 0-20 cm ou 10-20 cm Travail du sol nécessaire sur 0-20 cm



Objectif | **Etat parcelle** | **Choix préférentiels**

Structure poreuse sur 0-20 cm
- Sol non tassé sur 0-20 cm → Aucun travail nécessaire
- Sol tassé sur 0-10 cm → Fragmentation indispensable sur 0-10 cm → outils à dents
- Sol tassé sur 0 ou 10-20 cm → Fragmentation indispensable sur 0-20 cm → chisel, charrue ou décompacteur

Pas de gêne des résidus du précédent
- Résidus peu abondants ou semoir adapté → Enfouissement pas nécessaire. Ex. équipement adapté : semoir de semis direct à dents, à disques avec chasses paille
- Résidus abondants et semoir inadapté → Enfouissement nécessaire. Attention à ne pas concentrer les résidus dans le lit de semence ou par bandes de labour



En sol argileux (>22-25 % argiles)

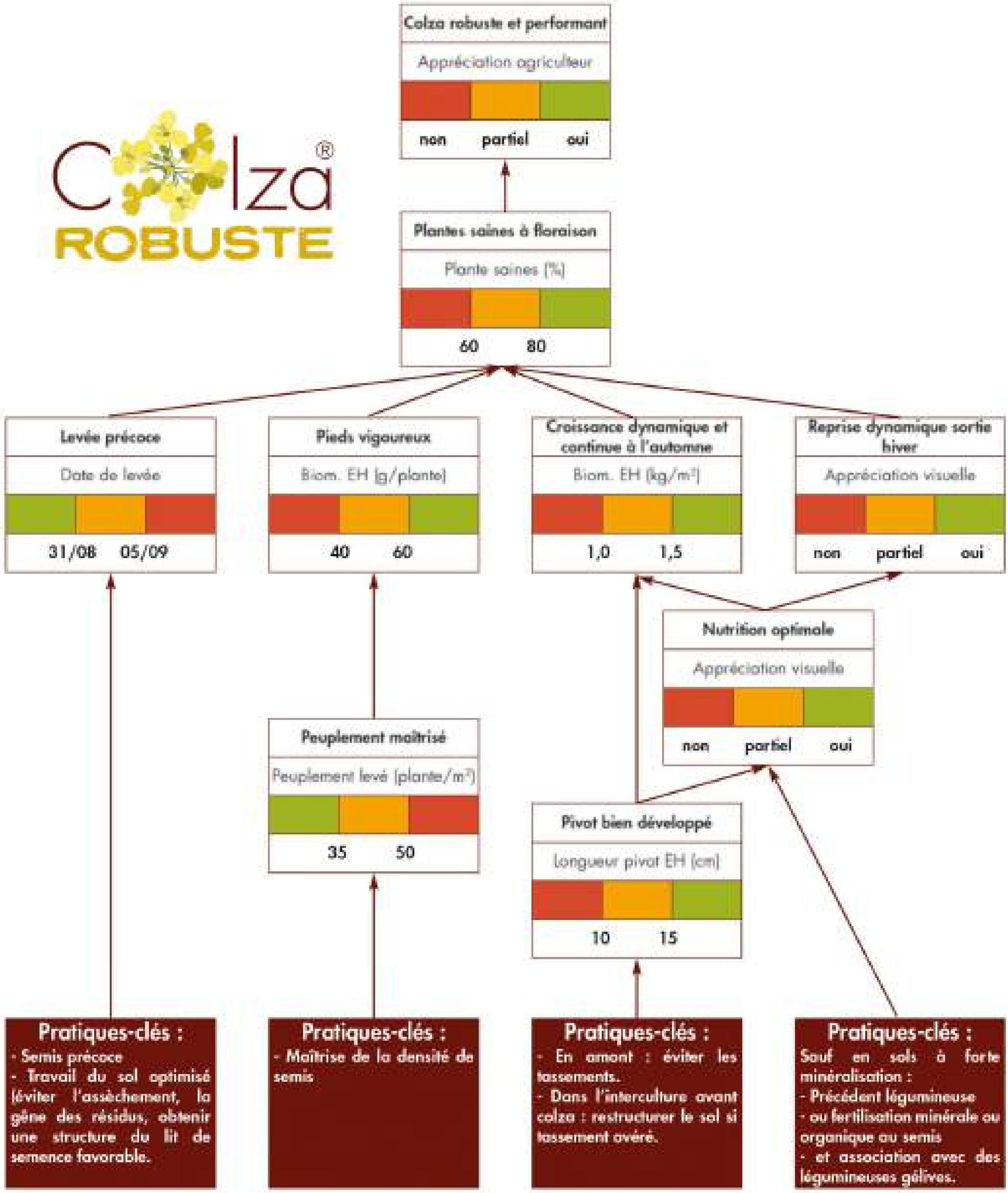
Structure | **Paille** | **Risque majeur** | **Décisions travail sol** (les plus favorables)

- Travail du sol préférable ou nécessaire sur 0-20 cm
  - → Sol tassé ou sec en surface → Superficiel (5cm) puis profond (15-20 cm) suivi de superficiel (5 cm) rappuyé avant 31/07
  - → Sinon → Profond (15-20 cm) suivi de superficiel (5 cm) rappuyé avant 31/07
- Travail du sol préférable ou nécessaire sur 0-10 cm → Superficiel (5 cm) puis profond (10 cm) rappuyé avant 31/07
- Non travail possible
  - → Abondante
    - → Graminées Ravageurs → Superficiel (3-5 cm) puis profond (8-10 cm) (+ passage superficiel selon paille et mottes) rappuyé avant 31/07
    - → Dicotylédones → Semis direct équipé
  - → Peu abondante
    - → Dicotylédones → Semis direct
    - → Graminées Ravageurs → Superficiel (3-5 cm) rappuyé x 2 passages avant 31/07

Terres Inovia l'agronomie en mouvement

Colza ROBUSTE®

General dashboard "robust rapeseed"



Colza ROBUSTE®

Colza robuste et performant
Appréciation agriculteur
🟥 🟧 🟩
non | partiel | oui

Plantes saines à floraison
Plante saines (%)
🟥 🟧 🟩
60 | 80

Levée précoce
Date de levée
🟩 🟧 🟥
31/08 | 05/09

Pieds vigoureux
Biom. EH (g/plante)
🟥 🟧 🟩
40 | 60

Croissance dynamique et continue à l'automne
Biom. EH (kg/m²)
🟥 🟧 🟩
1,0 | 1,5

Reprise dynamique sortie hiver
Appréciation visuelle
🟥 🟧 🟩
non | partiel | oui

Nutrition optimale
Appréciation visuelle
🟥 🟧 🟩
non | partiel | oui

Peuplement maîtrisé
Peuplement levé (plante/m²)
🟩 🟧 🟥
35 | 50

Pivot bien développé
Longueur pivot EH (cm)
🟥 🟧 🟩
10 | 15

Pratiques-clés :
- Semis précoce
- Travail du sol optimisé (éviter l'assèchement, la gêne des résidus, obtenir une structure du lit de semence favorable.

Pratiques-clés :
- Maîtrise de la densité de semis

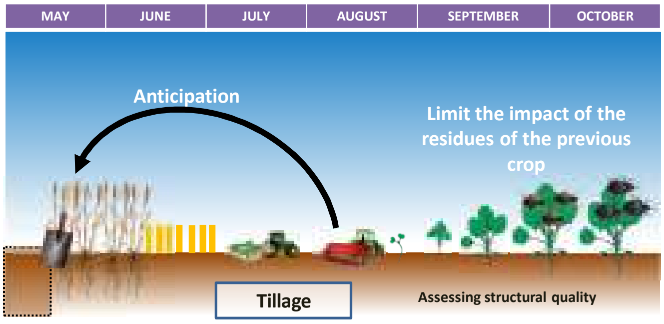
Pratiques-clés :
- En amont : éviter les tassements.
- Dans l'interculture avant colza : restructurer le sol si tassement avéré.

Pratiques-clés :
Sauf en sols à forte minéralisation :
- Précédent légumineuse
- ou fertilisation minérale ou organique au semis
- et association avec des légumineuses gélives.

The combination of levers for robust rapeseed

Les Culturales 2023 14-15 juin

The landmarks of a robust rapeseed: Anticipate and adapt



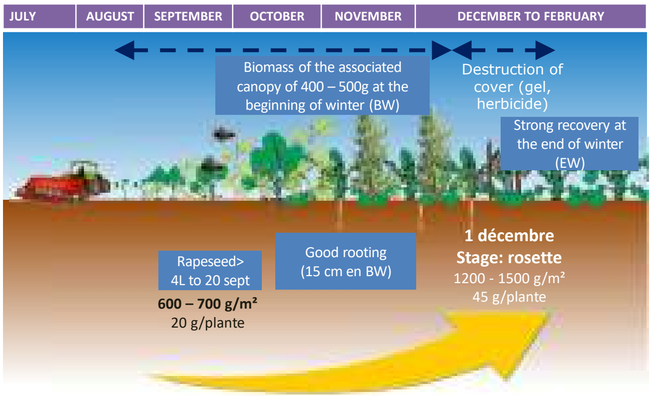
Tillage

Straw management

Assessing structural quality

Anticipating interculture work, as close as possible to the harvest of the previous crop, to rebuild the structure and preserve soil moisture.

2 mm of water to re-moisten 1 cm of dry soil!



Biomass of the associated canopy of 400 – 500g at the beginning of winter (BW)

Destruction of cover (gel, herbicide)

Strong recovery at the end of winter (EW)

Rapeseed> 4L to 20 sept

600 – 700 g/m²
20 g/plante

Good rooting (15 cm en BW)

1 décembre
Stage: rosette
1200 - 1500 g/m²
45 g/plante

Continued growth of rapeseed

Preserved soil moisture

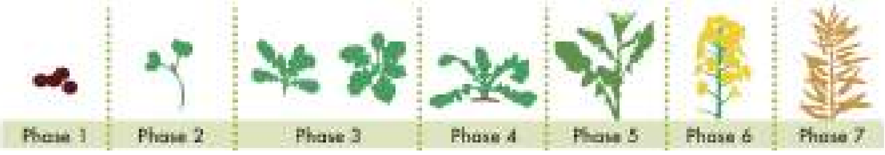
Dynamic and continuous growth

Early emergence

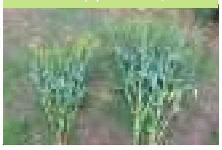
Vigorous seedlings

Dynamic recovery

Emergence 27/08



Healthy plants 15/04



Emergence date		
05/09>		>31/08

Biom./plte BW (g/plte)		
<40		<60

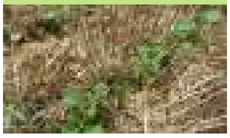
Biom. colza BW (kg/m²)		
<1		<1,5

Pivot length BW (cm)		
10<		<15

Hungry blush		
10/10<		none

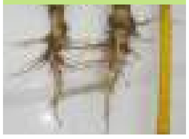
Good nitrogen status 10/12

3 leaves 11/09



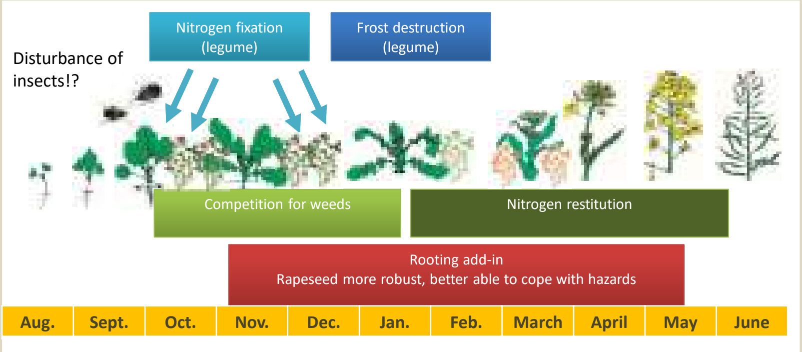
Active growth 01/10

Pivot > 15 cm 06/11



Rapeseed + companion plant: an additional lever

1. Contributing to soil fertility
2. Limiting the negative effects of hydromorphy and beating
3. Help limit insect damage
4. Improving nitrogen nutrition of rapeseed
5. Increase crop competition from weeds



Disturbance of insects!?

Nitrogen fixation (legume)

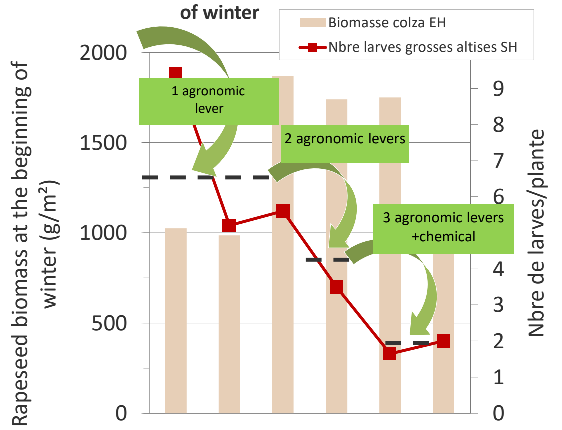
Frost destruction (legume)

Competition for weeds

Nitrogen restitution

Rooting add-in
Rapeseed more robust, better able to cope with hazards

Biomass rapeseed at the beginning of winter and Number of larvae of large flea beetles at the end of winter



N+P at sowing			oui	oui	oui	
Faba bean companion		oui		oui	oui	
Insecticide					oui	oui

E3_02_7

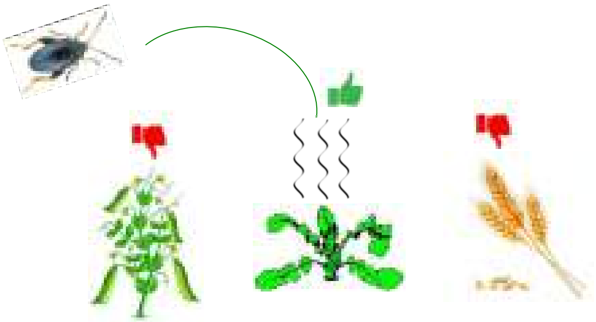
Les Culturales 2023 14-15 juin

Changing the behaviour of winter flea beetles, a promising way to reduce rapeseed damage

Effective **agronomic levers** to reduce winter flea beetle damage (early sowing, associations with frost-sensitive legumes, etc.) are challenged: the dry conditions at the end of summer penalize the establishment of rapeseed, a key step in limiting the harmfulness of autumn insects. Terres Inovia and research and development actors are **researching and experimenting new management levers, from field scale to landsca**

Objective: divert the flea beetles from rapeseed to protect it

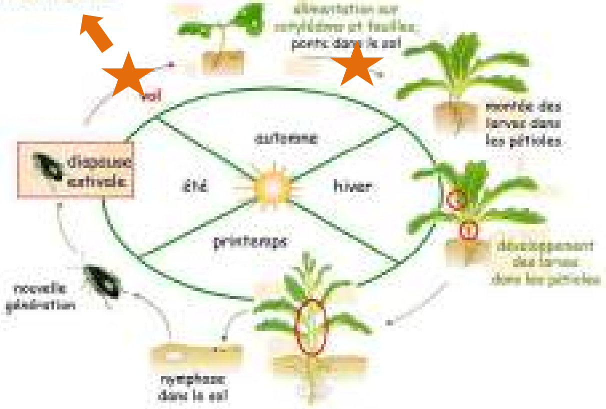
Flea beetles locate their host plants thanks to the odors they emit (Volatile Organic Compounds - VOC).



Identification of VOCs involved in the Ctrl–Alt.

Attraction (and trapping) / long-distance repulsion during flights

Attraction (and trapping) / short-distance repulsion in plots



Strategies currently tested (ADAPTACOL² project)

Territorial scale

Long-distance attraction/trapping during flights

Plant attractive crucifers in intercrop plots + destruction before winter.

Objective-> reduction of flea beetle populations in rapeseed years N and N+1

Since 2022, R2D2, a pilot territory.

Concerted action between farmers on the scale of a territory of 1300 ha

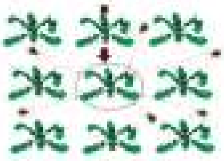
In 2023, testing of rapeseed/intercrop pairs (Chinese radishes) on about thirty partner sites

Plot scale

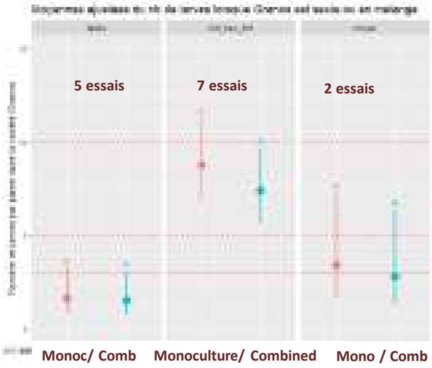
Short-distance attraction in the plot

Combining rapeseed plants to be protected with more attractive plants

Obj-> reduction in the number of larvae in rapeseed



In 2022 and 2023, testing of varietal mixtures with a variety called "insect trap".



No significant differences.
Attractive effect of the so-called "insect trap" variety not demonstrated.

Tomorrow's strategies

- **Combining service plants and VOCs at the plot and territory scales (Ctrl-Alt project)**
- **Combine these strategies in addition to all the levers of integrated protection.**

ADAPTACOL² : AXEREAL Actura

Ctrl-Alt : igepp INRAE INRAE Agronomie Terres Inovia agriodor

Financeurs : Plan d'action sortie du phosmet

Terres Inovia
l'agronomie en mouvement

Les Culturales 2023 14-15 juin

myvar

A new tool to choose your varieties (in French)

Find the right varieties for your production context

1. Choose the crop and your department


Consulter
Choisir

Je choisis une variété en fonction de mes besoins

Colza d'hiver
91 - Essonne
Choisir

2. Refine according to your situation and needs

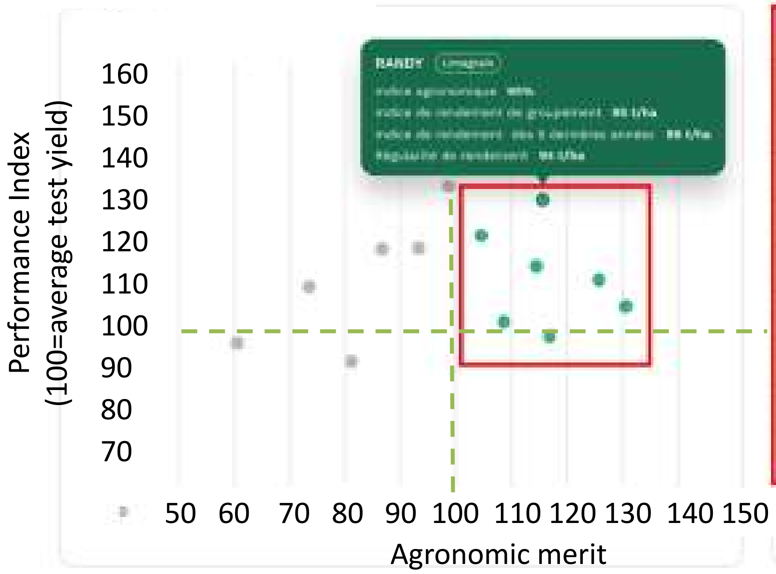

Modifiez vos informations

Nos ingénieurs ont sélectionné pour vous les risques les plus fréquents de votre département. Vous pouvez les modifier si nécessaire pour vous rapprocher davantage de la situation de vos parcelles.

Recherche de vigueur au départ ○ Nulle ○ Faible ● Moyenne ○ Forte
Risque Phoma ○ Non concerné ○ Faible ● Moyen ○ Fort
Risque Elongation ○ Non concerné ○ Faible ● Moyen ○ Fort
Risque Cylindrosporiose ○ Non concerné ● Faible ○ Moyen ○ Fort
Risque Verse ○ Non concerné ● Faible ○ Moyen ○ Fort
Risque TuYV (virus transmis par les pucerons verts) ○ Non ● Oui

← Retour
Valider

3. Visualize the varieties most adapted to the selected criteria



(score calculated according to the chosen criteria, 100 = average of the varieties)


Classement de nos meilleures variétés

1. ABSOLUT
2. ADELMO KWS
3. ALLESANDRO KWS
4. ANDROMEDA
5. ASPECT
6. KWS ARIANDS
7. RANDY
8. RGT JAKUZZI
9. SCOTCH
10. TREZZOR

4. Filter by other criteria

5. Choose / compare your varieties


Comparateur de variété - Colza d'hiver

Financé par :

CAP PROTÉINES

Terres Univia

Visit www.myvar.fr

Les Culturales 2023 14-15 juin

Climate change and rising pest pressure: a new deal for rapeseed

- ☒ **Climate change…** Summer drought, climatic shocks
- ☒ **Rising pressure from flea beetle pests and weevils** favored by mild autumns and winters
- ☒ **Limited range of effective insecticides, resistance**
- ☑ Increased T°C boosts growth and accelerates the rapeseed development

Plan d'action sortie du phosmet

The fight is based on the combination of agronomic levers to limit the use of available effective insecticides

A problem = a solution = a treatment threshold according to pest presence and rapeseed stage

YESTERDAY

TODAY TOMORROW

One or more problems = multifactorial risk analysis: crop (stage, growth dynamics) x pests. Decision support tool

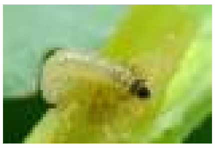
To support farmers, simple and free Decision Support Tools integrate Terres Inovia's expertise and decision rules

COLZA RISQUES altise adulte

*When to use it? In **September***
To estimate the risk associated with foliar damage by flea beetle adults

COLZA RISQUES charançon du bourgeon terminal

*When? In **October***
Completes information from a network of traps
Takes into account an agronomic risk, catches in basins and historical pressure of the plot



COLZA RISQUES larve de grosse altise

*When? From **November***
Takes into account agronomic risk and level of larval infestation (Berlese test required)

Agronomic risk assessment:
Rapeseed biomass in autumn
Dynamic autumn growth
Winter conditions and date of vegetation recovery in spring

\+

Insect risk:
- winter flea beetles pressure
- Rape winter stem weevil historical risk

=

Estimating a risk of damage by insect larvae at field scale

The overall risk estimate is associated with a recommendation: Intervention recommended or not, type of insecticide to be preferred depending on the context of insecticide resistance

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l'agronomie en mouvement

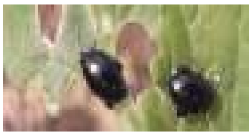
Taking into account resistance to pyrethroids

Adult winter flea beetle: control only if crop survival is compromised before 4 leaves

🟥 **High level of resistance (generalized SKDR)**
Pyrethroids totally ineffective
No alternative. Management involves sowing and early emergence

🟧 **First SKDR mutation case detected**
Pyrethroids still effective BUT high risk of resistance increase

▨ **No SKDR mutation but low resistance (KDR mutation)**
Flea beetles still sensitive to pyrethroids



In the absence of Skdr:
-Zeon Karate pyrethroids, Decis Protech and cypermethrin are of a similar effectiveness (50-60%), at T+7d
-Trebon 30EC (etofenprox) comparable to T+4 days but less than T+7 days.
-Mandarin Gold (esfenvalerate) is less effective

And the "Biocontrol" ?

Tests for nettle manure*, paraffin oil*, azadirachtin* or boron* without significant efficacy
(*) not authorized for this use
New solutions are being evaluated

Weevil control targets adults before laying eggs

Plan de sortie du phosmet - Dispositifs 2023
Panorama national des essais biocontrôle suivis par Terres Inovia

KDR mutations well established in the French regions:
Centre, a part of the North-East and «l'Ile de France».
No SKDR mutation.
In these situations, metabolic resistances observed in the laboratory.
No possibility to make an effective link to the field.

- **Comparable and effective Decis Protech pyrethroids, Zeon Karate and Cypermethrin**
- **Trebon 30EC (etofenprox) has lower efficiency**
- **No references for Mandarin Gold (esfenvalerate)**

Winter flea beetle larvae

☐ **Derogatory Marketing Authorization of Minecto Gold from 15/10/2022 to 12/02/2023 High level of**
🟥 **resistance (generalized SKDR)**
Use MINECTO Gold from November to December from the 6-leaf stage

▨ **First SKDR mutation case detected**
Pyrethroids still effective BUT high risk of resistance increase. Preferably use MINECTO Gold from Nov. to Dec.

▨ Lower risk of progression of Skdr resistance. Preferably use a lambda-cyhalothrin-based product

🟧 **No SKDR mutation but low resistance (KDR mutation)**
Preferably use an insecticide based on lambda-cyhalothrin

The insecticidal advice takes into account the state of resistance to pyrethroids, the derogatory marketing authorization of MINECTO Gold and issues related to selection pressure. Request for exemption for 2023/24

Prospects

Plan d'action sortie du phosmet

- 2022 to 2025
- €2.5 million in public funding
- **Identify and deploy operational strategies**
- 8 projects led by research and development partners

Terres Inovia
l'agronomie en mouvement

Pest and auxiliary knowledge
Adaptacol², AltisOR, LEGO

Strategies at plant scale:
- Biocontrol: VELCO-A, Colzactise, Certis
- Genetics: RESALT

Levers at field scale/landscape
Ctrl-Alt, Adaptacol²

Les Culturales 2023 14-15 juin

Rapeseed grass management: adapting to multiple challenges

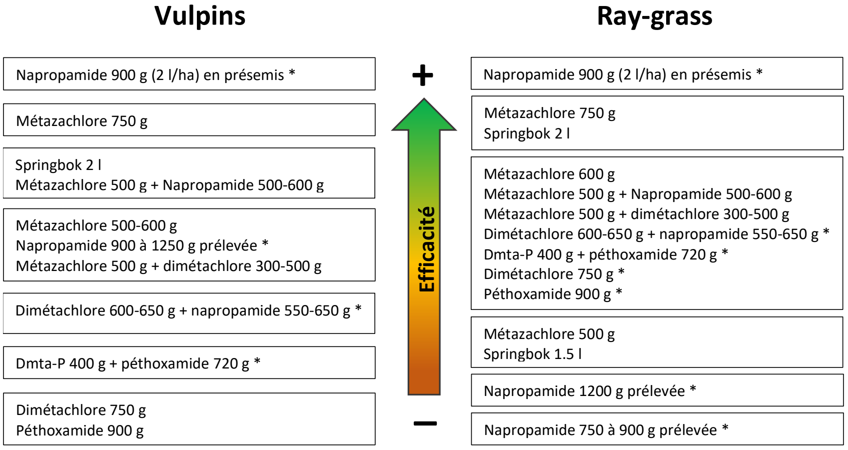
**The difficulties of rapeseed emergence and grass control argue
for a preventive approach to weed risk
and the responsible use of effective herbicides**

Maintain a limited number of weeds in plots over the long term

- Ploughing, false sowing, sowing without emerged weeds...
- Crop diversity, optimization of control means
- Successful weeding, chemical or mechanical
- Cleaning of machines and tools, using crop seed exempt from weed seed, destruction of plant cover before seeding
-

Better control in post-emergence, thanks to pre-emergence herbicides

At the time of treatment, moist soil optimizes root efficiency



Vulpins

- Napropamide 900 g (2 l/ha) en présemis *
- Métazachlore 750 g
- Springbok 2 l
  Métazachlore 500 g + Napropamide 500-600 g
- Métazachlore 500-600 g
  Napropamide 900 à 1250 g prélevée *
  Métazachlore 500 g + dimétachlore 300-500 g
- Dimétachlore 600-650 g + napropamide 550-650 g *
- Dmta-P 400 g + péthoxamide 720 g *
- Dimétachlore 750 g
  Péthoxamide 900 g

Ray-grass

- Napropamide 900 g (2 l/ha) en présemis *
- Métazachlore 750 g
  Springbok 2 l
- Métazachlore 600 g
  Métazachlore 500 g + Napropamide 500-600 g
  Métazachlore 500 g + dimétachlore 300-500 g
  Dimétachlore 600-650 g + napropamide 550-650 g *
  Dmta-P 400 g + péthoxamide 720 g *
  Dimétachlore 750 g *
  Péthoxamide 900 g *
- Métazachlore 500 g
  Springbok 1.5 l
- Napropamide 1200 g prélevée *
- Napropamide 750 à 900 g prélevée *

* programmes sans métazachlore

Métazachlore, dmta-P
What about "early" post-emergence?

☑ *OK if and only if very dry soil at the time of sowing and then return of wet conditions*

☑ *Be opportunistic and reactive (as soon as the rain returns in September)*

☑ *Effectiveness often remains good on black-grass*

☒ *More uncertain or even zero effectiveness on ryegrass!*

Use herbicides wisely to maintain their sustainability

Chloroacétamides, dimes, propyzamide :
To be reserved for cases of strict necessity,
Follow good practices

High grass pressures:
Building on the complementarity of existing solutions

Consider the environmental impact of root herbicides

METAZACHLOR	PROPYZAMIDE
A maximum application of 500 g/ha every 3 years or 750 g/ha every 4 years Prohibited on plot with referenced swallet	A maximum application of 750 g/ha per rapeseed campaign No double application!

- Limit soil compaction and do not treat on saturated soil, caution in hydromorphic soils
- In filtering contexts, karst types, limit as much as possible the risks in the points of preferential infiltration by adopting agri-environmental measures (e.g. hedges breaking slopes, grassy areas, areas without treatment)
- In clay soils with significant shrinkage slots, limit use or perform surface tillage

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Responsible herbicide management is a major challenge to preserve the sustainability of rapeseed weeding

E3_08_22

Climate change and disease risk management on rapeseed

What influence does climate change have on the incidence of rapeseed diseases?

Different parameters come into play in the onset of diseases, some of which cannot be predicted (e.g. precipitation, soil and air moisture)

→ The elements presented below (not exhaustive) are indications on short/medium term developments, to be placed in the local and annual context

Disease	**Theoretical evolution of risk (short/medium term)**
Cylindro-sporiosis	**Little change expected/uncertainty related to H_2O conditions:** Increase of autumn T°C favors early contamination. But rainfall and/or high relative humidity necessary for progression (splashing). Drought at flowering prevents passage on siliques.
Sclerotinia	**Little change expected/uncertainty related to H_2O conditions:** Increase of T ° C favors the germination of sclerotia and early appearance of apothecia. But H_2O and the presence of the susceptible stage of rapeseed are decisive for the success of contamination. Matching these factors?
Mycos-phaerella	**Increase/uncertainty related to H_2O conditions**: Poorly known epidemiology: increase in autumn/winter T°C would favor early contamination but H_2O seems to be decisive in the spread of contamination → Unfavorable dry springs? What about late contamination?
Alternaria	**Increase:** Contamination favored by the rise in T°C at spring. H_2O Determining for plant contamination (stormy episodes allow disease progression and spread)
Verticilliosis	**Increase:** Contamination favored by increasing T°C in autumn and spring. Expression during hot and dry springs.

Focus on sclerotiniasis (stem rot): should we still apply a flowering fungicide with the climate change?

Attack of sclerotinia on rapeseed stem (Photo L JUNG)

FOR	**AGAINST**
• A one-off risk of yield loss that is difficult to anticipate and has an impact on the sector (e.g. 2007) • Very partial effectiveness of alternative means of control against sclerotinia • Concomitant management of other diseases (powdery mildew, cylindro, myco) • An intervention cost amortized in most situations by a yield gain (≈1 q/ha) in the absence of symptoms	• Less frequent harmful attacks • New alternative control levers to combine: varieties tolerant to *S. sclerotiorum* (e.g. BRV 703 and BRV 712 from BREVANT and other seed companies in the future), biocontrols

→ With the evolution of the climate and the means of control, a reflection on the global management of rapeseed diseases is underway, taking into account territorial specificities.

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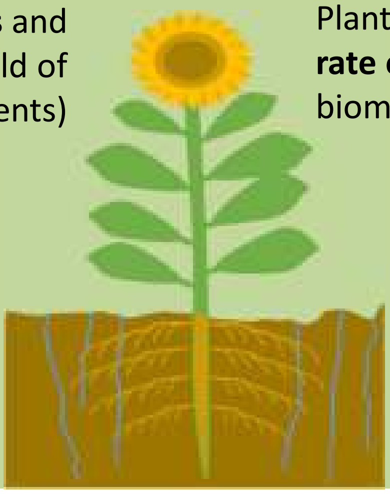
Sunflower: a crop that adapts to climate change

A crop tolerant to climate evolutions

Moderate water requirements and good use of water (maximum yield of 75% of requirements)

Ability to **regulate leaf area according to** water availability

Deep taproots capable of drawing water from deep underground



Plant in C3 benefits from the **increased rate of photosynthesis** (+ CO_2): ⇧ biomass and ⇧ yield

Rapid growth at relatively low temperatures, allowing **early sowing**

⇧ **Production areas** with favourable climatic conditions

But there are a few risks too:

- **A summer crop** whose cycle takes place during periods of high heat and drought:
  ⇩ yield ⇩ oil content ⇩ fatty acid quality
- Risk of **poor establishment**: staggered emergence
- Capable of **"wasting" water** if overgrown before flowering
- Little capacity for **compensation** (no branching)

Adapting to ensure "robust" sunflowers

Careful planting to encourage rooting = better access to water

Optimising irrigation by limiting excessive development

Water efficiency

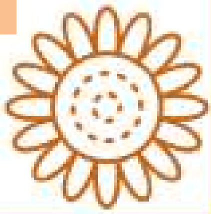
Improve genetics (earliness, stress tolerance)

Robustness ✕ Avoidance

Sow as early as possible to avoid stress

Adaptability ✕ Impacts

Vulnerability



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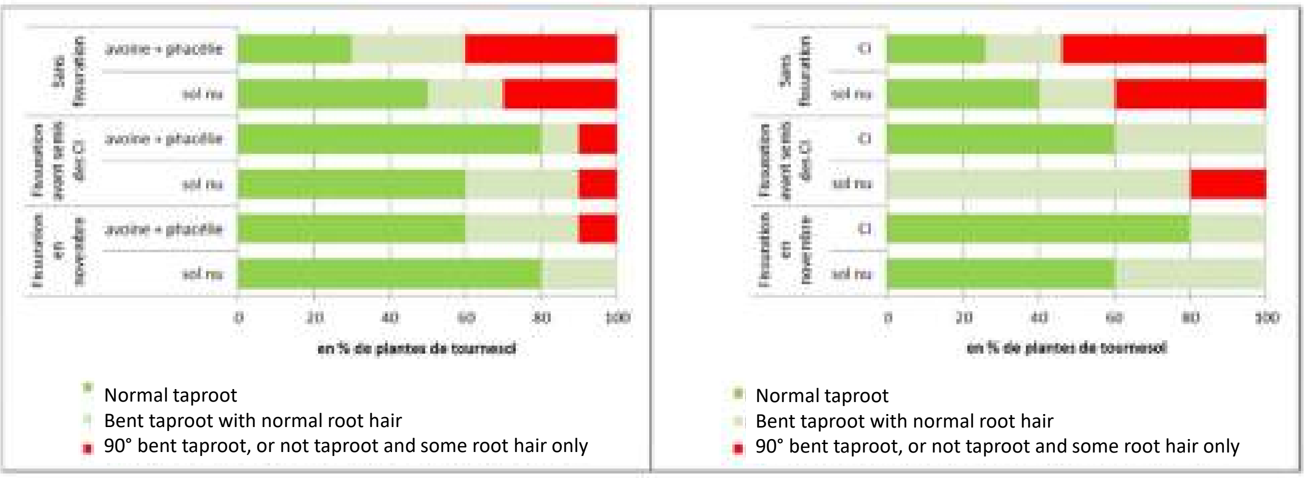
Choosing and managing plant cover crops before sunflowers

Choice of cover crop

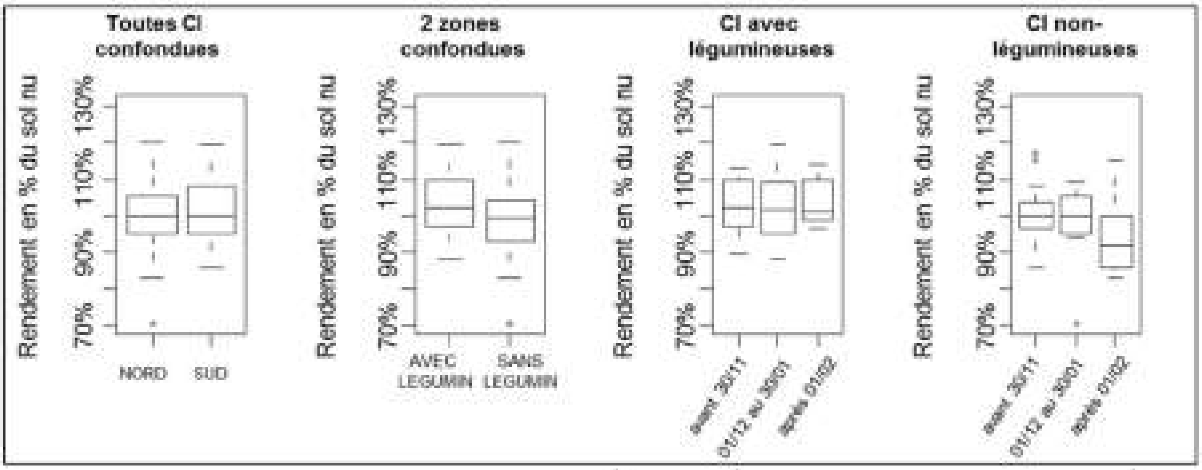
Brassicaceae	limit if rapeseed returns frequently (risk of clubroot) prefer in nitrogen-rich soils
Grasses	interest in the return of organic matter by roots
Legumes	interest in nitrogen-poor soils Beware of the aphanomyces risk
Hydrophylaceae	interest in breaking the cycle of diseases
Compositae	to be avoided because of the risk of downy mildew

Don’t penalise the rooting of sunflowers



Sunflower taproot growth according to the type of tillage (two different trials on the left and right)

Don't penalise sunflower yields



Successful intercropping = obtaining the benefits of plant cover and not compromising sunflower establishment or yield potential

- **Observe your soil** to adapt tillage, cover crop management and sowing success.
- Plant cover is not a substitute for tillage
- **Legume-based** cover crops tend to make intercropping management safer.
- Destruction of cover crops at least 2 months before sunflower sowing (depending on the type of cover crop).

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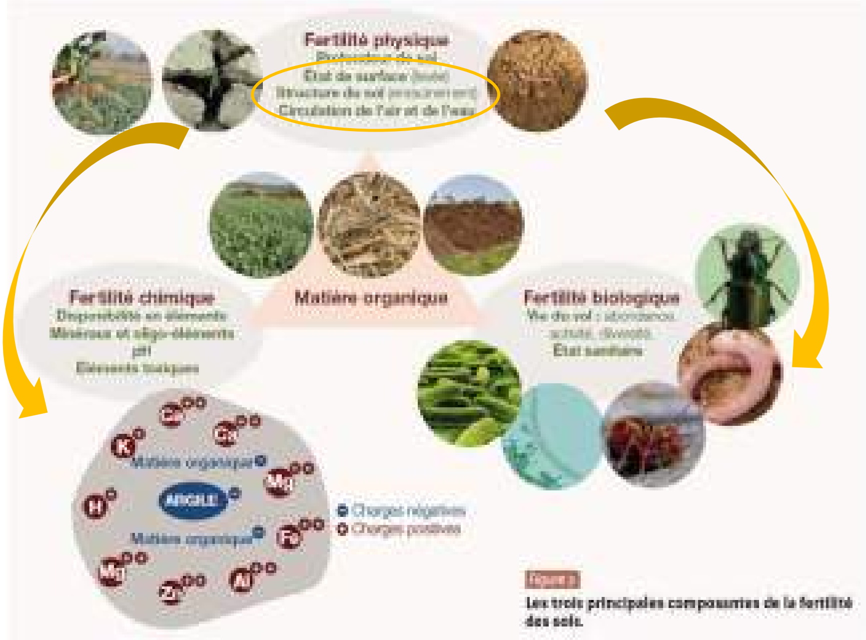
Soil tillage: observe and act at rotation level

Soil structure: one of the components of soil fertility



Observation objectives: diagnose, assess, decide

1- Remove a block

2- Observe the general condition of the block

3- Observe the internal state of the rootballs

General condition Open (O)

General condition Block (B)

General condition Continuous (C)

Internal condition Porous (Γ)

Internal condition Porous (Γ)

Internal condition compacted (Δ)

Internal condition Cracked (φ)

And don't forget to look at the activity of the earthworms

Sunflower planting

Rationalising intercropping management

Soil profile required

Good mix of fine soil + clods
No smoothing

Porous structure in the underlying horizon so as not to penalise deep rooting

Observe to decide

After the harvest

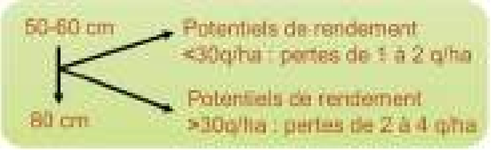
Optimising seedbed preparation

Criteria for successful preparation	**Cultivated soil**	**Soil with residues**
Not to have penalised the structure in depth	- Preferably work on dry soil - Clay soils: avoid passing through in plastic conditions - Use equipment such as twin wheels or low-pressure tyres	
Have produced at least as much fine soil as clods on the surface	- Do not create too much fine soil with too many passes - If 2 passes are planned, make the 1er at 10-15cm to warm the soil, the 2ème at 6-8cm to level it.	
No plant residues in the furrow		- In the absence of equipment, surface crumbling recommended (break up residues, warm the soil) - Debris removal equipment recommended for seed drills
Helping to control slugs	- Be careful not to create cavities (excess clods) which are shelters for slugs.	- Start monitoring as soon as the canopy is planted - Destroy cover crops early enough - Carry out shallow stubble ploughing if there is a proven risk
Allowing the soil to warm up		- Anticipate the destruction of the cover crop to facilitate soil warming
Helping to sow on clean soil	- Carry out false seeding if conditions permit - Be careful not to dry out the soil too much with repeated passes	- Anticipate the destruction of the cover crop if significant weed infestation - It's better to delay sunflower establishment to sow on clean soil

Successful sowing

Position the seed correctly

Choose the right spacing



Choose the right seeding rate

	Objectif de densité levée (optimum vis-à-vis du rendement et de la richesse en huile)	Cas général	Conditions optimales (lit de semences, conditions de levée, risque très faible de parasitisme et/ou déprédation³)
		Taux de levée indicatif	
		75 %	85 %
Conditions très contraintes en eau (sols superficiels et sols intermédiaires en région méditerranéenne¹)	50 000 plantes/ha	65 000 graines/ha	60 000 graines/ha
Conditions moyennement contraintes en eau (sols intermédiaires hors région méditerranéenne, tournesol irrigué en sol superficiel)	55 000 plantes/ha	70 000 graines/ha	65 000 graines/ha
Conditions faiblement contraintes en eau (sols profonds, tournesol irrigué en sol intermédiaire ou profond) et zones "fraîches" et/ou à fin de cycle humide²	60 000 plantes/ha si écartement entre rangs ≤ 60 cm	75 000 à 80 000 graines/ha si écartement entre rangs ≤ 60 cm	70 000 graines/ha si écartement entre rangs ≤ 60 cm
	50 000 à 55 000 plantes/ha si écartement large⁴	65 000 à 70 000 graines/ha si écartement large⁴	60 000 à 65 000 graines/ha si écartement large⁴

1 : Région méditerranéenne : à climats méditerranéen et méditerranéen dégradé.
2 : Zones avec culture de variétés précoces à très précoces avec une fin de cycle fraîche et/ou humide (exemples : Lorraine, Champagne, Picardie, bordures de l'Atlantique et de la Manche).
3 : Parasitisme : limaces, larves de taupins... ; déprédation : oiseaux (pigeons), lapins, lièvres...
4 : Les écartements entre rangs ≤ 60 cm sont les plus adaptés au tournesol.

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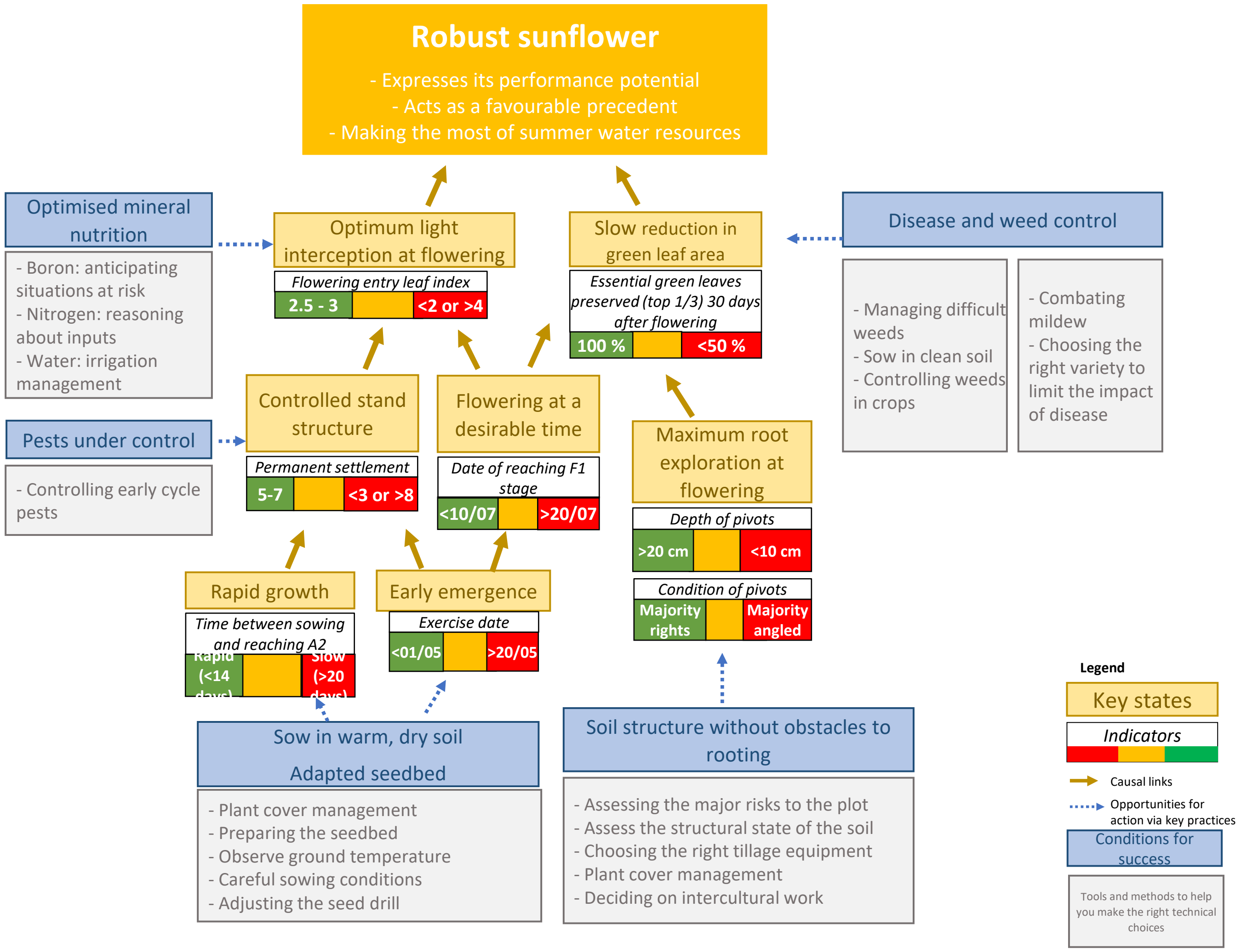
General dashboard « robust » sunflower



Robust sunflower

- Expresses its performance potential
- Acts as a favourable precedent
- Making the most of summer water resources

Optimised mineral nutrition

- Boron: anticipating situations at risk
- Nitrogen: reasoning about inputs
- Water: irrigation management

Pests under control

- Controlling early cycle pests

Optimum light interception at flowering

Flowering entry leaf index		
2.5 - 3		<2 or >4

Slow reduction in green leaf area

Essential green leaves preserved (top 1/3) 30 days after flowering		
100 %		<50 %

Disease and weed control

- Managing difficult weeds
- Sow in clean soil
- Controlling weeds in crops

- Combating mildew
- Choosing the right variety to limit the impact of disease

Controlled stand structure

Permanent settlement		
5-7		<3 or >8

Flowering at a desirable time

Date of reaching F1 stage		
<10/07		>20/07

Maximum root exploration at flowering

Depth of pivots		
>20 cm		<10 cm

Condition of pivots		
Majority rights		Majority angled

Rapid growth

Time between sowing and reaching A2		
Rapid (<14 days)		Slow (>20 days)

Early emergence

Exercise date		
<01/05		>20/05

Sow in warm, dry soil

Adapted seedbed

- Plant cover management
- Preparing the seedbed
- Observe ground temperature
- Careful sowing conditions
- Adjusting the seed drill

Soil structure without obstacles to rooting

- Assessing the major risks to the plot
- Assess the structural state of the soil
- Choosing the right tillage equipment
- Plant cover management
- Deciding on intercultural work

Legend

Key states

Indicators		
🟥	🟨	🟩

Causal links

Opportunities for action via key practices

Conditions for success

Tools and methods to help you make the right technical choices

Key state: state of the crop that is decisive in establishing the final result. Resulting from one (or more) causal key states and/or success conditions

Condition for success: condition linked to one or more biotic or abiotic factors, which can be influenced by cultivation practices.

Indicator: agronomic observation carried out on the soil or crop to determine whether or not a key condition has been achieved.

This dashboard can be used :

- Before the start of the growing season, to draw up a strategy for implementation
- During the campaign: to organise an observatory of the key states obtained
- At the end of the campaign: to identify areas for improvement for the coming campaign

10 golden rules for successful sunflower planting

Capitalising on plot history
Structural problems, problematic summer weeds, pests and diseases

Observing the ground
Diagnose soil conditions and adapt intercropping management strategy

Working with crumbly soil
Across the entire profile

Controlling difficult weeds at the start of intercropping

Covering the ground
Before sunflower, many species can be used, use mixtures based on legumes.

Sow early enough
Emergence before 1er May. Only shift the sowing date if it is a health priority.

Promote rapid emergence
Sow with a precision seeder in warm soil, at an even depth. Do not create too much fine soil.

Disrupting pests
Anticipating situations where slugs and wireworms are at risk. Human presence is currently the only effective way of limiting bird damage.

Controlling **grass cover**
Sow on clean soil. Prefer scalping and tine tools

Optimising nutrition
Rationalise the nitrogen dose. Anticipate possible deficiencies in boron, phosphorus and potash.

Find out more in the sunflower planting guide

In the **Points techniques** collection of Terres Inovia
Order on our website
www.terresinovia.fr

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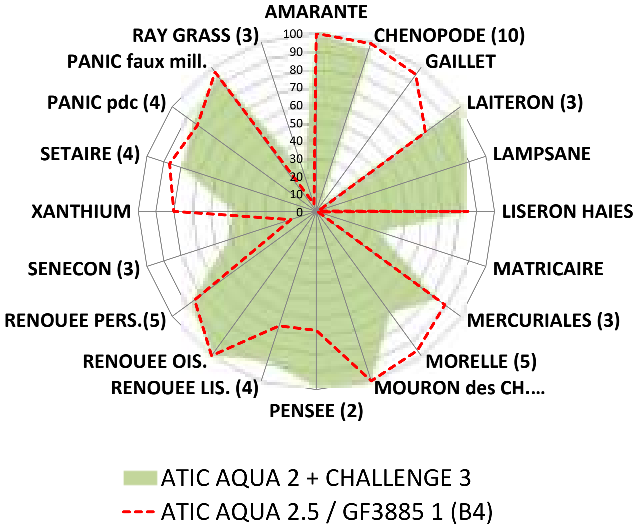
Les Culturales 2023 14-15 juin

VIBALLA in sunflowers: what's the difference?

On classic flora

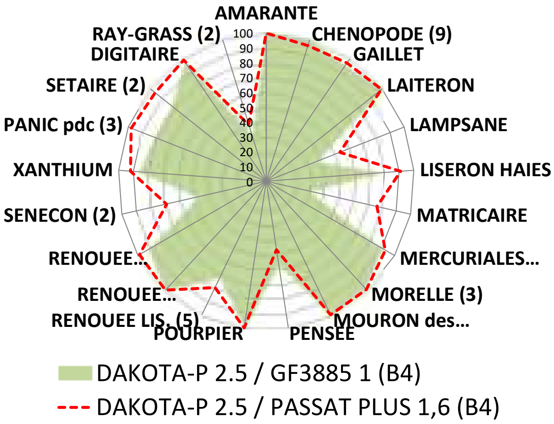
- **Strong point on** goosefoot, mercurial, ammi-majus, ethuse, but also bedstraw, geranium, abutilon, xanthium and ragweed
- **Average effectiveness on** nightshade
- **Insufficient on** pigweed, milkweed, sow thistle, groundsel and knotweed



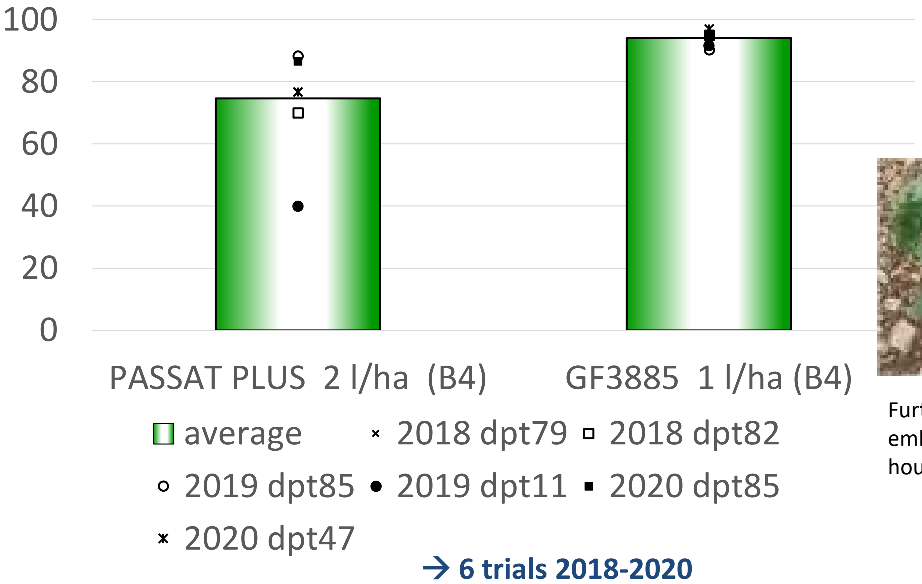
Build programmes based on pendimethalin to balance the spectrum on :

- ☐ grasses
- ☐ Knotweed, in particular wild buckwheat

Atic-Aqua or Dakota-P base at 2.5 l/ha



On Ambrosia



→ **6 trials 2018-2020**
242 pl/m² - (10 to 880)

Furtive symptoms of embossing within 48 hours of application

Symptoms of stem deformation sometimes observed (application at juvenile stage, boom recrossing).

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Programmes for all situations

Simple flora at moderate pressure
→ DAKOTA-P alone at 2.5 l/ha

45 à 50 €

Simple flora under heavy pressure knotweed
→ Atic-Aqua 2l + Proman 2l

85 €

Or

→ Atic Aqua 2l + Challenge 2.5 to 3l

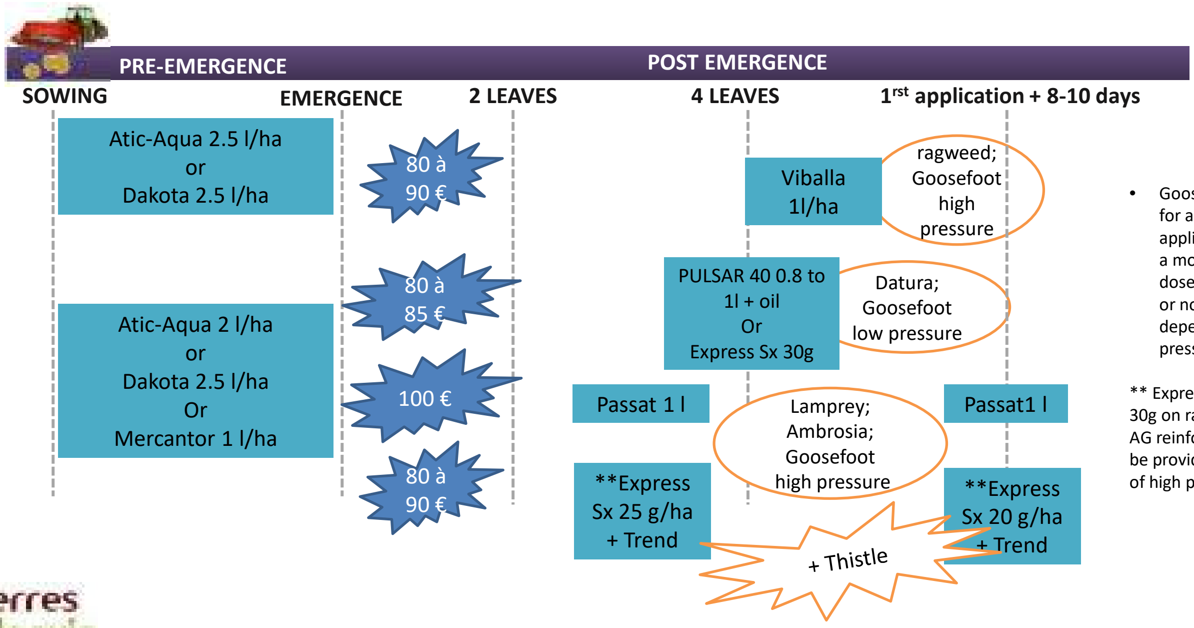
85 à 100 €

(Challenge strengthens on bedstraw, and slight mercurial effect insufficient in strong pressure)

Possible replacement of Atic-Aqua with Dakota-P 2l to reinforce on nightshade. Prefer Atic on nightshade if programmed with Proman 2l

	Dakota-P 2.5 to 3 l/ha	Atic-Aqua 2 l/ha + Challenge 600 3 l/ha	Atic-Aqua 2 l/ha + Proman Proman 2 l
Crabgrass	🟩	🟩	🟩
Panic	🟩	🟩	🟩
Ryegrass	🟨 *	🟥	🟥
Foxtail	🟩	🟩	🟩
Amaranth	🟩	🟩	🟩
Ambrosia	🟥 *	🟥	🟨
High Ammi	🟥 *	🟥	🟥
Arroche	🟨 *	🟩	🟩
Bidens (water hemp)	🟥	🟥	🟥
Capselle	🟩	🟩	🟩
Goosefoot	🟩	🟩	🟩
Rape seedlings	🟥	🟩	🟩
Datura	🟥	🟥	🟥
Ethuse	🟥 *	🟥	🟥
Bedstraw	🟥 *	🟩	🟥
Sow-thistle	🟩	🟩	🟩
Bastard toadflax	🟩	🟨	🟩 *
Field bindweed	🟥 *	-	🟥 *
Hedge bindweed	🟥	🟥	🟥
Matricaria	🟩 *	🟩	-
Mercurial	🟥	🟨	🟥
Morelle	🟩	🟨	🟨
Crowfoot	🟩	🟩	🟨
Deschamps mustard	🟥	🟩	🟩
Ravenelle	🟥	🟩 *	🟩
Wild buckwheat	🟥	🟩	🟩
Knotweed	🟩 *	🟩	🟩
Persian Knotweed	🟨 *	🟩	🟩
Groundsel	🟨 *	🟨	-
Stellar	🟩	🟩	🟩
Véronique	🟩	🟩	🟩

Examples of management in difficult flora situations (ambrosia, xanthium, datura)



PRE-EMERGENCE
POST EMERGENCE
SOWING
EMERGENCE
2 LEAVES
4 LEAVES
1rst application + 8-10 days

Atic-Aqua 2.5 l/ha
or
Dakota 2.5 l/ha

80 à 90 €

80 à 85 €

Atic-Aqua 2 l/ha
or
Dakota 2.5 l/ha
Or
Mercantor 1 l/ha

100 €

80 à 90 €

Viballa 1l/ha

ragweed; Goosefoot high pressure

PULSAR 40 0.8 to 1l + oil
Or
Express Sx 30g

Datura; Goosefoot low pressure

Passat 1 l

Lamprey; Ambrosia; Goosefoot high pressure

Passat1 l

**Express Sx 25 g/ha + Trend

**Express Sx 20 g/ha + Trend

+ Thistle

- Goosefoot: opt for an early application with a modulated dose, repeated or not depending on pressure.

** Express 30g then 30g on ragweed. AG reinforcement to be provided in case of high pressure.

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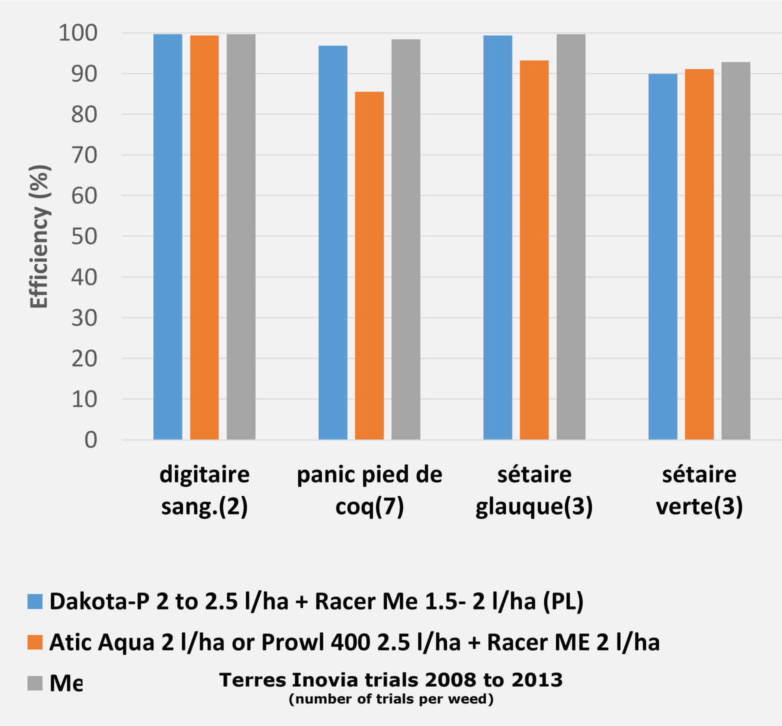
Maintenance of grasses without s-metolachlor

Panic, foxtail, crabgrass: an update on existing solutions

- **Pendimethalin** alone or in combination with **DMTA-p** offers equivalent protection in a large number of situations.
- Possible use of foliar grass suppressants



Terres Inovia trials 2008 to 2013
(number of trials per weed)

Ryegrass/blackgrass

- A worrying situation :
  - Almost widespread resistance to ACCase inhibitors (fop/dymes) and ALS inhibitors (imazamox)
- What are the alternatives?
  - Solutions based on dmta-P (DAKOTA-P, dmta-P solo expected)
  - Reconsider strengthening these solutions with Novall (trials underway)

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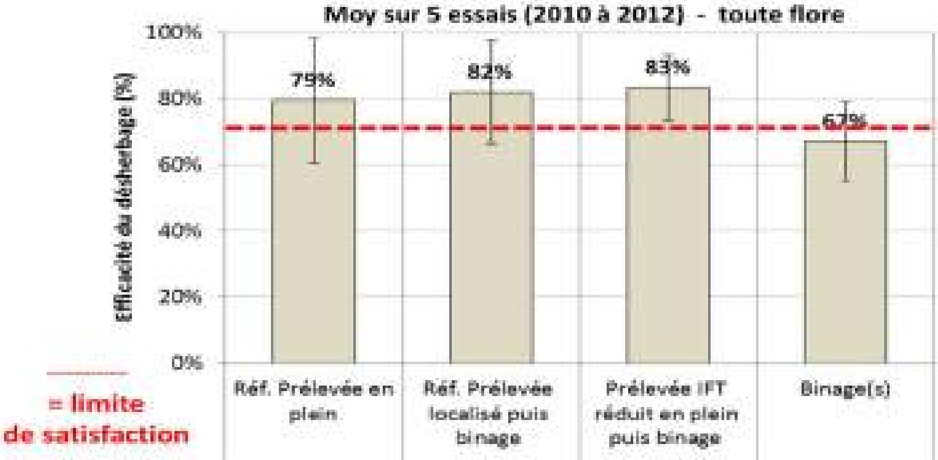
Mixed weeding of sunflowers with hoeing

Herbicide followed by hoeing

Pre-emergence herbicide on the row with a kit on the seeder (herbisemis) THEN hoeing




Herbisemis

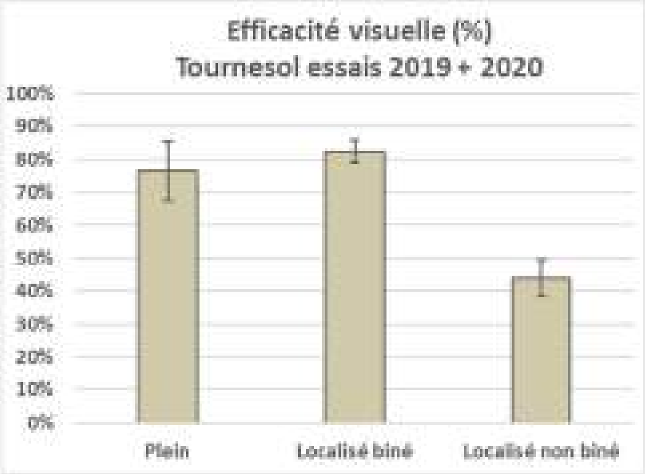

Hoeing

- The two complement each other well
- Effectiveness equivalent to herbicide applied on the entire surface
- Reduced treatment frequency index (67%) and lower costs (71%)

Post-emergence localised herbicide followed by hoeing

Post-emergence treatment (e.g. Pulsar 40, used in these trials, on a tolerant variety) on the row ALSO hoeing → use of a specific Maréchal boom

Spraying boom localized on the row



- Complementarity of the two is essential
- Efficiency equivalent to or better than herbicide applied on the entire surface
- Reduced treatment frequency index by 56

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What are the levers to secure an optimal plant stand?

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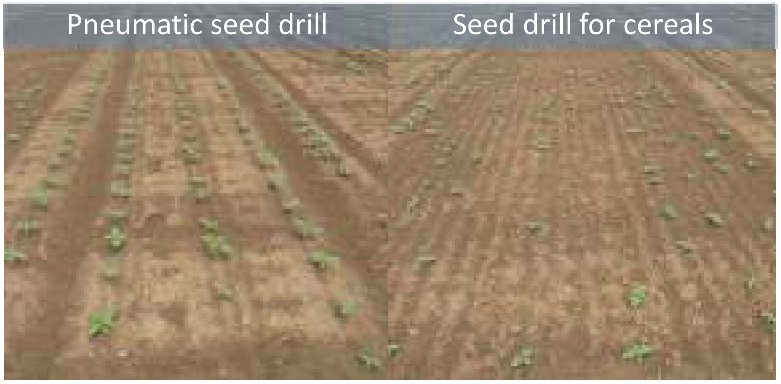
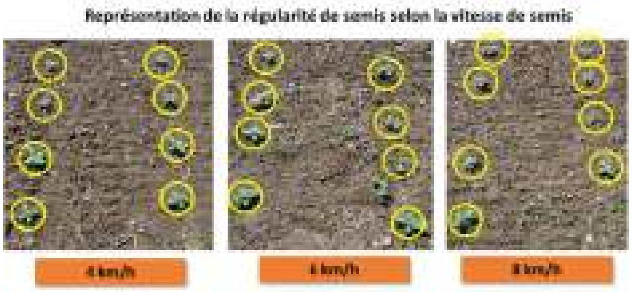
The combination of sowing period and earliness

	21 au 31 mars	1er au 20 avril	21 au 30 avril	Après le 1er mai
Période de semis	**	***	**	*
Précocité	P, MP	P	P	P, TP
Période de semis	*	***	***	*
Précocité	P, MP	P	P	P, TP
Période de semis	**	***	**	*
Précocité	MP	P, MP	P, MP	P, TP
Période de semis	*	**	***	*
Précocité	P	P	P	P, TP
Période de semis	**	***	**	*
Précocité	MP, MT, T	P, MP, MT, T	P, MP	P, TP
Période de semis	**	***	**	*
Précocité	P, TP	P, TP	P, TP	TP
Période de semis	*	***	**	*
Précocité	MP, P	MP, P, TP	P, TP	TP

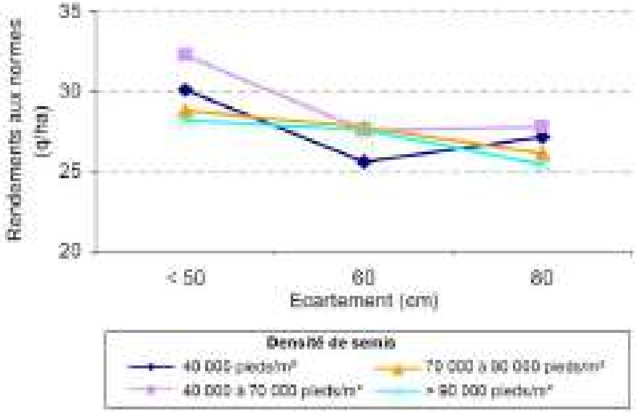
Type of seed drill and seeding speed





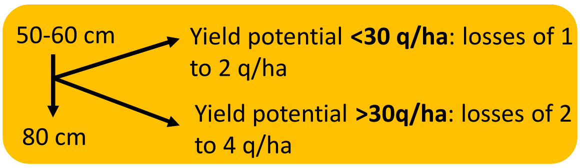
Sowing at 6 km/h maximum, ideally 4 km/h
(depending on the seed drill)

Row spacing



→Row spacing: wide row spacings can :

- increase competition between plants on the same row,
- limit the canopy's ability to intercept light,
  ↳ A drop in the number of seeds per m² that was not offset by an increase in seed weight.

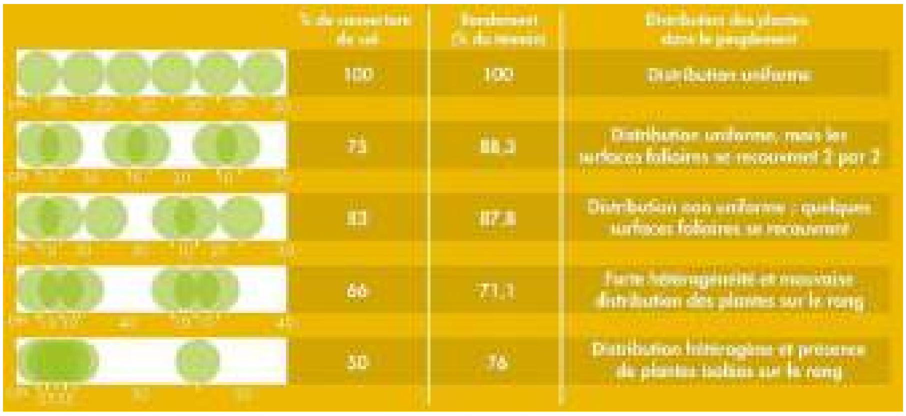


50-60 cm → Yield potential **<30 q/ha**: losses of 1 to 2 q/ha

80 cm → Yield potential **>30q/ha**: losses of 2 to 4 q/ha

Regular planting is vital for yield

Impact of stand heterogeneity on yield



	% de couverture du sol	Rendement (% du témoin)	Distribution des plantes dans le peuplement
	100	100	Distribution uniforme
	75	88.3	Distribution uniforme, mais les surfaces foliaires se recouvrent 2 par 2
	83	87.8	Distribution non uniforme : quelques surfaces foliaires se recouvrent
	66	71,1	Forte hétérogénéité et mauvaise distribution des plantes sur le rang
	50	76	Distribution hétérogène et présence de plantes isolées sur le rang

Terres Inovia
l'agronomie en mouvement

Fertilising sunflowers

Identify the needs of the crop (e.g. for a yield of 35 q/ha) ...

- ➔ General needs largely covered by returns.
- ➔ **Nitrogen** and **boron** are the priority elements in fertilisation management!
- ➔ **In some cases, the sunflower finds everything it needs in its environment (no need for supplements).**

... So you can respond more effectively if necessary!

Nitrogen

		Objectif de rendement	
		25 q/ha (sols superficiels) (1)	35 q/ha (sols profonds) (2)
Reliquat d'azote minéral au semis	Faible (30 u)	40 à 80 u	80 à 100 u
	Moyen (60 u)	moins de 40 u	40 à 80 u
	Elevé (90 u)	0 u	moins de 40 u

(1) shallow clay-limestone, sandy soil, notch...
(2) silt, clayey silt, silty clay, chalk, etc.

If the mineralisation is high, choose the lower value of the range and vice versa.
Nitrogen residues at sowing can be measured up to 90 cm, or even 120 cm for the deepest soils.

Prioritise nitrogen application during vegetation :

- ➔ Nitrogen application during vegetation (6 to 14 leaves) is at least as effective as application at sowing, because it is carried out when the crop's needs are highest.
- ➔ It improves the estimation of the yield target by taking into account the condition of the planted stand.
- ➔ To apply nitrogen safely during the growing season, use a solid form (ammonium nitrate or urea) in dry weather, before the star bud appears.

Boron

Apport	Stade	Forme	Dose de bore (B)
Au sol	Incorporer ou pas avant le semis (1)	Solide ou liquide	1.2 kg/ha (3)
En application foliaire	Entre les stades "10 feuilles" et LPT (1)(2)	Liquide : apporter au moins 200 l/ha de bouillie	300 à 500 g/ha (4)

(1) Can be carried out at the same time as weeding or fungicide application.
(2) LPT: tractor passage limit. Sunflowers measure 55 to 60 cm.
(3) Chelal B: 250 g B/ha soil application - 200 g B/ha foliar application
(4) Approximately 3 l of liquid product with 150 g/l boron

Risk and aggravating factors

- ➔ pH above 7.0
- ➔ More than 10% active limestone in the soil
- ➔ Light, filtering and superficial soils
- ➔ Liming (boron blocking)
- ➔ Thermal shock between "10 leaves" and "early flowering".
- ➔ Frequent return of sunflowers without boron supplementation

Terres Inovia
l'agronomie en mouvement

Example of a technical itinerary sunflower

- Preparing the soil: intercropping, structure, weeds
- Optimising your choice of variety: outlets, earliness, diseases, technologies, etc.
- Sow before the weather warms up
- Adapting weed control: pre-emergence, post-emergence, mechanical, mixed
- Managing pests and diseases: slugs, birds, green aphids, etc.
- Feed correctly: water, NPK, boron

Sowing | **Survey** | **4 sheets** | **Button starred** | **Flowering** | **Maturation**

Certified seeds
110 €/ha

Density
70 seeds/sq.m.

Fertilization
230 €/ha

P: 50 kg/ha
K: 50 kg/ha

Boron: 500 g/ha

Nitrogen: 0 to 60 kg/ha (40 kg/ha in the example)

Herbicides
95 €/ha

Levy
Mercantor Gold 1.05 l/ha + Challenge 3 l/ha

Insecticides - pests
25 to 110 €/ha

Birds and game
Frightening

Slugs
Metaldehyde base
25 €/ha

(Soil insects
Belem 12 kg/ha)
0 to 46 €/ha

Green aphids
Product Mavrik Jet 3 l/ha
0 to 36 €/ha

Phomopsis/Phoma
Choice of variety

Verticillium Varietal choice

Sclerotinia Varietal choice

Harvest

Downy mildew Varietal choice and rotation

harvest by a service provider
100 €/ha

Operating costs + service harvesting
= 560 to 645 €/ha

Indicative gross margin
≈ 600 €/ha
range of
155 to 840 €/ha ("dry")

Irrigation is possible: gain of 8 to 10 q/ha with 100 mm of water, i.e. + €100 to + €180/ha gross margin (at €2.2/mm of water)

Oleic sunflower versus linoleic sunflower

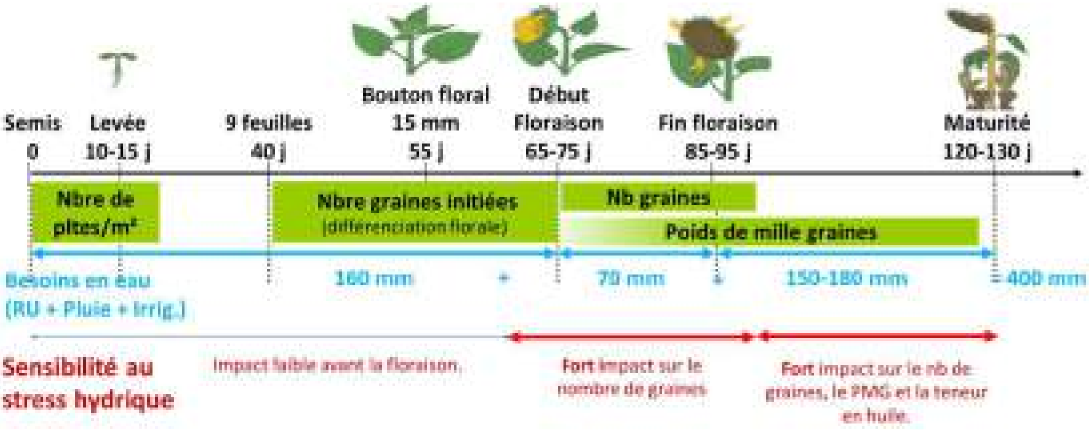
price range from 0 to + 70 €/t (median$_{2013\text{ - }2021}$ = + 25 €/t)

Average yield :	20-30-35 q/ha dry
Suggested retail price :	400 €/t
Indicative gross revenue	800-1200-1400 €/ha

Sunflower irrigation : success and economic advantage

Les Culturales 2023 14-15 juin

Water requirements

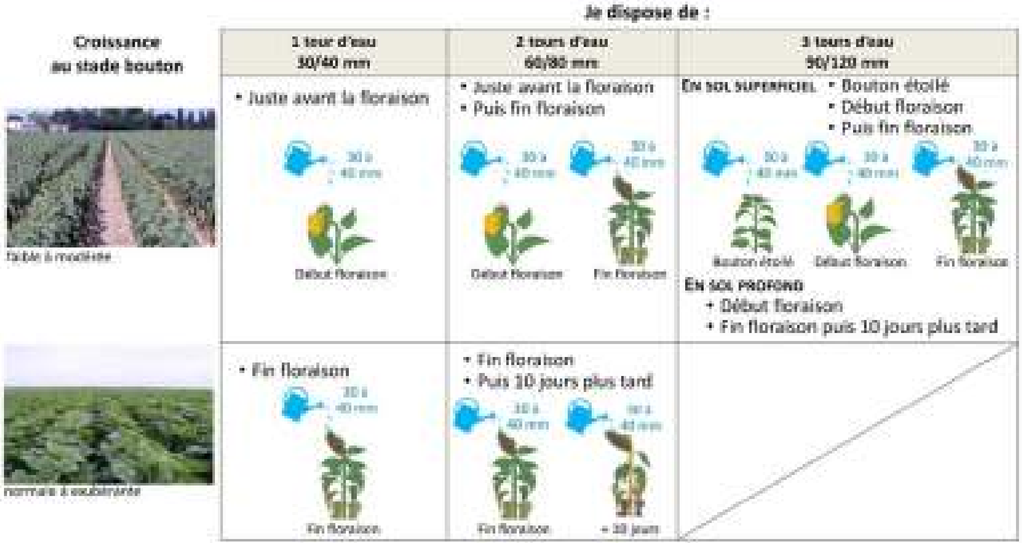


- Mechanisms of hardening before flowering
- Obtain moderate foliage development before flowering (Foliar Index = 2.5), avoid exuberant foliage.
- Maintain a "green" leaf surface to ensure proper functioning until maturity

Good irrigation practices

1 to 3 applications of water at the right time to maximise the efficacy of limited quantities of irrigation water

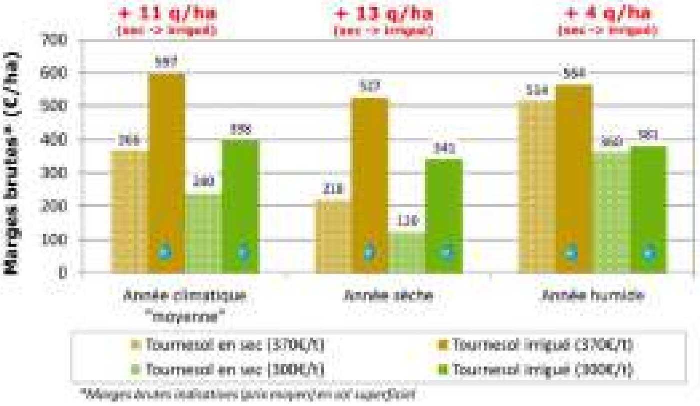
Favour varieties with very low or low susceptibility to sclerotinia and phomopsis



	Je dispose de :		
Croissance au stade bouton	1 tour d'eau 30/40 mm	2 tours d'eau 60/80 mm	3 tours d'eau 90/120 mm
faible à modérée	• Juste avant la floraison	• Juste avant la floraison • Puis fin floraison	En sol superficiel • Bouton étoilé • Début floraison • Puis fin floraison En sol profond • Début floraison • Fin floraison puis 10 jours plus tard
normale à exubérante	• Fin floraison	• Fin floraison • Puis 10 jours plus tard	

The economic benefits of irrigation

- Very good response to water
- **Average efficiency: ~ 10 q/ha** for 100 mm of irrigation water
- Irrigation greatly improves gross margin

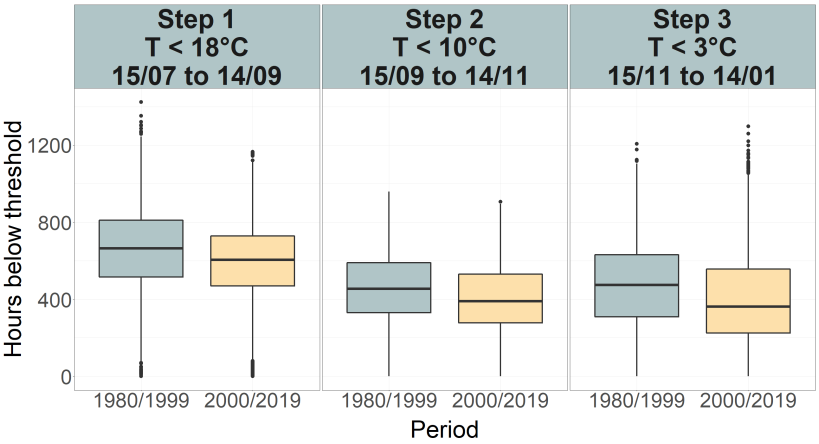


Terres Inovia
l'agronomie en mouvement

Less climatic opportunities for grain aeration

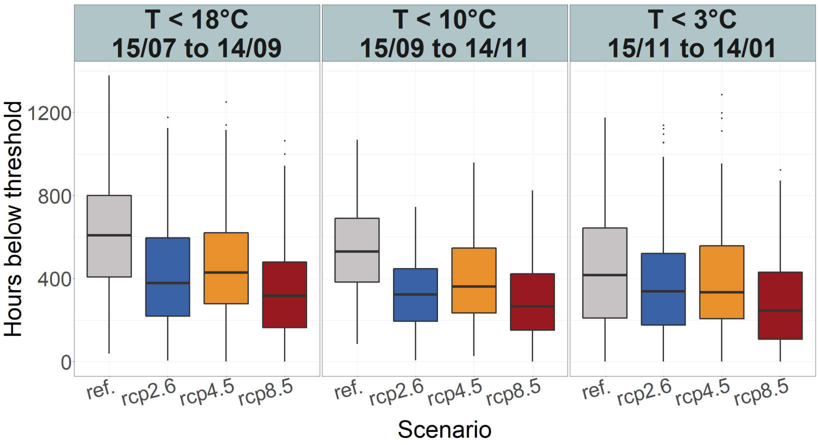
Aeration with ambient air is a very common practice in French storages. **Weather conditions** are crucial to the effectiveness of this technique. Arvalis recommends cooling the grain in **three successive steps**, based on the seasonal variations of temperature.

Observing recent past (191 weather stations – 1980/2019)



Our data show a mean decrease of **7 to 12%** since the period 1980/1999

Mid-term projected impact (11 stations – 2041/2060)



In the years to come, the hours below fan activation temperature could decrease by **15 to 45%**, depending on emission scenarios.

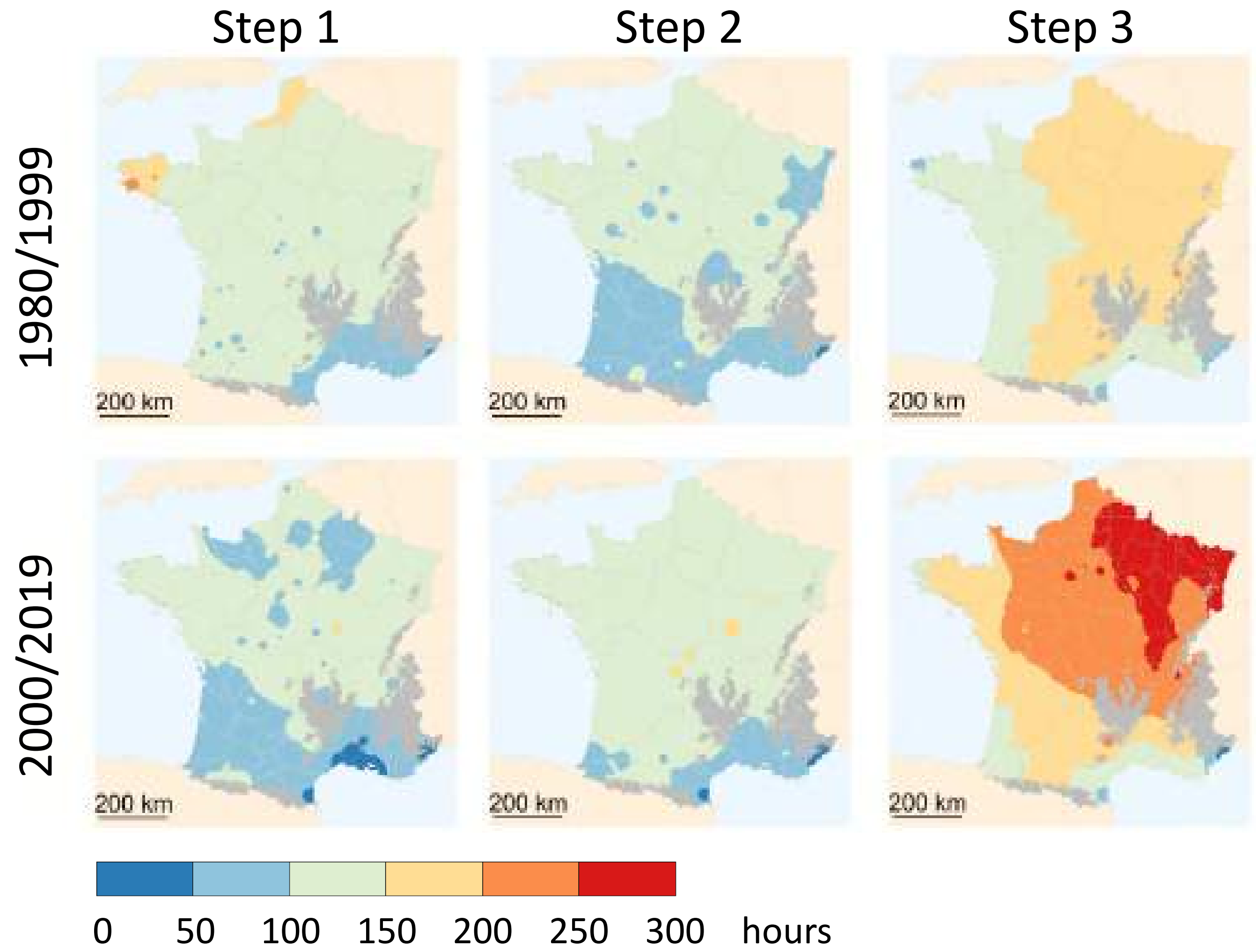
How long does it take to cool a farm storage ?

In most cases, in farms, aerating a metallic bin **during 40 to 50 hours** is sufficient to decrease its temperature by 7 to 10°C.

An increasing inter-annual variability in the winter

For the future, climate experts predict longer, more intense and more frequent extreme events (heatwaves for example). In the recent past, how did this affect the possibilities to aerate grain storages ? Was the effect the same in all French regions ?

Standard deviation of the hours below fan activation temperature per year



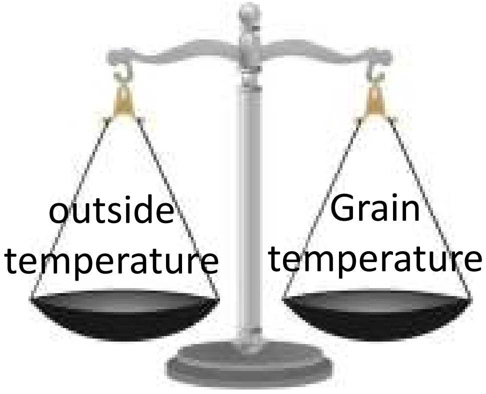
Step 1 : decrease of SD in the South-> cooling the grain to 20°C became difficult all the time
Step 2 : more variability in the South-West
Step 3 : increasing variability in the North-East-> the possibilities to reach 5°C in the grain bins are now different every year

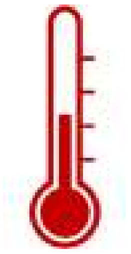
Adapting aeration to a warmer climate

Blow faster

Increase the **fan's flow**

Be as close as possible to the hours below fan activation temperature → You'll **make the most of every opportunity**



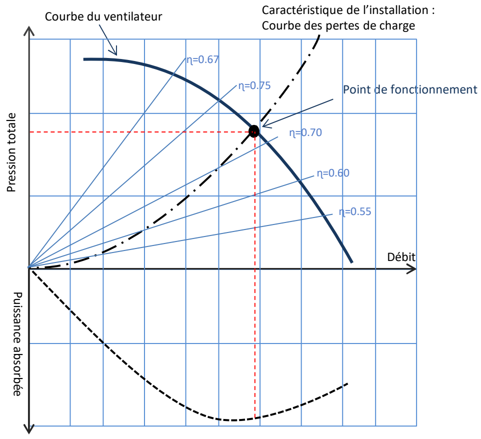


Control the temperature of the grain to ventilate enough… And not too much !

Limit the air's temperature rise and pressure drops

With suitable and efficient air dispensers, not with agricultural drain

Aerating cleaned and sorted grain increases airflow

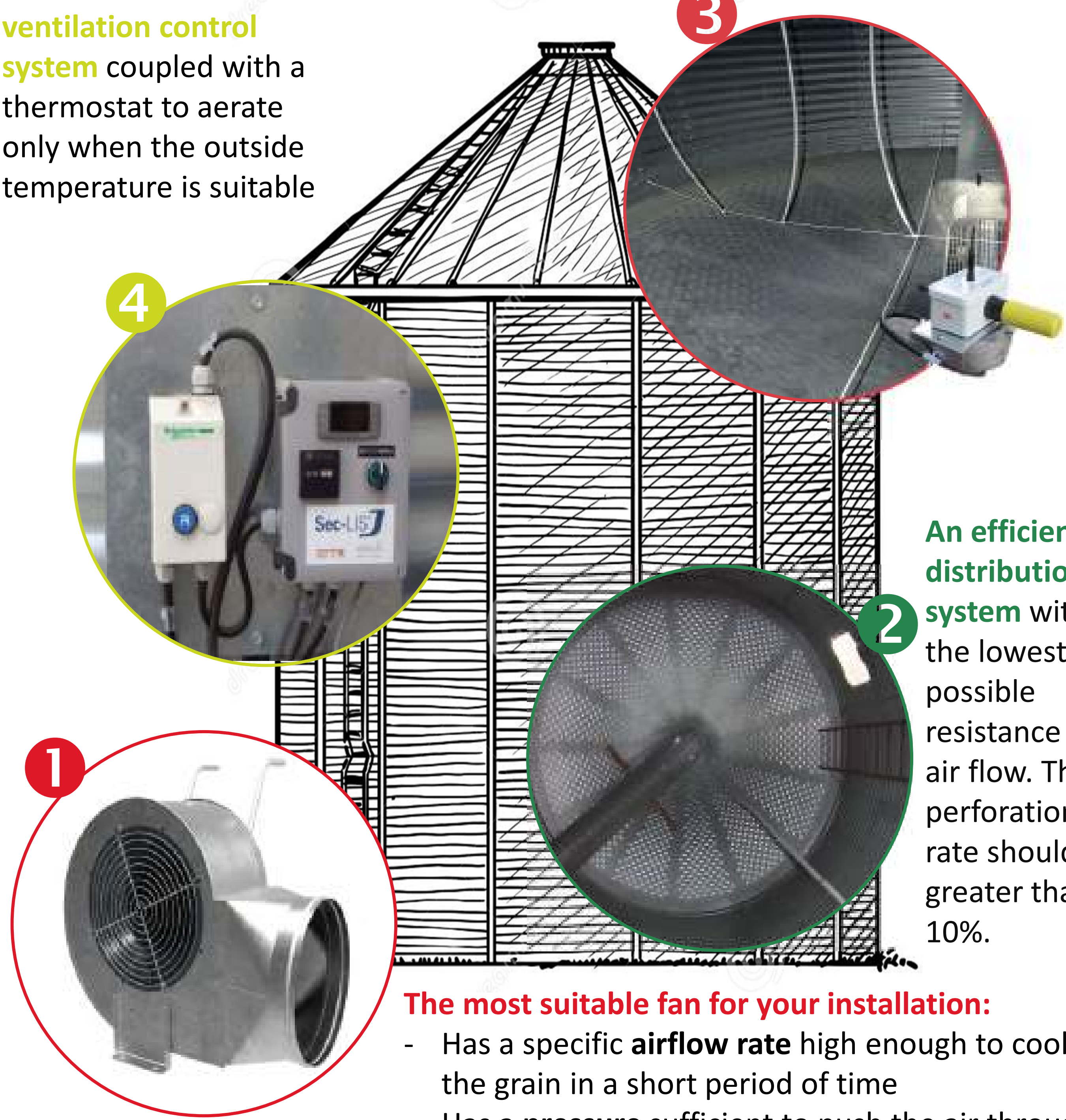


The fan should operate in its optimum efficiency zone

The right equipment for grain aeration

A thermometry system to follow the progress of the aeration phases, to monitor the conservation of the grain and to detect punctual overheating at an early stage

An automatic ventilation control system coupled with a thermostat to aerate only when the outside temperature is suitable



An efficient air distribution system with the lowest possible resistance to air flow. The perforation rate should be greater than 10%.

The most suitable fan for your installation:

- Has a specific **airflow rate** high enough to cool the grain in a short period of time
- Has a **pressure** sufficient to push the air through the distribution system and through the grain
- Consumes the less electrical **energy** possible

To choose your fan: https://ventilis.arvalis-infos.fr/ventilis-agri/accueil

Venti-LIS AGRI

ARVALIS

Arvalis helps you with some tools:

To control your aeration system:

An automatic system designed for farmers:
The Sec-LIS® box automatically switches on the aeration as soon as the outside temperature is low enough.

Contact : contact@mte-silo.com

To choose the right fan for you:

Venti-LIS® AGRI

Venti-LIS ® agri helps farmers **to choose the most appropriate fan** for their storage. You can also ckeck if your current fan is adapted to your storage installation.

https://ventilis.arvalis-infos.fr/ventilis-agri/accueil

To audit your practices:

Venti-LIS® AUDIT

Venti-LIS® audit allows you to **self-assess your on-farm storage practices**, to best preserve the quality of your grain.

https://ventilis.arvalis-infos.fr/ventilis-audit/accueil

To identify the insects of your storage ecosystem:

ARVALIS Insectes du silo

ARVALIS

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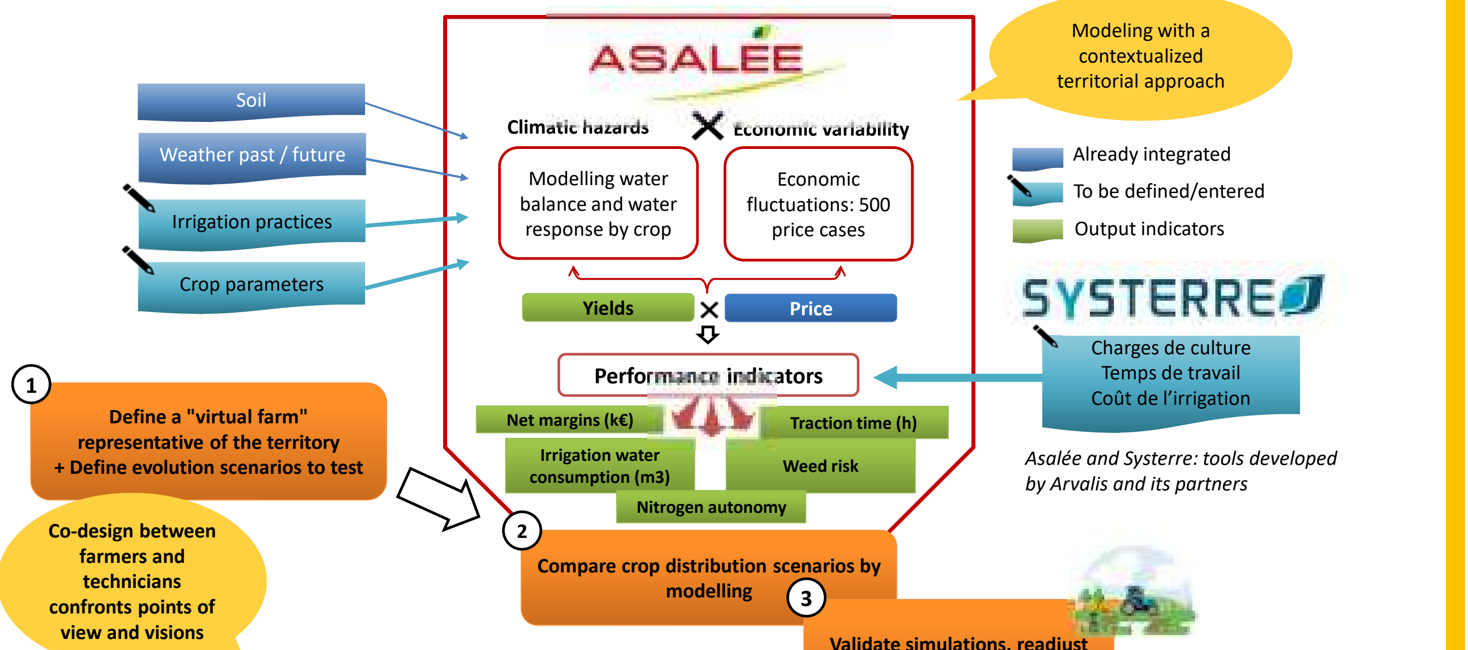
Adapting to climate change: the ASALEE approach

The ASALEE approach based on co-design workshops and modelling



Modeling with a contextualized territorial approach

Modelling water balance and water response by crop

Economic fluctuations: 500 price cases

Performance indicators

Asalée and Systerre: tools developed by Arvalis and its partners

1 **Define a "virtual farm" representative of the territory + Define evolution scenarios to test**

Co-design between farmers and technicians confronts points of view and visions

2 **Compare crop distribution scenarios by modelling**

3 **Validate simulations, readjust adaptation scenarios**

4 **Collectively assess the results and the tracks to be retained**

Medium-long term reflection, sheds light on evolution choices

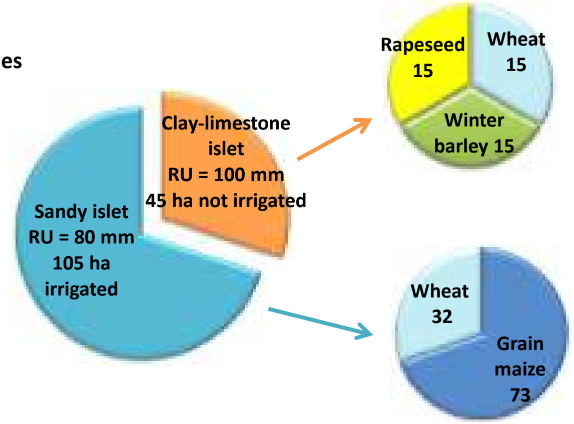
CLIMATVEG La Ménitré, déc 2021, Pays de la Loire

Focus on the Sarthe territory - CLIMATVEG Pays de la Loire project *

Reference farm: crops & broiler breeding

- **150 ha of annual crops, 1 labour unit / crop production, 4 poultry houses**
- **Irrigable area: 105 ha, soils with low water reserves**
- 300,000 m3 max available taken from the river, 1 pivot, 2 reels
- 73ha irrigated in summer – 1,600 m^3/ha
- Total cost of access to water: 0,16 €/m^3

Farm-level indicators – current climate	
Total median net margin	35 175 €
with grants	234 €/ha
Median volumes of water consumption	167 549 m^3
Total traction time h/labour unit/year	948 h/an



Tested adaptation scenarios

① Development of the crop and breeding activity	② Development of vegetable proteins for human consumption and oilseed and protein crops	③ Reduction of irrigation compensated by expansion and crop rotation winter
+50 ha, 8 poultry houses	+50 ha, 4 poultry houses	+70 ha, 4 poultry houses
+0.5 labour unit	+0.5 labour unit	+0.5 labour unit
+50 ha irrigated	+3 ha irrigated	+11 ha irrigated

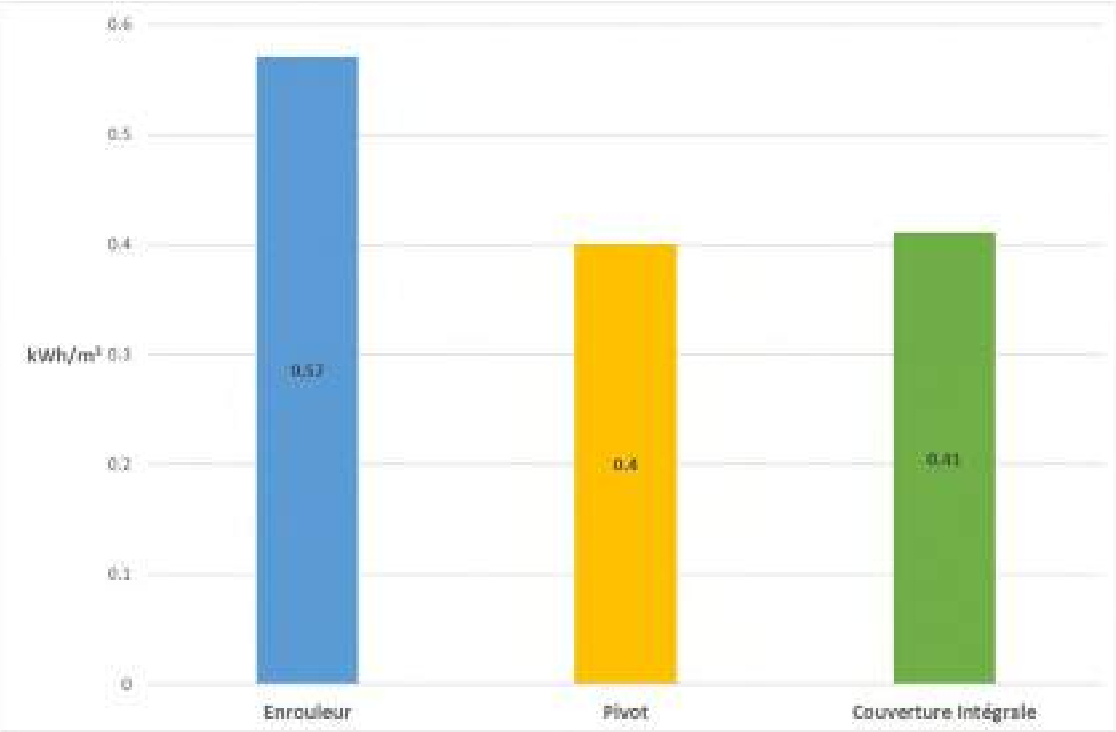
Future climate developments compared to the current situation

Multi-criteria analysis, global approach

	Without adaptation	Tested scenarios			
		①	①	②	③
Water resources	river	reserve + river	river	river	river
Irrigation water cons./ ha	+11%	+17%	+17%	-30%	-55%
€ **Net margin**	-53%	-48%	-27%	-23%	-23%
h **Traction time**	+1%	-6%	-6%	-20%	-24%
Nitrogen autonomy (index)	100	150	150	75	68
Weed pressure / rotations	--	-	-	-	--

* en partenariat avec

Irrigation system : which quantity of energy needed ?



kWh /m³ irrigation systems in the Garonne Valley (water pumping from river without elevation gain) [1]

	Hose reel	Center Pivot	Ramp + hose reel	Sprinkler irrigation	On surface drip	Sub surface drip
kWh/m³	+++	+(+)	++	++	+	+
With an adapted pumping station (+ Low power consumption +++ High consumption)						

How to estimate your irrigation energy consumption ?

Before and after a medium irrigation position

- Reading water meter
- Reading electricity meter
- Calculating ratio

[1] EDEN irrigation part 2012-2013-2014-2015 ARVALIS CA31 INRAE (funding CASDAR - Agence de L'Eau Adour-Garonne)

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE

Irrigate with a limiting volume

Maximizing water efficiency

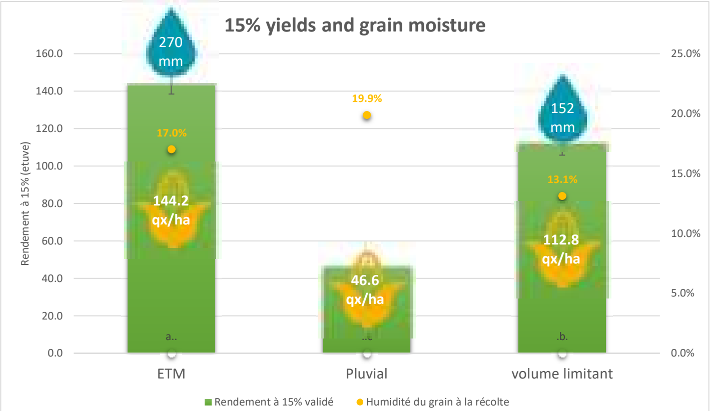
Bringing the right dose at the right time

Maize trial – Le Magneraud 2022

➢ Irrigation at ETM vs Limiting volume

- ETM Driving via Irrélis – classic version
- LV Driving via Irrélis « LV »:

10 leaves • 20 mm • Every 8d → **15 leaves** • 30 mm • Every 6d → **SLAG** • 25 mm • Every 6d → **H50** Stopping irrigation



ETM Driving	Irrigation Efficiency	LV Driving
0.36 q/mm		0.44 q/mm

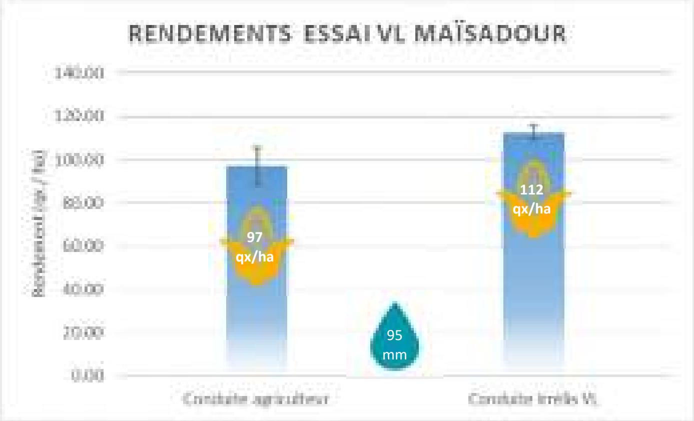
Irrigation water efficiency:
+ 7.42 quintals/ 100 mm brought in LV

Maize trial MAÏSADOUR *– Gers 2022*

➢ At the same volume (930 m³ /ha)

- Farmer driving via Irrélis – classic version
- LV Driving via Irrélis « LV »:

15 leaves • 25 mm • Every 8d → **H50** Stopping irrigation



LV: +15 % of yield compared to driving with classic version

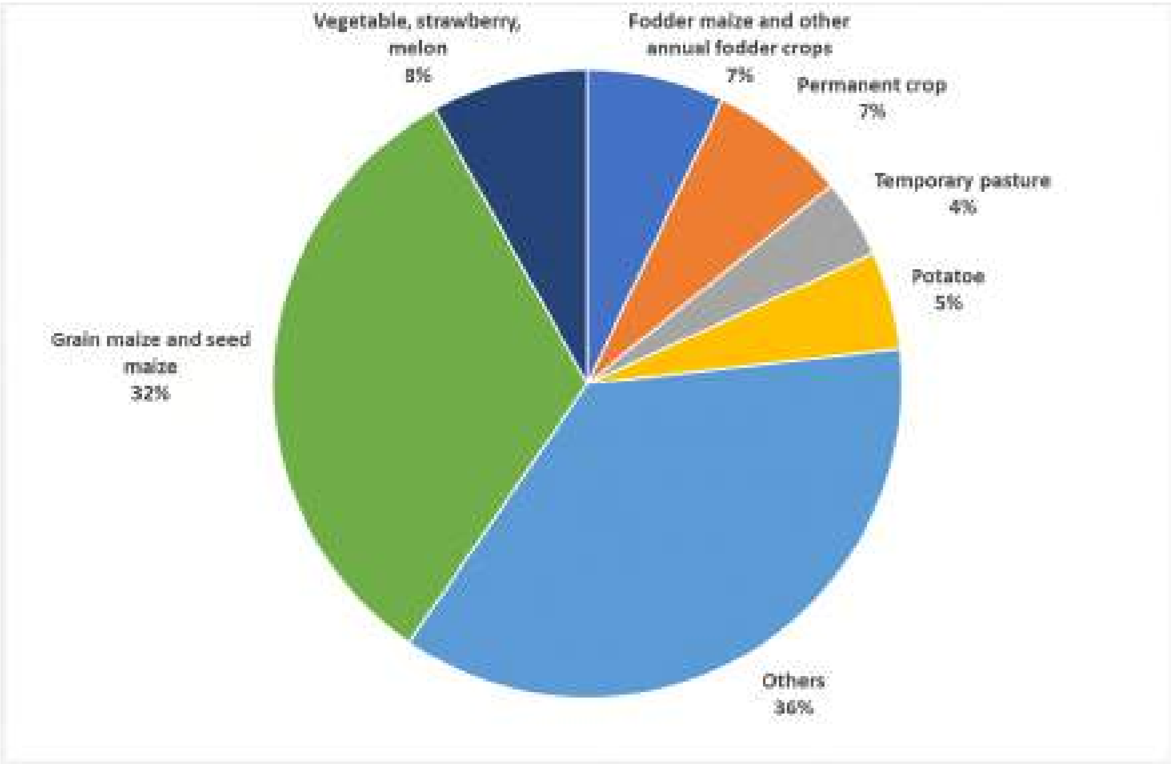
- Irrigate in limited volume: bring water to key stages, adapt the water turn in terms of doses and return time on the field
- **At the same volume:** a LV strategy leads to better technical results
- **Compared to a non-limiting situation:** a LV strategy makes it possible to produce more per mm brought (better irrigation efficiency)

Rdmt moyen
Eau irrigation

En partenariat avec MAÏSADOUR ARVALIS

Irrigation in France

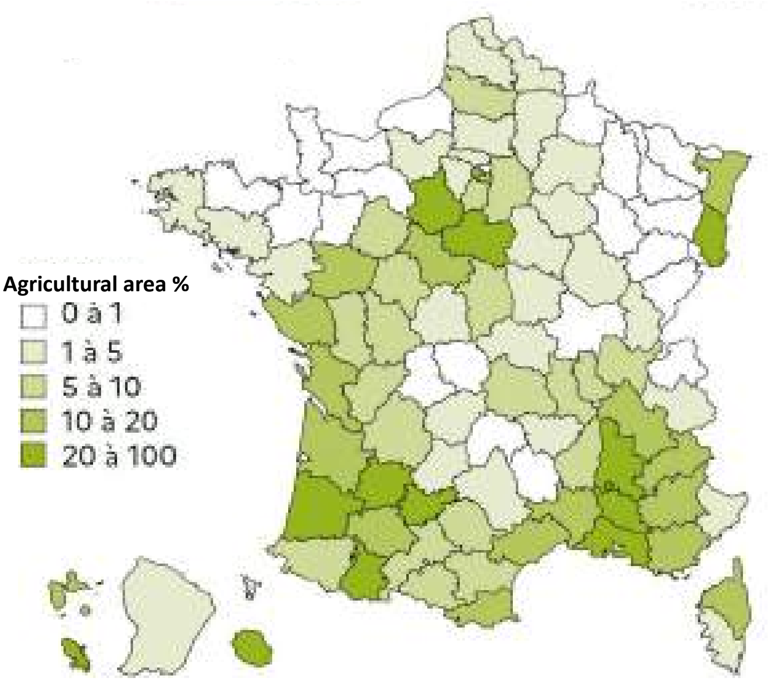
Type of irrigated crops in France



Source: Agreste – Agricultural Census 2020

1.8 million hectares

% of irrigated plot



Source: Agreste – Agricultural Census 2020

France average: 6,8 %

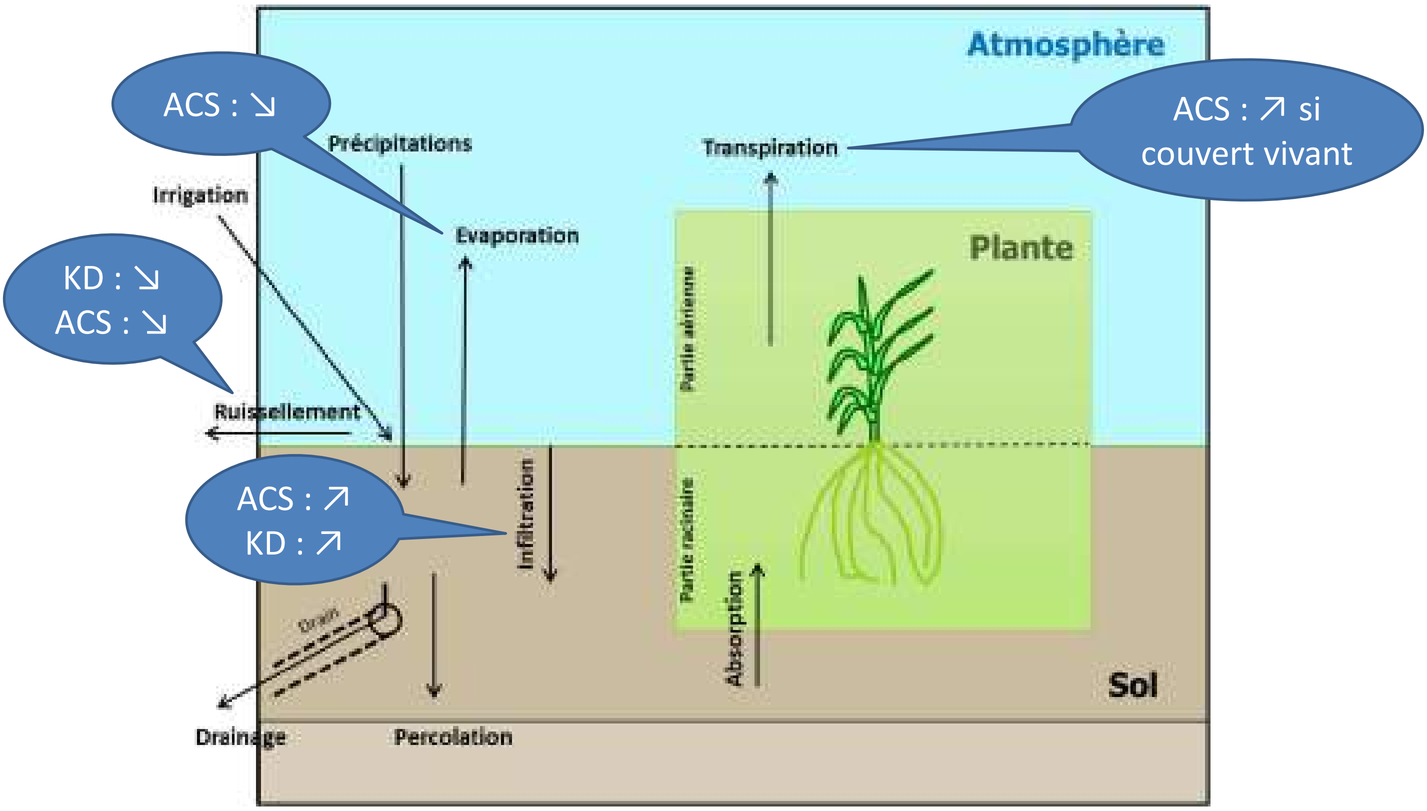
Focus group « Solutions fondées sur la nature et gestion de l'eau »

Funded by the European Commission

Exemples de SFN à l'échelle parcellaire

- Agriculture de conservation

- Keyline design



Etude de l'effet des pratiques sur le cycle de l'eau à l'échelle parcellaire

Pour + d'infos : ***https://ec.europa.eu/eip/agriculture/sites/default/files/fg46-mp1-nature_based_solutions_at_a_field_scale.pdf***

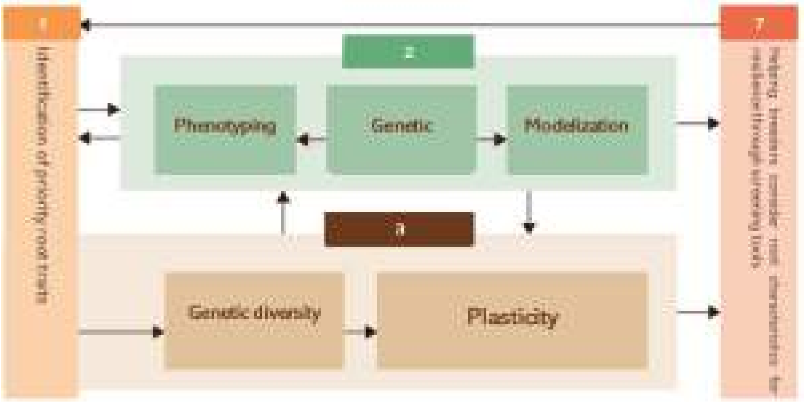
Select by the roots

Context and objectives

The European project **Root2Res** (2022 - 2027) studies **root systems** as levers for improving the **resilience** of cropping systems to the effects of **climate change**. It aims to provide farmers with varieties that are more resilient to thermal and water stress.

Methodology

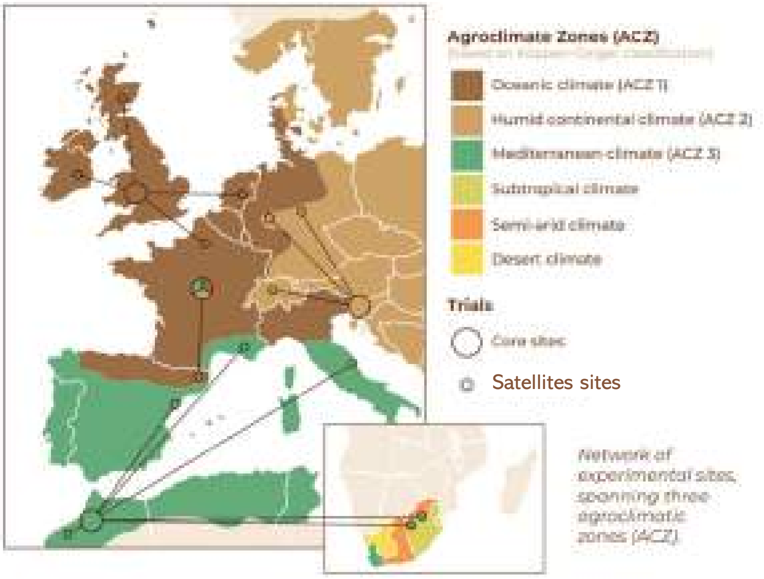
① **Identification** and **testing** of the types of **varieties** most likely to meet the climatic challenges of tomorrow, i.e. tolerant to abiotic stresses and which store carbon.



② Development of a **toolbox** to assist selection and varietal characterization

Genetic	Phenotyping	Modelization
Identification and development of molecular makers Innovative germplasms	Root architecture Rhizosphere Envirotyping	Root growth Interactions within the rhizosphere (microbiome, exudates…) Responses to stress

③ Testing varieties and quantifying root phenotype plasticity in a **network of experimental sites** reflecting European climate and soil variability.



Network of experimental sites, spanning three agroclimatic zones (ACZ)

Root2Res

Funded by the European Union

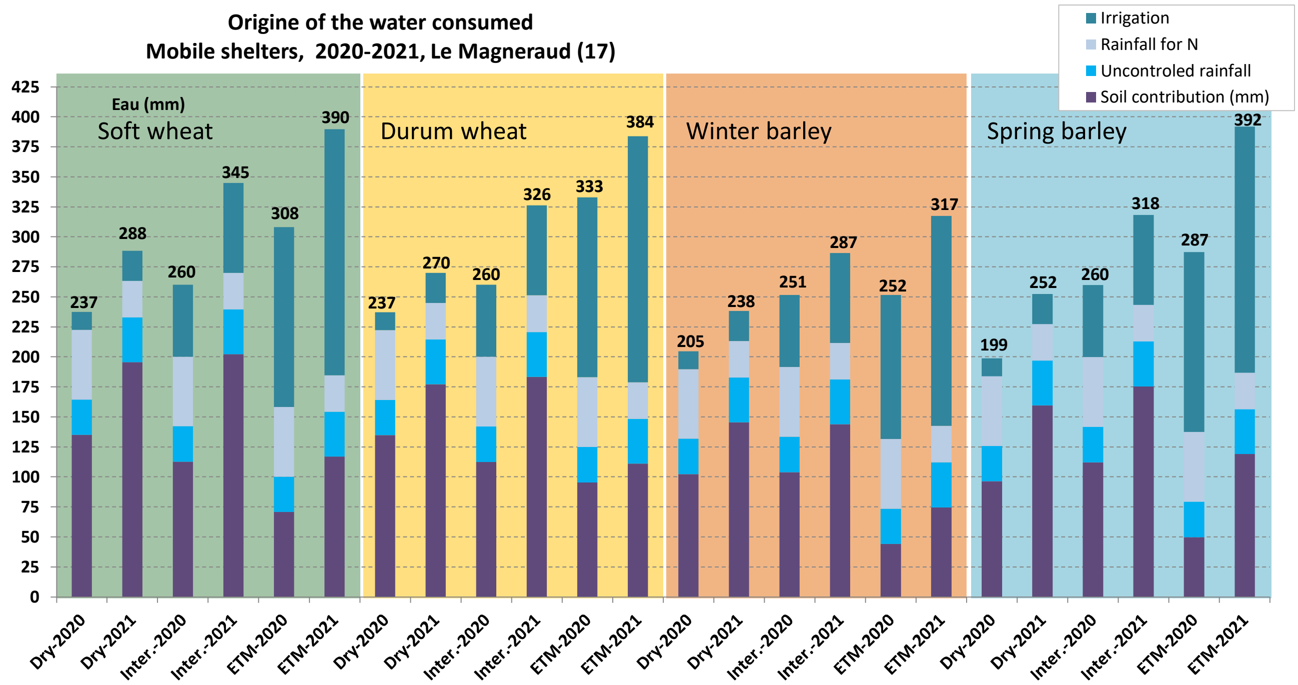
ARVALIS

Straw cereals and water

Magneraud (17) clay-limestone soils, AWC: 150 mm
Sowing winter cereals : 29/10/19 – 31/10/20
Sowing spring barley : 24/01/20 – 17/02/21

- Maximum evapotranspiration (ETM) : covering water needs – piloting of tensiometer probes
- Intermediate : ~ 85 % of the ETM
- Dry : ~ 70-75 % of the ETM

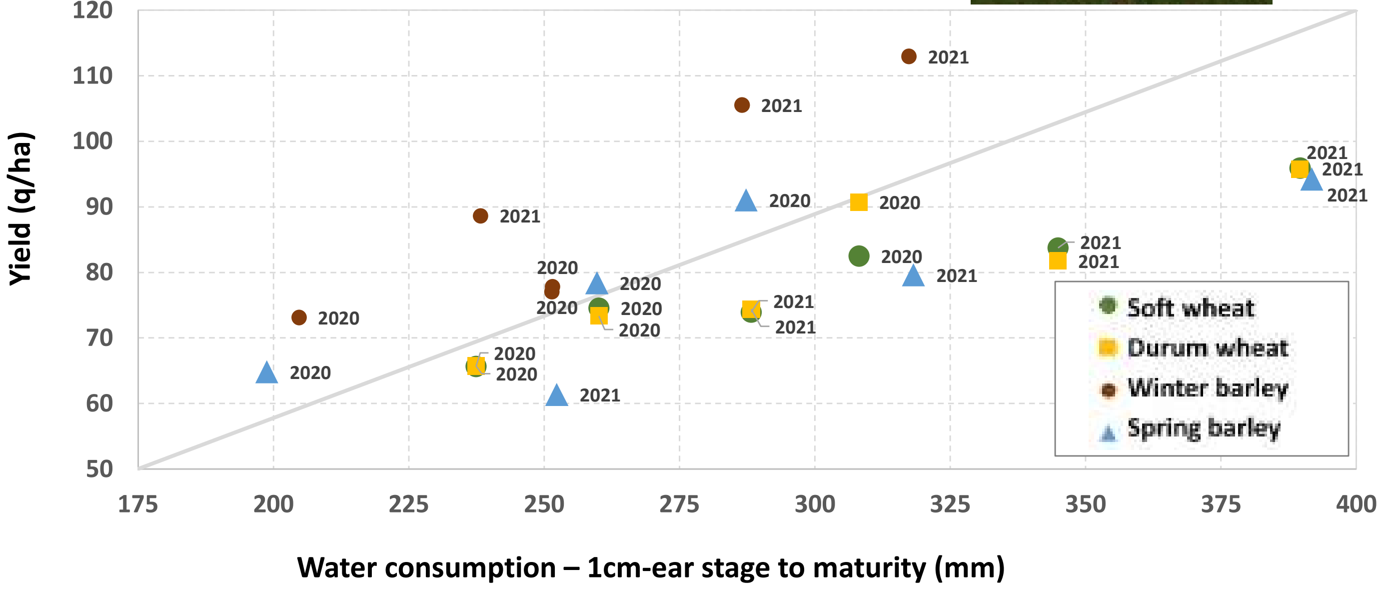
Winter barley consumes less water…



Origine of the water consumed
Mobile shelters, 2020-2021, Le Magneraud (17)

… and is more efficient

Water efficiency – 1cm-ear stage to maturity
Mobile shelters, 2020-2021, Le Magneraud (17)

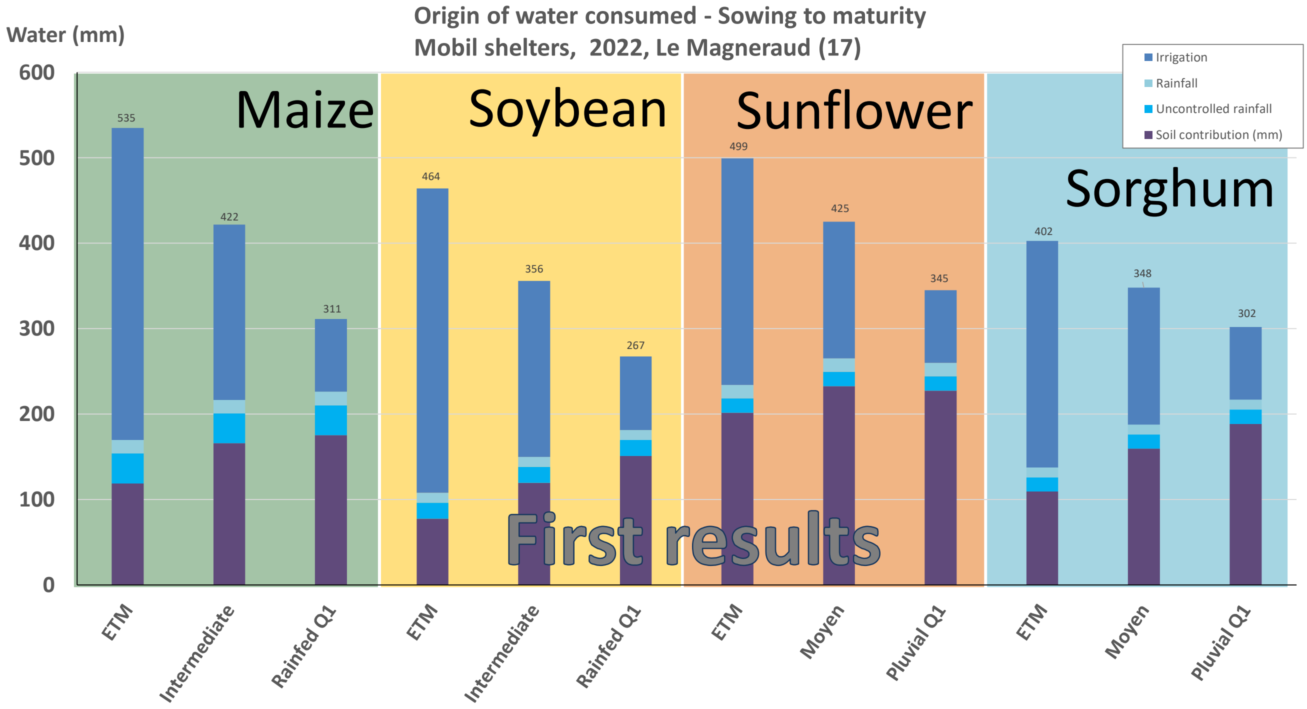


Summer crops and water

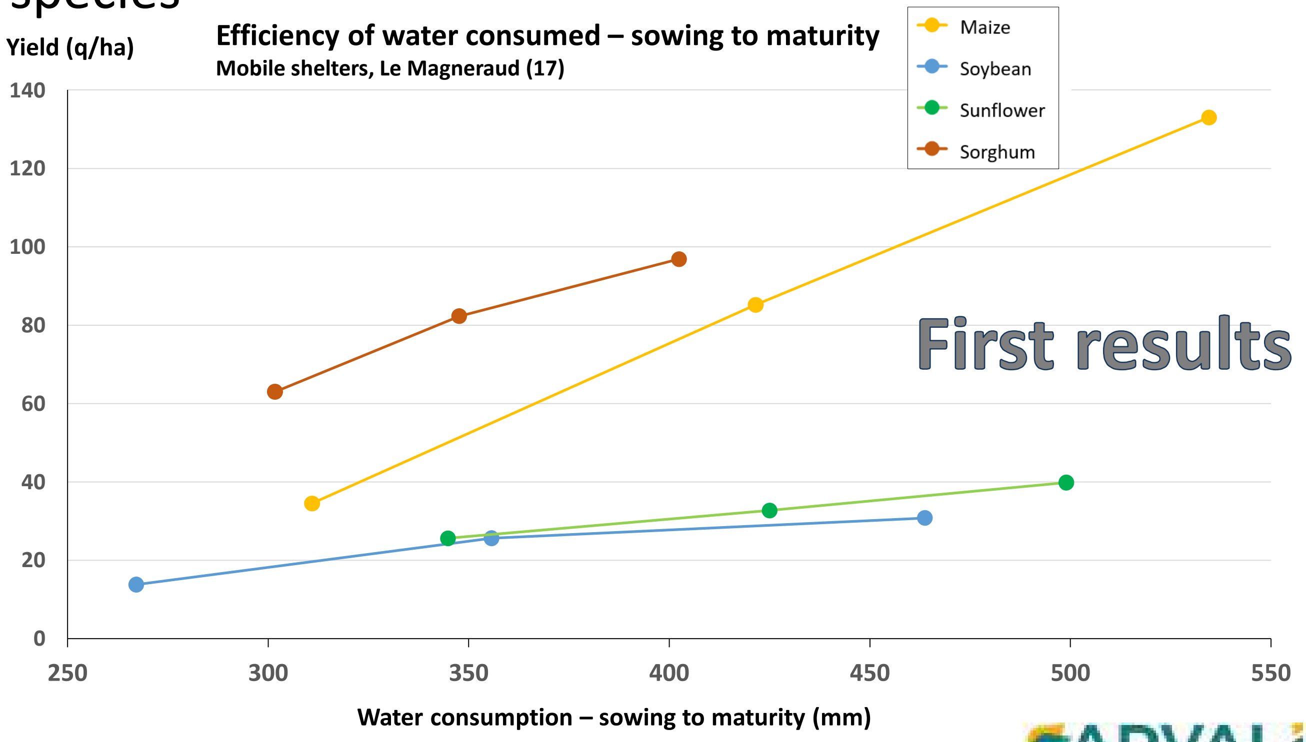
Magneraud (17) clay-limestone soils, AWC: 150 mm
Sowing maize – sunflower : 13/04/22
Sowing sorghum – soybean : 13/05/22

- Maximum evapotranspiration (ETM) : covering water needs – piloting of tensiometer probes
- Intermediate : ~80 % of the ETM
- Rainfed Q1 : ~60-70 % of the ETM

- Stronger water extraction by the sunflower



- Variable efficiency depending on the potential of the species



Les Culturales 2023 14-15 juin

Characterizing the root system for crop resilience

The root system is considered as a lever for improving the **resilience** of **cropping systems** to **climate change** impacts. In the framework of the Horizon Europe project ROOT2RES, we will evaluate and compare methods to measure the **root system** in order to characterize different species and varieties in the field.

Architecture

- Root angle
- Branching density
- Width and depth

Density

- % of soil with root
- Root length density
- Root diameter

Biomass

- Aerial biomass
- Root biomass

Observation methods

Shovelomics

Shovel sampling to a depth of 20cm

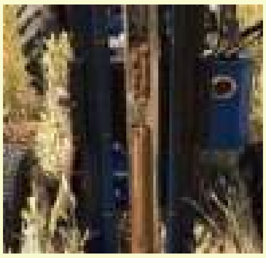
Soil pit

Pit dug to a depth of 1.50m

MiniRhizotron

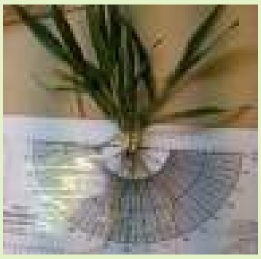
Imaging by rotary scanner in a transparent tube

Soil coring

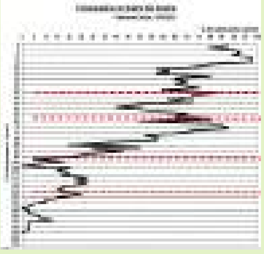


Mechanical sampling of a soil core

Measured traits

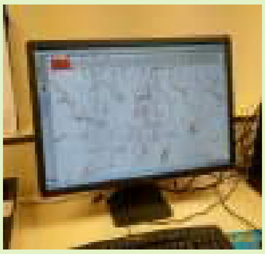


Hand measurements (angle, root type, number, length..)



Root colonization profile for each cm² of soil

Detection and measurement of roots (length and diameter per cm ²)



Scan and analysis of roots (length, diameter and biomass)

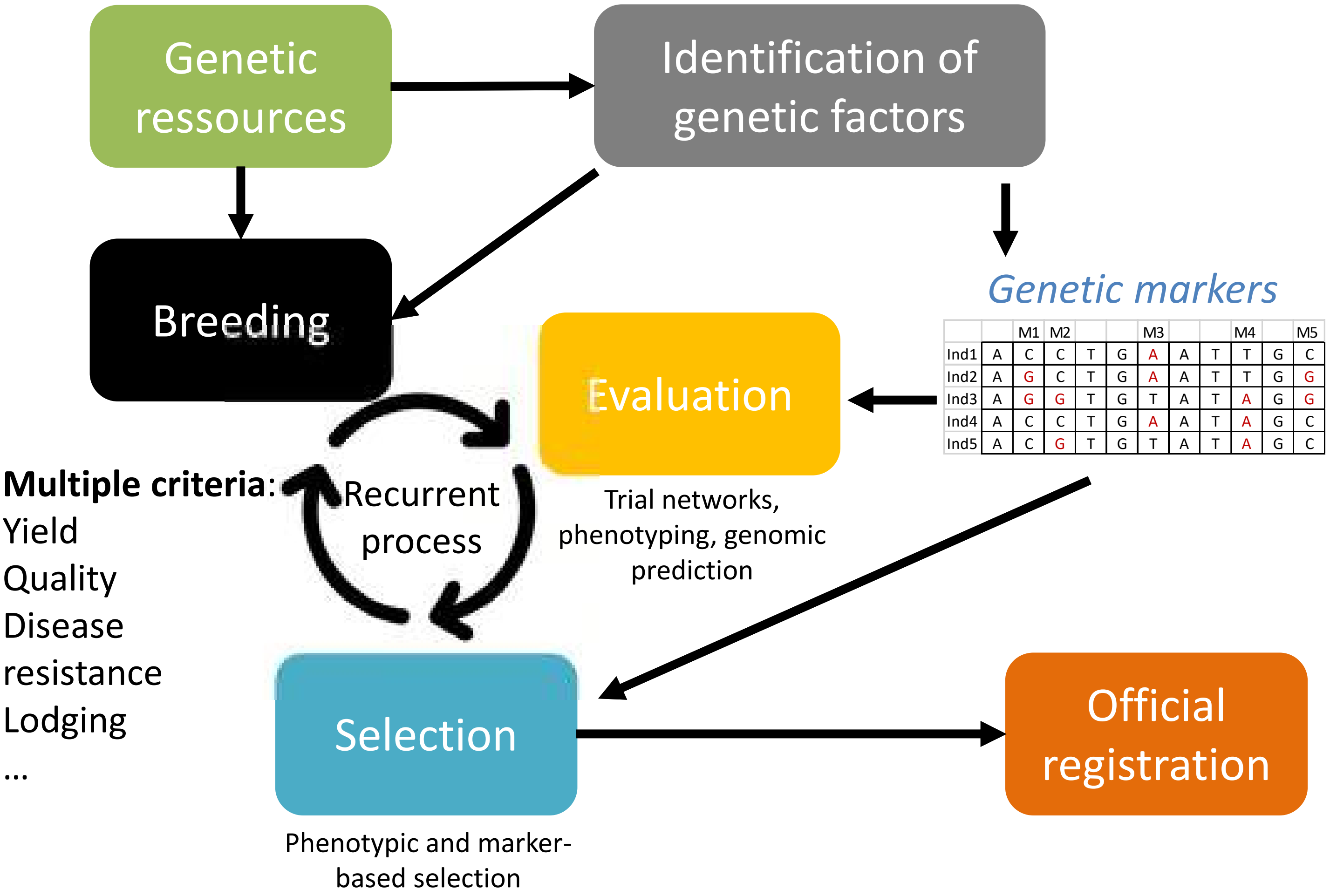
Method evaluation

	Shovelomics	Soil pit	MiniRhizotron	Soil coring
Destructive	**Yes** (0.1 m²)	**Very** (3m³)	**No** (6 cm diameter)	**Few** (machine passage)
Depth	**0-20 cm**	**0-2 m**	**0-1 m**	**0-90 cm**
Number of measurements	**1-2**	**1**	**1 by week**	**1-2**
Measurement time	**Medium** (about 4h)	**Medium** (about 2h)	**Short** (about 30 min)	**Long** (about 5h)
Applications	**Nutrition Interactions with microorganisms**	**Nutrition Adaptation to water stress**	**Adaptation to water stress**	**Nutrition Adaptation to water stress**

Root2Res

ARVALIS

Plant breeding is a major lever to adapt crops to climate change



Genetic ressources

Identification of genetic factors

Breeding

Genetic markers

		M1	M2			M3			M4		M5
Ind1	A	C	C	T	G	A	A	T	T	G	C
Ind2	A	G	C	T	G	A	A	T	T	G	G
Ind3	A	G	G	T	G	T	A	T	A	G	G
Ind4	A	C	C	T	G	A	A	T	A	G	C
Ind5	A	C	G	T	G	T	A	T	A	G	C

Evaluation

Trial networks, phenotyping, genomic prediction

Multiple criteria:
Yield
Quality
Disease resistance
Lodging
…

Recurrent process

Selection

Phenotypic and marker-based selection

Official registration

- Plant breeding contributes to the adaptation of crops to climate change by improving the **response to abiotic stress** (drought, heat):
  - **Stress escape** (earliness)
  - **Stress avoidance** by increasing access to ressources (root traits)
  - **Stress tolerance** (reduced impact)

- **Different levers** allow accelerating and facilitating plant breeding :
  - The identification of interesting **genetic ressources**
  - The identification of favorable **genetic factors**
  - The use of **genetic markers**
  - Improved **phenotyping techniques**

Introgression of a heat stress tolerance gene

Context

- **Climate change** will increase the **occurrence and the intensity of extreme events** including **heat waves**
- A **heat stress tolerance gene** (*WtmsDW*) was found in an australian spring wheat variety called « Waagan » (Erena et *al.* 2021)
- WtmsDW **reduces the impact** of a strong stress before heading of about 50%
- **Genetic markers** allow identifying varieties carrying this gene
- The introgression of this gene in french winter wheat material could allow **improving heat stress tolerance**

Identification of the gene of interest

Creation of the study population

Drysdale × Waagan

↓

F1 hybrids

↓

144 doubled haploid lines

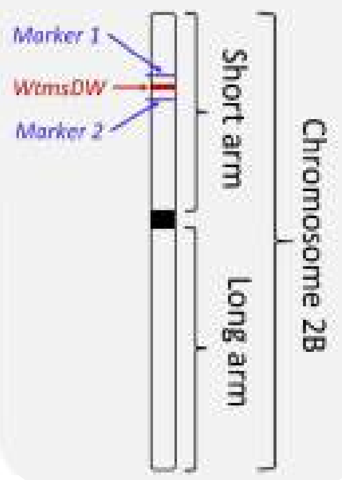
Characterization of the population

DNA analysis (genetic markers)

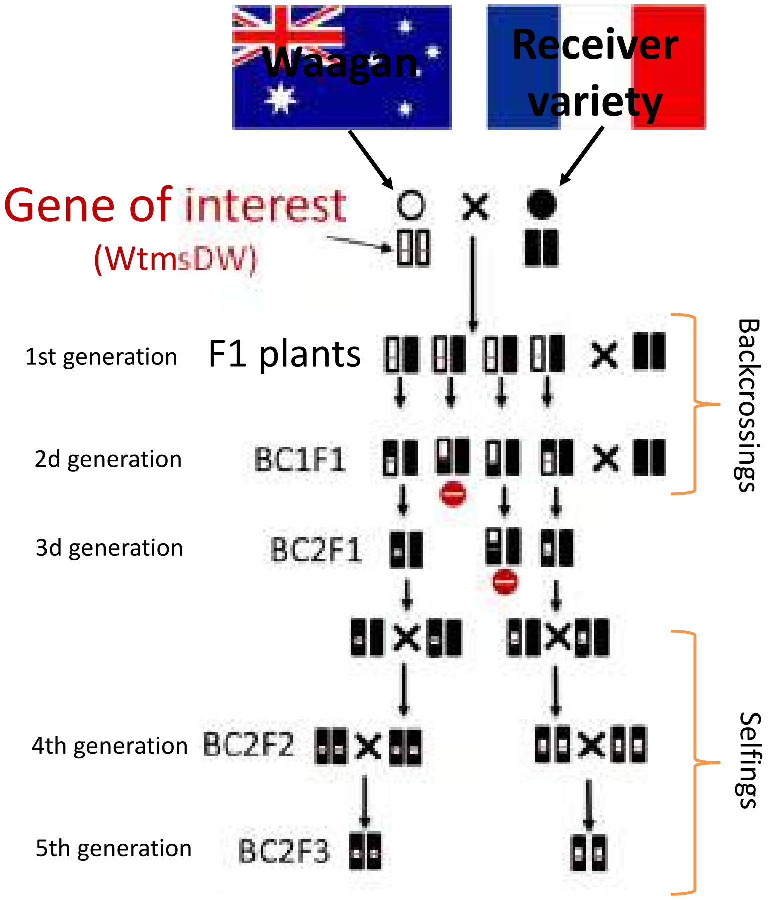
\+

Phenotyping heat stress tolerance

Mapping of the *WtmsDW locus*



Breeding scheme



- Waagan holds the gene of interest and **will be crossed with a french variety**
- F1 plants will be **backcrossed** with the french receiver variety
- Genetic markers will be used to identify **lines carrying the gene of interest**
- Lines of interest will be **selfed to get pure lines**

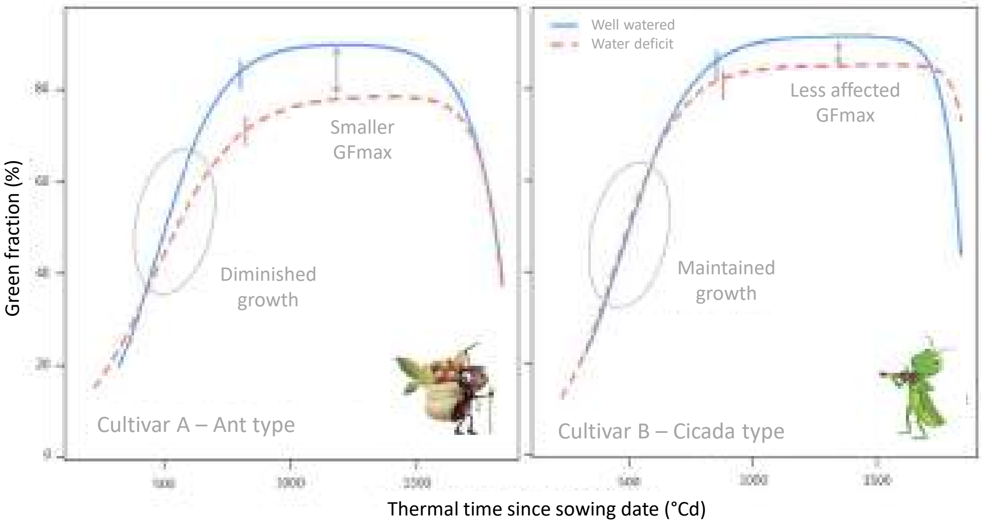
Identifying contrasting corn cultivar tolerance to water deficit

Climate change significantly affects the duration, the intensity and the frequency of water deficit. According to the stress scenario, all maize yield components can be more or less affected. High troughput phenotyping help us caraterize cultivar response to a precisely managed water deficit.

Caravage Project **(Casdar, 2018) :**

11 cultivars
X
2 hydric treatments
(Well watered et stress before silking)

Cultivated on a phenotyping plateform:
Phenofield (France, 41)



Two distinct cultivar behaviours:

Ant: maintains its ressources by diminishing its growth as soon as deficit arrives, ideal if the stress last

Cicada: tolerate the stress by maintaining its growth, will be penalizing if the stress last (exhaustion)

Two contrasting responses of yield and its components:

Ant: tends to maintain their grain number but diminish their grain wieght

Cicada: tends to maintain their grain weight but diminish their grain number

		Yield (qx/ha)		Grain weigth (g per 1000)		Grain number (/m²)	
Ant	WW	124	- 16.1 %	426	- 10.1 %	4341	+ 7.0 %
	WD	104		379		4645	
Cicada	WW	140	- 19.3 %	343	+11.3 %	6219	- 28 %
	WD	113		383		4453	

High througput phenotyping allows a **precise cultivar evaluation.**
This open new possibilities of agronomic advises, by considering to **adapt cultivar choice to the precise hydric situation** of a field

Testing the genetic material in extreme weather in order to anticipate our futur needs

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Contexte

Global warming is changing our weather: we have to figure out what is going to happen in the futur.

Chartres Today

In 2070 ?

RCP 4.5

Avignon (84)

Source : *https://shiny.cism.ucl.ac.be/pbarriat/analog/*

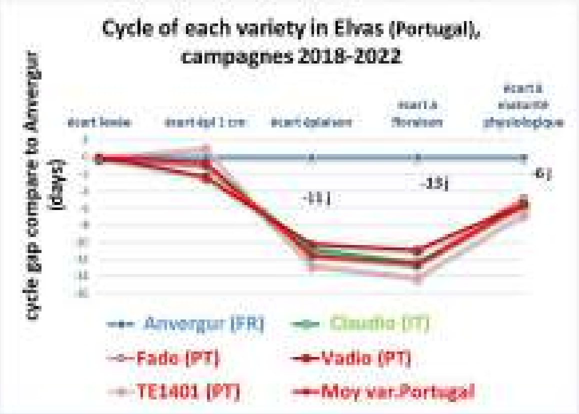
We can observe what is happening abroad in countries where the actual weather is going to be our weather in the futur

Trials at Elvas in Portugal

Main Objectives

- Testing the French varieties that we are using today with our futur weather conditions.
- Compare those French varieties with varieties that have been selected abroad in more stressfull weather conditions.
- Understand the differences between varieties and the strengths and weaknesses of each variety in extreme weather.

Differences in physiology…



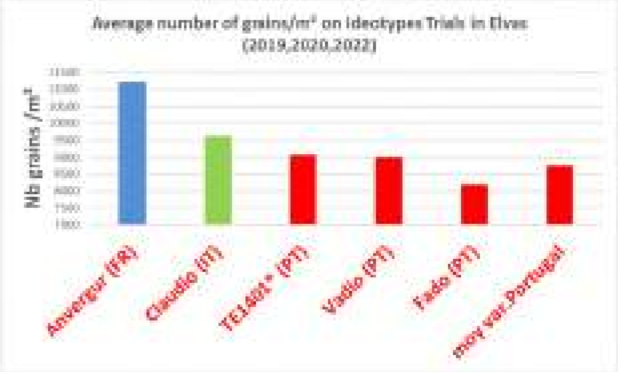
	French Variety (medium early)	Protuguese varieties (early)
Average number of days to fill the grain	39	46

Portuguese varieties (in red =PT) cultivated in Elvas head more quickly than the French variety Anvergur (in blue = FR). Their physiological maturity is also faster.

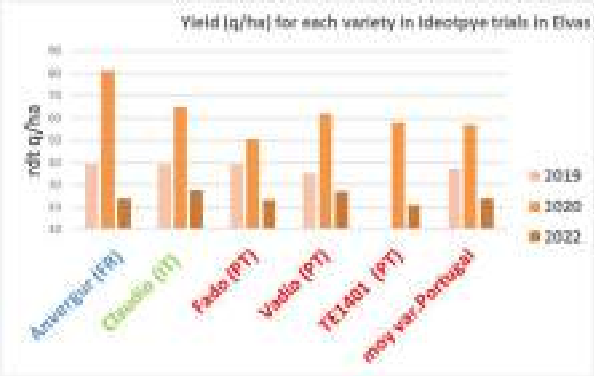
Finally their grain filling lasts longer.

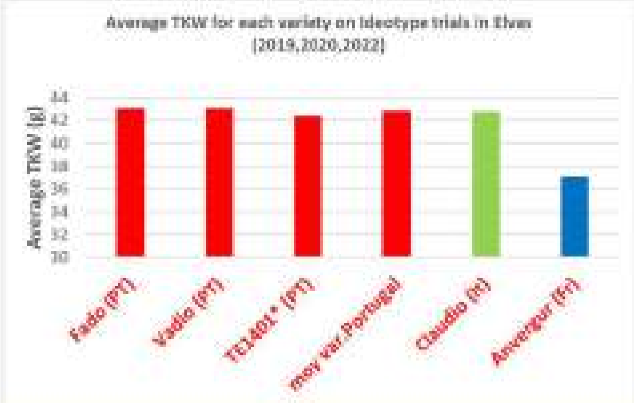
-> More time to fill the grains and less exposure to the hydric and thermic stresses.

…and also in the way to build the yield.



* TE 1401 have been in trials since 2020.





Portuguese varieties that have been tested have a bigger TKW but they produce less grains per m² compared to the very fertile variety Anvergur. Anvergur's yield is close to the portuguese varieties's yields during the dry years (2019 et 2022) and higher during the rainy years (2020) .

There is no perfect profile for yield components:

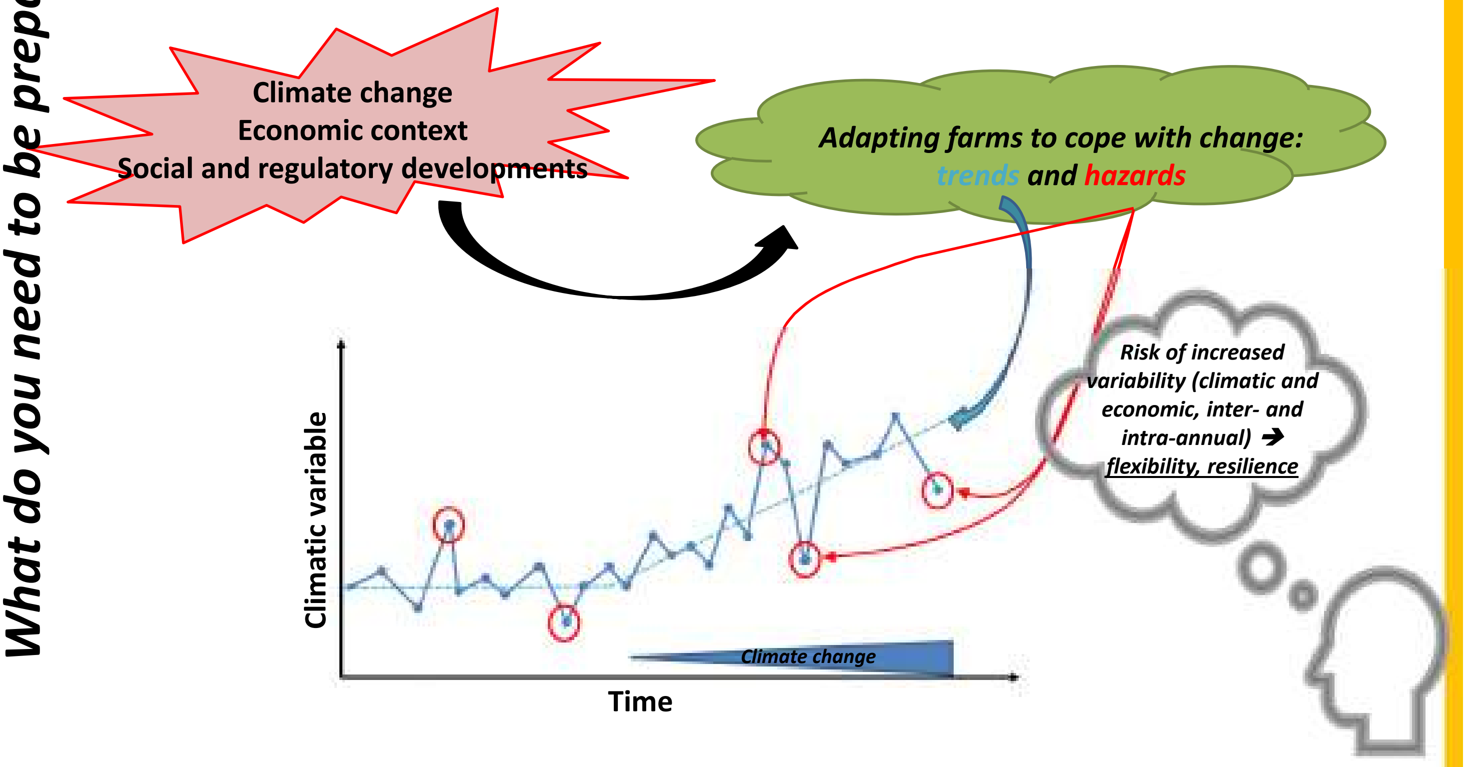
-> If the end of the wheat cycle is dry, having a good fertility of ears but a small TKW or having a big TKW but a low ears fertility looks to be the same.

-> a lack of fertility seems to limit the yield if the weather conditions become better at the end of the cycle.

ARVALIS

Increasing constraints and hazards: adapting cropping systems to new contexts

What do you need to be prepared for?

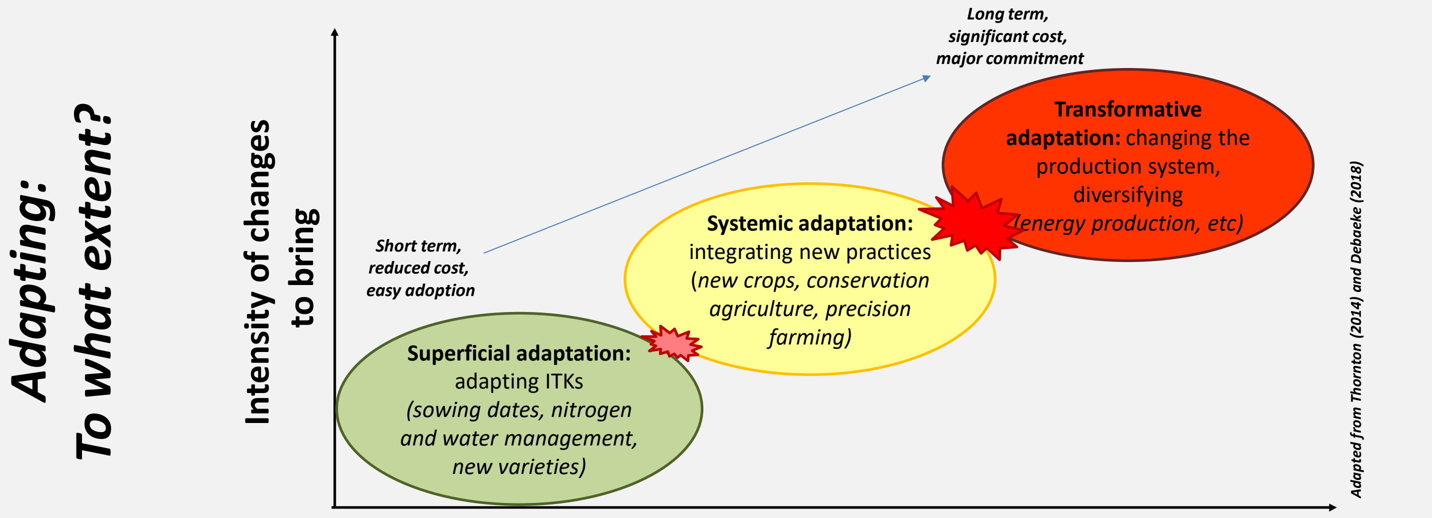


Climate change
Economic context
Social and regulatory developments

Adapting farms to cope with change: trends and hazards

Risk of increased variability (climatic and economic, inter- and intra-annual) ➔ <u>flexibility, resilience</u>

Adapting: To what extent?



Superficial adaptation: adapting ITKs *(sowing dates, nitrogen and water management, new varieties)*

Systemic adaptation: integrating new practices (*new crops, conservation agriculture, precision farming)*

Transformative adaptation: changing the production system, diversifying *(energy production, etc)*

Adapted from Thornton (2014) and Debaeke (2018)

➔ Adaptation must be adjusted to the intensity of the constraints

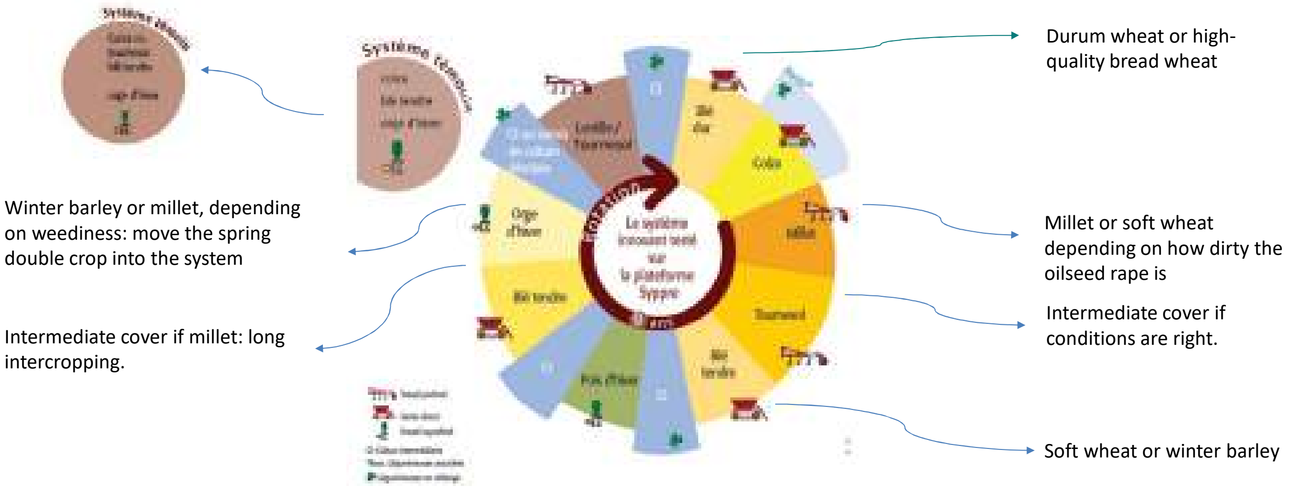
In search of solutions

Climate change:

-	***Temperatures on the rise!*** ➔	*Winter versus spring crops?*
-	***Increased water deficit in summer!*** ➔	*Water management on the farm?*
-	***Risk of climatic hazards!*** ➔	*Diversification? Protection?*

Syppre Berry, flexibility as a way of adapting to Climate Change

Climate change in Berry area:
- Increased variability in spring crop performance
- Difficulty in establishing cover crops
- High temperatures and water stress



Durum wheat or high-quality bread wheat

Winter barley or millet, depending on weediness: move the spring double crop into the system

Millet or soft wheat depending on how dirty the oilseed rape is

Intermediate cover if millet: long intercropping.

Intermediate cover if conditions are right.

Soft wheat or winter barley

Indicators	Objectives	Average Innovative 2017-2022	Deviation from control	Coefficient of variation for the innovator	Coefficient of variation for the control
Gross energy production (MJ/ha)	>=Timer	**65** 680	- 21 %	15%	12%
Direct margin with aids (€/ha)	>=Timer	435	- 13 %	37%	15%
EBITDA (€/UTH Family)	>=Timer	**58** 762	- 12 %	43%	19%
IFT **Total** (excluding TS)	50% off / Reg. Ref. ^{1}	**3.6**	**- 37** % - 28%/tem	18%	26%
Mineral nitrogen input (kg/ha)	-20% off / Control	104	- 32 %	12%	13%
GHG emissions (kgeqCO2/ha)	-20% off / Control	1456	- 29 %	7%	16%

Major weed problem: **Black-grass and geranium**
- Positive effect of double **succession of spring crops**
- Negative effect of **a succession of 4 winter crops**
- Failure of other levers used (ploughing/false seeding)
- Diversification crops do **not provide** the expected economic strength

System redesign: greater flexibility in crop choice for greater robustness

- Integrating **and adapting** phases of weed cycle disruption **to the pressure observed** thanks to the succession of 2 spring crops.
- Introduce **symbiotic nitrogen** using **leguminous** crops or cover crops.
- Adapting intercropping and tillage practices according to weed pressure in the plot to continue to meet the **objectives of maintaining soil fertility.**
- **Making the most of the system effect** to improve **pest management** and **reduce** production **costs.**

Comparison of Robust Rapeseed management between control and innovative varieties

Average 2017 - 2022 (excluding 2019)	Rapeseed Indicator	Rapeseed Innovative	Δ
Yield (q/ha)	23	27	+ 4
Autumn insecticide IFT/ha	1.26	0.96	- **0.3**
Direct margin with aids (€/ha)	436	573	+ 136

Comparison of Wheat management between control and innovative varieties

Average (2018 - 2022)	Control rapeseed wheat	Innovative sunflower wheat	Difference
Yield (q/ha)	66	72	+ 6
Herbicide IFT/ha	3.2	2.1	- **1**.1
Direct margin with aids (€/ha)	748	992	+ 244
Mineral N (kg/ha)	171	161	- 10
GHG emissions (kgeqCO2/ha)	2 398	2 145	- 253

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE

Syppre Lauragais, preserving the soil and diversifying crops to adapt to climate change

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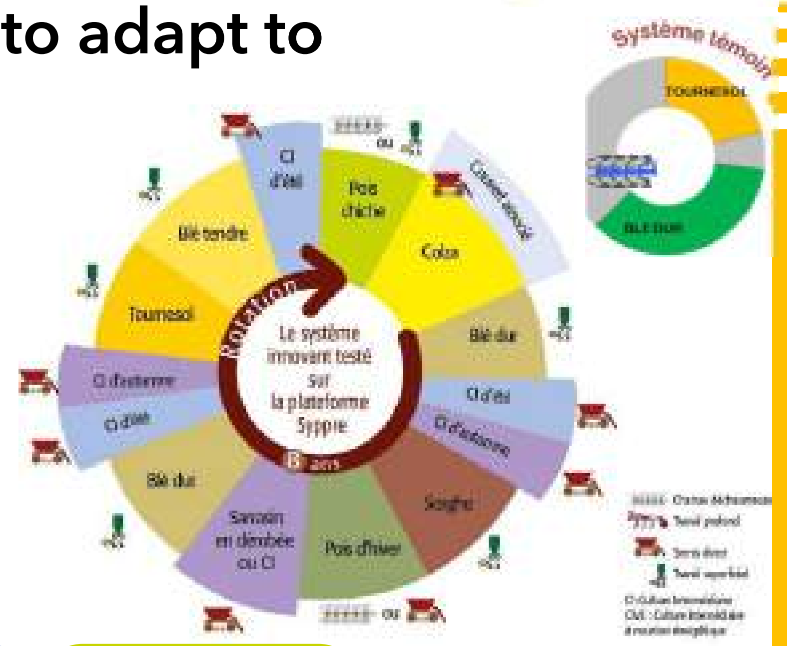
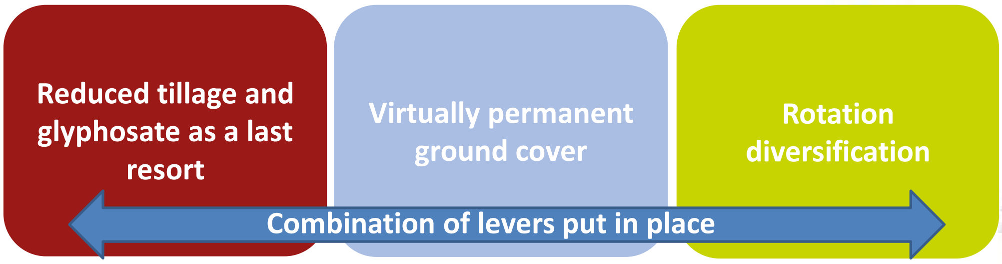


Pedo-climatic context: Clay-limestone **slopes** susceptible to erosion and with low OM content (1.7% in 2015) - **rain-fed system.**

Perspectives on Climate Change:

- **Water stress** more marked in spring and lasted longer, impacting all crops.
- Thunderstorms: **spatial and temporal irregularity of** rainfall
- **High** temperatures



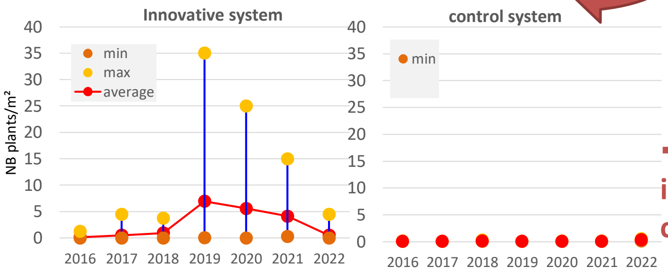
Reduced tillage and glyphosate as a last resort

Virtually permanent ground cover

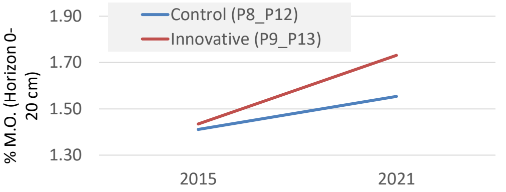
Rotation diversification

Combination of levers put in place

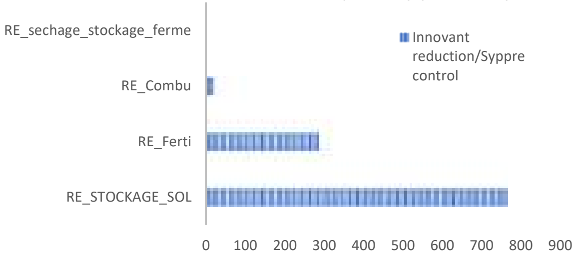
Counting ryegrass after weeding



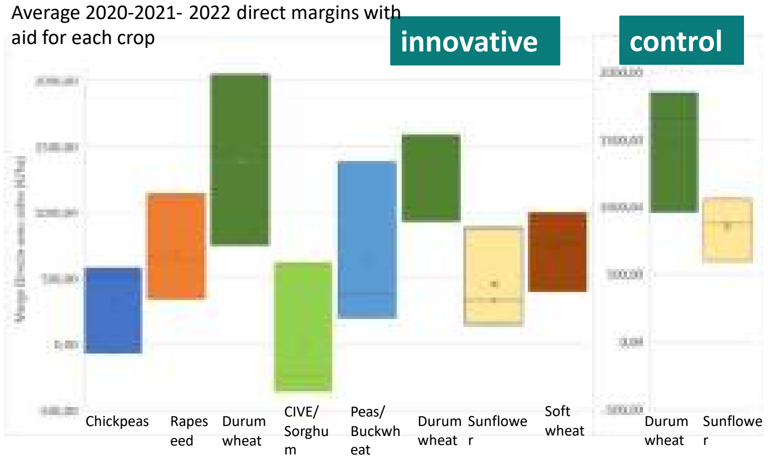
➔ Effet negative impact on weed cover



SUMMARY OF C REDUCTIONS OBTAINED OVER THE DURATION OF THE LBC PROJECT (5 YEARS) PER ITEM AND OVER THE ENTIRE FARM (170 HA) (IN TQCO2)



Average 2020-2021- 2022 direct margins with aid for each crop



Variable performance of diversification crops

➔ Effet negative impact on margins due to dilution of profitable crops

→ Opportunistic strategy for using cover crops as CIVE or catch crop depending on the year's biomass

Protection of the soil against erosion, improved structural stability, increased OM and C stocks in the soil.

→ Preservation of soil capital

→ Mitigating CC and improving the GHG balance

Syppre
MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE
ClieNFarms

Increased constraints and hazards: adapting the cropping system to the new context

Adapting systems: Syppre systems provide us with lessons learned:

- There are **many constraints** (agronomic, environmental, economic, social).
- **There are various levers** (tillage, choice of species) which **must be combined** to achieve the desired objectives.
- There is **no ideal scheme**: the results are performance **compromises** between criteria of interest.
- **Identifying/mastering solutions takes time**

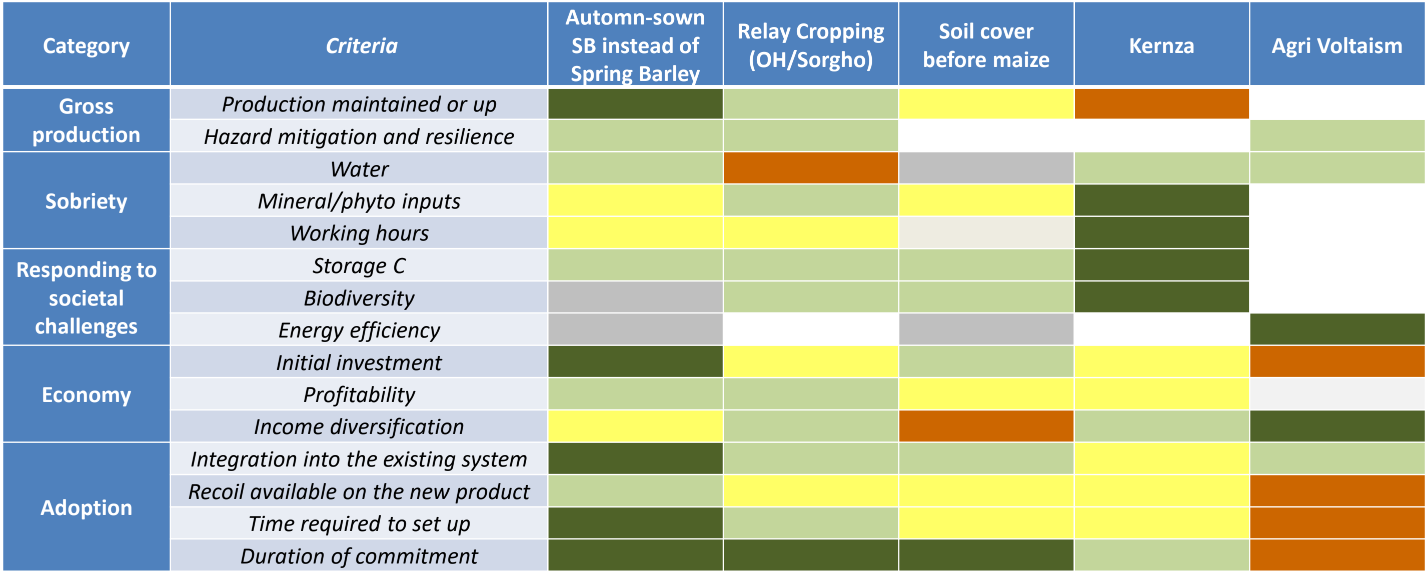
To remember:

- **It is not possible to carry out comprehensive field trials today** to recommend the system(s) of tomorrow.
- **Climate change is** a long-term phenomenon; it will require both "short-term" adaptation, which will influence technical itineraries, and very often profound long-term changes to production systems.
- **Hazards** (climatic, economic, health) **will have to be taken into account just as much** as the warming trend, because it is destabilising.
- **There will be many forms of adaptation**, specific to each environment and each farm.

What can we expect from the technical solutions presented here (in the context of the Southern Paris Basin)?

Favourable ➔ Unfavourable 🟩 🟢 ▨ 🟨 🟧

Little referenced ⬜



Category	*Criteria*	Automn-sown SB instead of Spring Barley	Relay Cropping (OH/Sorgho)	Soil cover before maize	Kernza	Agri Voltaism
Gross production	*Production maintained or up*	🟩	🟢	🟨	🟧	⬜
	Hazard mitigation and resilience	🟢	🟢	⬜	⬜	🟢
Sobriety	*Water*	🟢	🟧	▨	🟢	🟢
	Mineral/phyto inputs	🟨	🟢	🟨	🟩	⬜
	Working hours	🟨	🟨	⬜	🟩	⬜
Responding to societal challenges	*Storage C*	🟢	🟢	🟢	🟩	⬜
	Biodiversity	▨	🟢	🟢	🟩	⬜
	Energy efficiency	▨	⬜	▨	⬜	🟩
Economy	*Initial investment*	🟩	🟨	🟢	🟨	🟧
	Profitability	🟢	🟢	🟨	🟨	⬜
	Income diversification	🟨	🟢	🟧	🟢	🟩
Adoption	*Integration into the existing system*	🟩	🟢	🟢	🟨	🟢
	Recoil available on the new product	🟢	🟨	🟨	🟨	🟧
	Time required to set up	🟩	🟢	🟨	🟨	🟧
	Duration of commitment	🟩	🟩	🟩	🟢	🟧

Do you have any ideas or experience? Let us know!

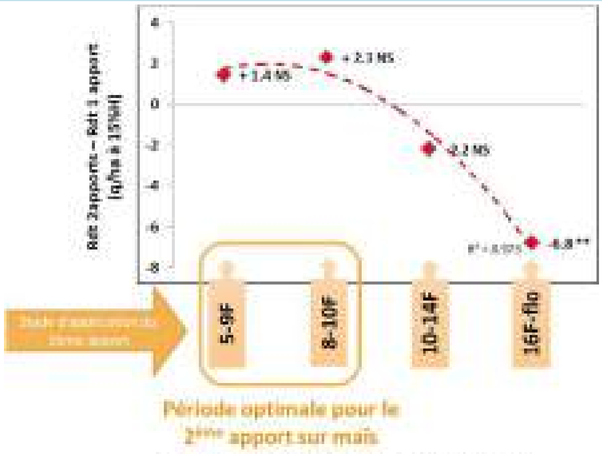
➔ *write them on the board*

Space 4 :

PLANT NUTRITION

Maize fertilization: keys to success

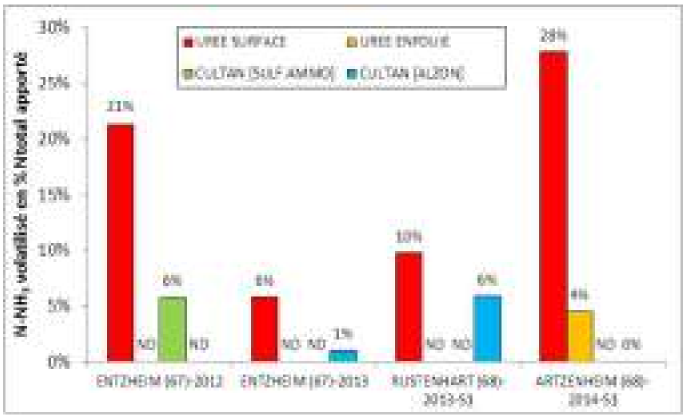
FRACTIONATING NITROGEN INPUTS



Comparisons at the same total dose N.
1st supply : 40 to 70 kgN/ha of urea on the surface between sowing and 4 leaves
2nd supply between 5 leaves and flowering.
Trials 1992-2017 (France).

+ 0.76 t/ha !	Gain from carry-over to 5-9 leaves of input rather than sowing (in case of significant nitrogen residues) (averages of 3 comparisons)

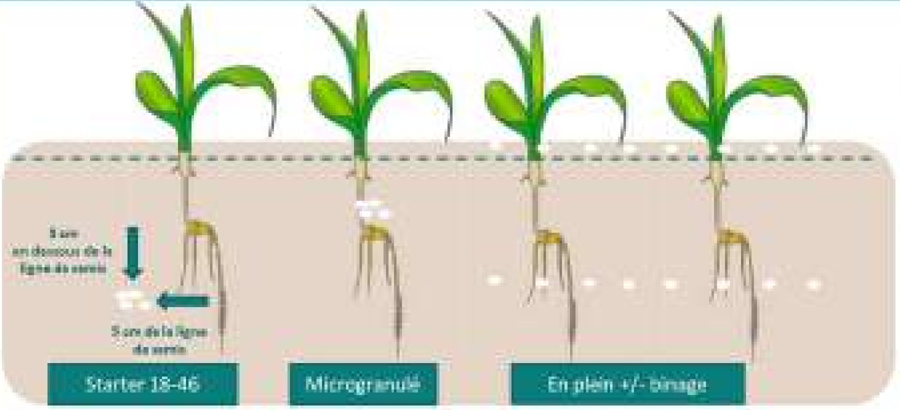
LANDFILL INPUTS TO LIMIT NH3 VOLATILIZATION



Comparison of volatilized N at the same dose of N for different forms of nitrogen fertilizer.
Arvalis - 4 trials 2012-2014, Interreg INDEE

Landfill = physical barrier to volatilization

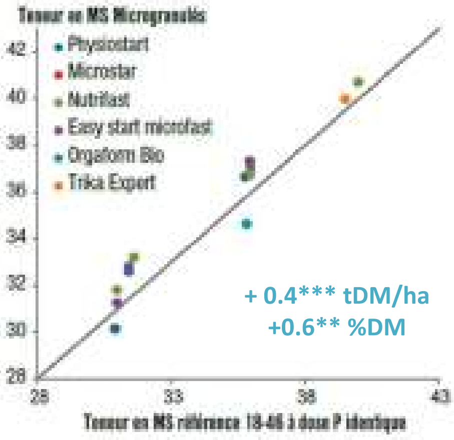
STARTER FERTILIZER : phosphorus to stimulate root growth



Recommanded for :
- For early sowing
- In difficult conditions (cool, moist soils, acidity, presence of soil pests)
- According to availability in P of the soil

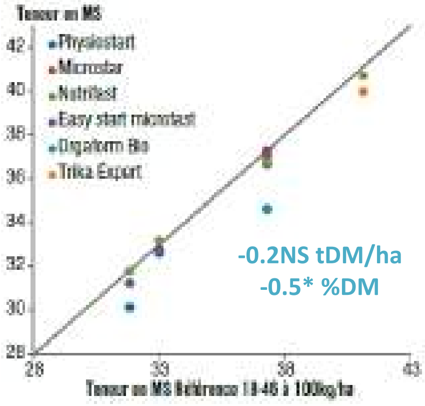
Comparison of different microgranulated starter fertilizers to the localized starter reference 18-46

At the same phosphorus dose approx. 10 kg P2O5/ha



+ 0.4*** tDM/ha
+0.6** %DM

At the usual dose of 100 kg/ha or 46 kg P2O5/ha



-0.2NS tDM/ha
-0.5* %DM

Interest of the starter

- ↘ basal dressing
- ↗ Homogeneity of culture
- ↗ the speed of maize installation
- ↘ the risk of pest attack
- Advanced flowering (1.5 to 2 days)
- ↗ Yield :
  - Better preservation if foliage diseases are early
  - Possible depending on the soil (light soils >> clays)

ARVALIS

Maize biostimulants

« Plant biostimulant »

- A european fertilizer
- With functions to stimulate plant nutrition processes regardless of the nutrients it contains
- To enhance one or more of the following plant or rhizosphere characteristics:

QUALITATIVE CHARACTERISTICS

TOLERANCE TO ABIOTIC STRESSES

NUTRIENT USE EFFICIENCY

AVAILABILITY OF NUTRIENTS IN SOIL AND RHIZOSPHERE

Different origins

"Simple" organic compounds
Acides aminés et dérivés protéiques d'origine végétale ou animale, lipides, glucides)

Plant and algae extracts

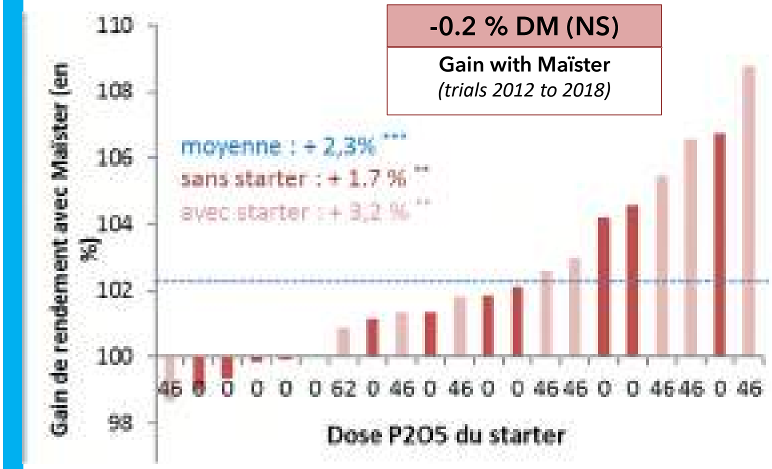
Non-nutritive mineral substances (e.g. silicon)

Organic macromolecules (humic acids, fulvics, chitosan…)

Micro-organisms (bacteria, fungi including mycorrhizae, yeasts) and derived extracts

Maïster®, UPL
«Improved nutrient use efficiency »

Yield gains obtained with Maïster in addition or not to a supply of 18-46



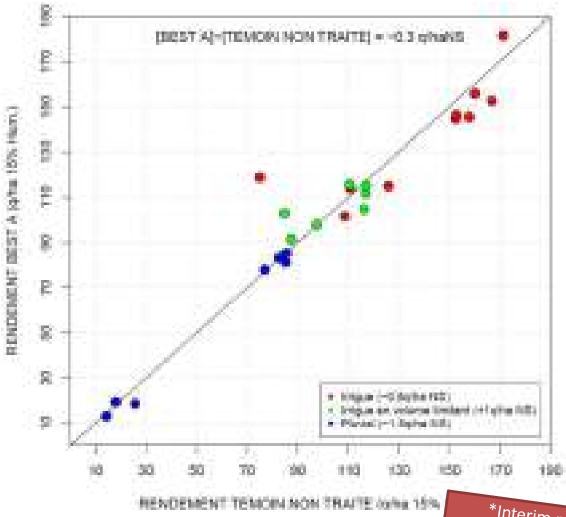
-0.2 % DM (NS)

Gain with Maïster
(trials 2012 to 2018)

Results of the 11 trials conducted between 2012 and 2021:
- Significant yield gain (+2.3%)
- Gain with or without the use of a starter
- No significant gains of vigor were identified

Best-A®, Elicit Plant
« Improved tolerance to abiotic (water) stresses"

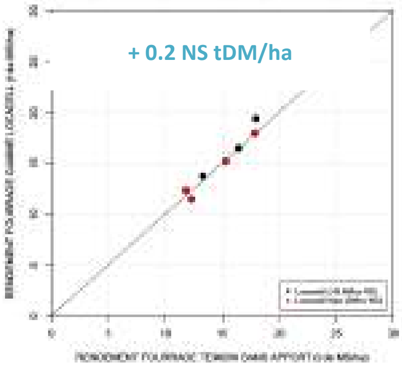
Comparative performance of untreated control and BEST A on maize yield



*Interim results
To be continued in 2023

Results of a single trial year (2022)*:
- No significant yield gain in 2022, marked by no rain and early water stress
- Gain on the weight of a thousand grains
- Continued testing to better identify optimal application contexts

Rise-P Locacell® or Rise-P Locacell Neo®, LALLEMAND
« improved availability of nutrients from the rhizosphere and soil »



+ 0.2 NS tDM/ha

Comparative performance of the control without input and Locacell bisotimulants on maize forage yield.

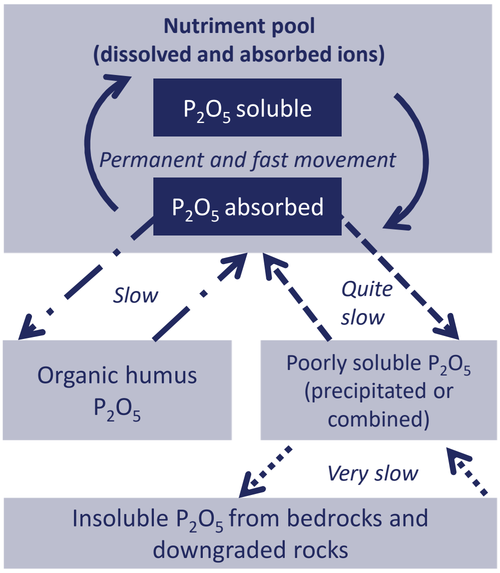
Interim results
To be continued in 2023

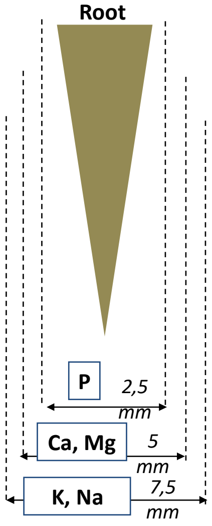
Results of the 7 trials conducted between 2014 and 2017 on forage maize:
No significant gain in yield, vigor, flowering date, %H.
Variable results, which can be related to: soil richness in P? Climatic conditions (cold after sowing, drought, …)? N fertilization at sowing? … trials renewed in 2023 in sweet corn and seeds.

ARVALIS

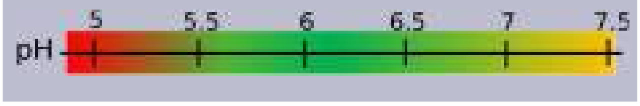
How to bring phosphorus?

Dynamics of Phosphorus in Soils

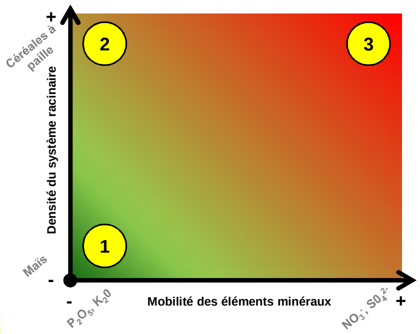




- **Distribution:**
- 1/3 organic
- 2/3 mineral or associated
- **Quantity in the horizon 0-30 cm:**
- 9 to 18 t/ha total P_2O_5
- **In solution in the 0-30 cm horizon:**
- The concentration of P in solution is low: 400 g of P_2O_5/ha
- **Bioavailability of P according to pH value**



Location: what's the benefit?



1 **INTEREST +++** **EXAMPLE** P_2O_5 on maize

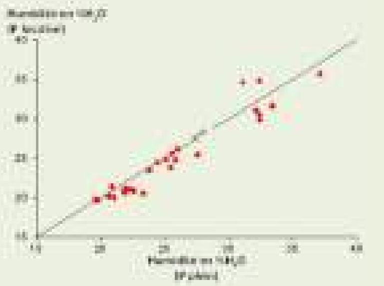
- Minimally mobile nutrients
- On the wide inter-row
- Root development problem (cold soil ...)

Grain maize

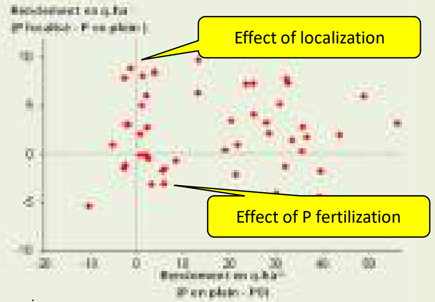
The location of P at the sowing of maize resulted in:

- **an average gain of 2.5 q/ha** ($IC_{0.10}$=1.4 q/ha)
- **an average gain of 1.1 %H_20** ($IC_{0.10}$=0.4%H_2O)

synthesis of 52 trials – 1989 to 2004 / AGPM - ITCF - Arvalis



synthesis of 15 trials – 1967 to 1985 / ITCF-AGPM



P in full: 18-46 or super 45 incorporated into the soil before sowing
Localized P: 18-46 or super 45 localized at sowing (5-5 cm)

Fodder maize

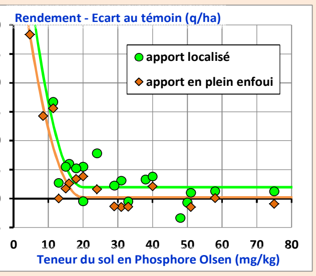
The location of P at the sowing of maize resulted in:

- **an average gain of 1 tDM/ha** (S)
- **an average gain of 2.4 % DM** (S)

Availability of P in soil	Difficult conditions Cold soil, excess water, high acidity...	Healthy soil
Very low	Recommended (to be completed by a input in full)	Recommended (to be completed by a input in full)
Low to medium	Recommended	Recommended
High	Recommended	Unnecessary P input

2 **INTEREST +/- ? EXAMPLE** P_2O_5 on cereals

- Narrow inter-row



Incorporated P
16 trials Arvalis
1996 to 2018$^{\$}$
Plateau to 0.2^{NS} q/ha
Plateau begins at 20***
ppm P_2O_5 Olsen

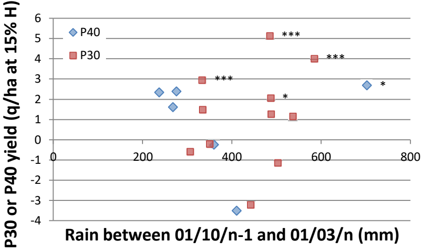
Incorporated and localized P
18 trials Arvalis + CA41
1996 to 2018 $^{\$}$
Plateau to +1.9** q/ha
Plateau begins at 20***
ppm P_2O_5 Olsen

3 **INTÉRÊT - - - EXEMPLE** NO_3^- on cereals

- Mobile nutrient element
- Narrow inter-row

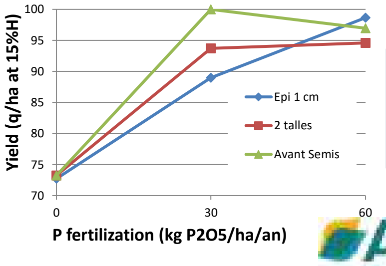
Positioning: autumn or at the end of winter ?

P input at the end of winter (tillering) : This is not justified by a rainy winter. The answer is related to the soil content



Relationship between winter rainfall and yield gain from phosphorus input in the spring. P30 = 30 kg/ha P2O5/ha et P40 = 40 in the form of superphosphates.
6 Arvalis trials and 11 partners (CA 44, 49, 59, 60, 62, 72, 85, Calliance,

The P is better valued with a input close to sowing



Montants, 1998, loamy soil with little phosphorus

Les Culturales 2023 14-15 juin

Is my plot deficient in Phosphorus? (in french)

Assess the risk of not making phosphorus and potassium inputs

Is my plot deficient in Potassium? (in french)

ARVALIS accident forms
https://www.arvalis.fr/outils-et-services/outils-et-fiches/les-fiches-accidents

4 criteria to calculate the dose

1. Crop requirement
2. Soil analysis and soil type
3. Past fertilization
4. Residues of the previous crop

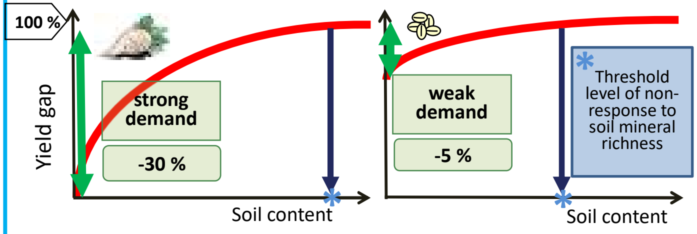
The objectives of the method

- Preservation of soil fertility P and K
- Non-limiting P and K supply

comifer

1. Crop requirement

Crop response curve to increasing soil mineral availability



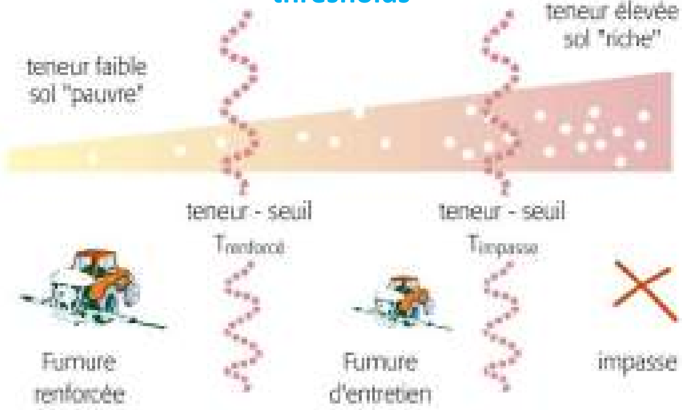
P

Very demanding	Sugar beet, rapeseed, alfalfa, potato
Averagely Demanding	Peas, wheat following a wheat, durum wheat, fodder maize, barley, ryegrass, sorghum
Undemanding	Oats, wheat, grain maize, rye, soybeans, sunflower

K

Very demanding	Sugar beet, potato
Averagely Demanding	Rapeseed, grain maize, peas, sunflower, alfalfa
Undemanding	Oats, rye, soybeans, wheat, durum wheat

2. Soil analysis and soil types: Determination of thresholds



Type de sol pour le Nord-Picardie	**Seuils P_2O_5, en mg/kg - Méthode Olsen**					
	Forte exigence		Moyenne exigence		Faible exigence	
	Trenf	Timp	Trenf	Timp	Trenf	Timp
Limons battants	50	80	50	80	20	70
Limons argileux	50	80	50	80	20	70
Argiles	50	80	50	80	20	70
Cranettes	90	130	80	100	50	80

3. Past fertilization

- Mobility and loss of bioavailability of elements of past fertilizer inputs
- The older the last fertilization, the less bioavailable the elements are still

Dose calculation

Multiplicative coefficient of exports ✖ Expected Yield ✖ PK content in exports

4. Destination of residues from the previous crop

- Same availability as a fertilizer
- Very important impact for K_2O (100 kg/ha K_2O for cereal straw)
- Lower impact for P_2O_5 (maxi 40 kg/ha)

❖ Exported
❖ incorporated or burned

P

Main function of **phosphorus** inputs:
properly feed young plants
when the roots are growing (emergence to the end of tillering)
in order to then allow them to access sufficient quantities of the element contained in the soil.

K

Main functions of **potassium** intake:
water supply, leaf assimilation
and cellular resistance to biotic and abiotic stresses.

PK content in soil	How often?	On what date?
Weak (<$T_{renforcé}$ des cultures les moins exigeantes)	Annual input	As close as possible to sowing and before weaning
Intermediary	Inputs in priority on the most demanding crops (Possible deadlocks on the least demanding crops)	For the most demanding crops, as close as possible to the sowing
High (>$T_{impasse}$ des cultures les plus exigeantes)	Blocking PK fertilization on the most demanding crops in the rotation	No agronomic constraints, autumn or spring

ARVALIS

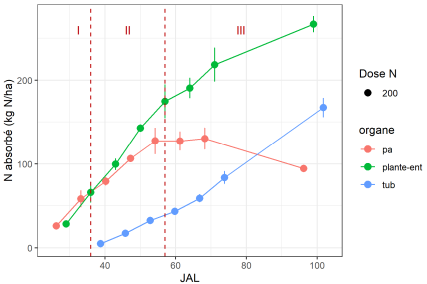
E4_02_2

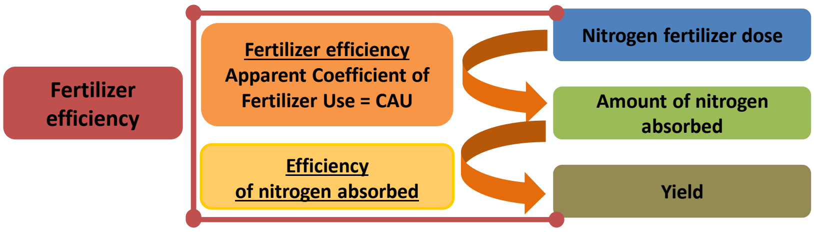
A Decision Support Tool for Potato Nitrogen Management

Les Culturales 2023 14-15 juin

Increasing nitrogen efficiency

Increase the nitrogen use efficiency of fertilizer: Maximize the amount of nitrogen valued in yield compared to the amount of nitrogen added with the fertilizer





Fertilizer efficiency

Fertilizer efficiency
Apparent Coefficient of Fertilizer Use = CAU

Efficiency of nitrogen absorbed

Nitrogen fertilizer dose

Amount of nitrogen absorbed

Yield

With which levers? The 5 points

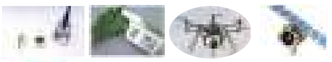
1. **Forms of N fertilizer** (ammonium nitrate, liquid UAN...)
2. **Total dose:** estimer correctement avec le reliquat sortie d'hiver et le paramétrage de la méthode du bilan.
3. **Application modes** (incorporated, localized)
4. **Splitting and monitoring - Input period:** as close as possible to the maximum needs of the plant and its absorption capacity
5. **Valorization of inputs:** by irrigation or positioning according to rainfall

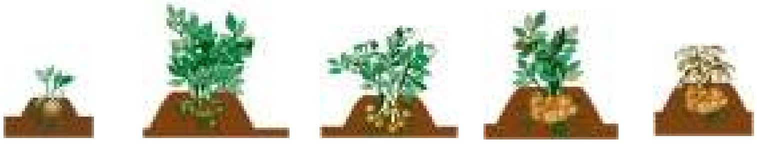
The principle of monitoring

Plantation
N imput
(dose X – MER)

Emergence + 30 à 45 d
Diagnosis
One to several sample(s) / measurement(s) / taking of views according to the method

To émergence + 45 d
Complementary input
if indicator < trigger threshold

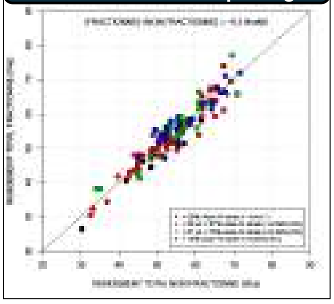




- **Step 1 :** Using an indicator to diagnose nitrogen nutrition status
- **Step 2 :** Interpretation of the indicator value using a repository (decision rules or decision support tool)
- **Step 3 :** Correction of fertilization during cultivation

RATIO and RATE: How much N should be applied to planting?

Total yield
With and without splitting



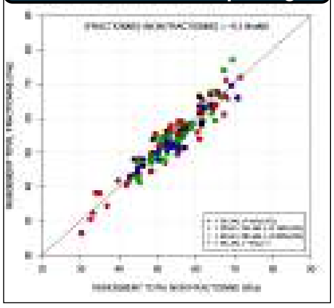
The 1st input must represent at least 50% of the total amount of nitrogen fertilizer

Hensel & Locascio (1987): To maximize yields, at least 67% of fertilizer should be applied to planting.

Total yield	Dose X at planting		yield> 50 mm
-1t/ha*	**< 50 % Dose X**	⬛	0t/ha^{NS}
-0.5t/ha^{NS}	**50%<Dose X <67%**	🟥	-1.2t/ha***
0.4t/ha^{NS}	**67%<Dose X <75%**	🟩	-0.4t/ha^{NS}
+0.8t/ha^{NS}	**>75%**	🟦	+0.4t/ha^{NS}

INPUT PERIOD: At what stages of the crop cycle is nitrogen input most effective?

Total yield
With and without splitting

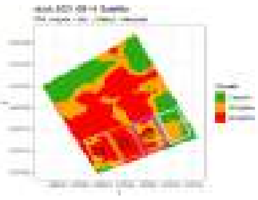


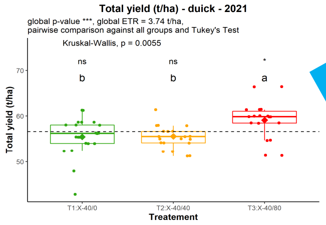
The best effectiveness is observed for applications between 30 days and up to 60 days after the emergence of the plant.

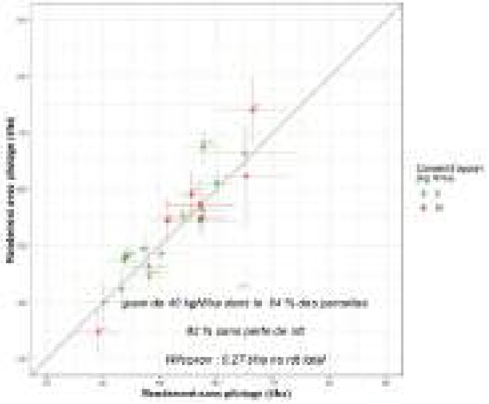
Vos (1999) up to 60 days after emergence.

Total yield	Sum of the effective T°C between the emergence and the 2nd input		yield > 50 mm
+1t/ha^{NS}	**< 471 °C**	⬛	+2.3t/ha***
-0.1t/ha^{NS}	**> 471 °C et < 624 °C**	🟥	-0.8t/ha^{NS}
-0.5t/ha^{NS}	**> 624 °C et < 813 °C**	🟩	-1.2t/ha***
-1t/ha*	**> 813 °C**	🟦	-1.9t/ha***

DIAGNOSIS: Is potato crop lacking in nitrogen?
PROGNOSIS: How much nitrogen does the potato crop need?







Farmer plot trials:
Large strips of farmers to assess the robustness of estimated values and their correlation with agricultural variables.

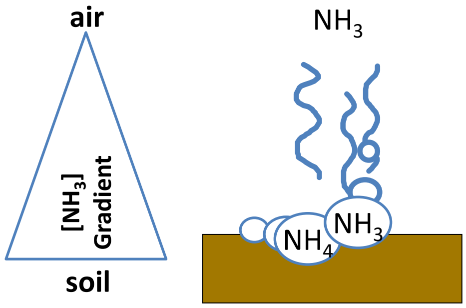
Reducing volatilization induced nitrogen losses

Results obtained during VOLAT'NH3 and EVAMIN projects

Physico-chemical process :

$NH_4^+ \rightarrow NH_3 + H^+ \rightarrow NH_3$ gaz

Soluble ammoniacal nitrogen → Ammonia in air



Orders of importance:
- 0 - 50% of nitrogen fertilizer inputs
- 0 - 70% of NH_4 contained in liquide manures

Factors influencing NH_3 volatilization
- **NH_4^+ concentration at soil surface**
  - ⇒ Fertilizer forms effect
  - ⇒ Fertilizer application methods (incorporated or not)
- **pH and soil buffering capacity**
- **Temperature** => Risk if > 10°C
- **Soil surface moisture**
- **Wind**
- **Slow N absorption by crop**
  - ⇒ Delay between N input and following rainfall
  - ⇒ Low instantaneous N requirements of the crop

Measurement method

1. Monitoring of NH_3 concentrations at field

Step 1 : monitoring of emitted NH_3 quantities thanks to stakes supporting acid-soaked filters (ALPHA badge) set and picked up at regular intervals at the field.

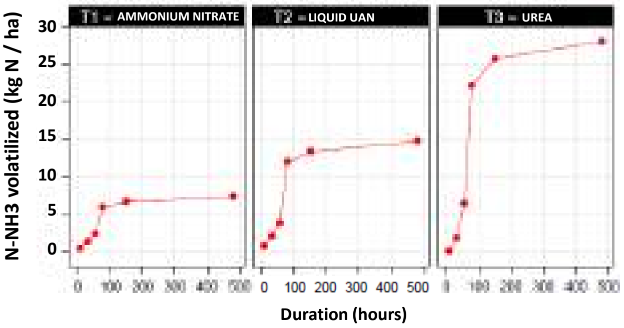
Step 2 : 2 measurement heights (30 cm & 1 m) for each treatment + monitoring with 3 m high masts surrounding the field to capture the ambient NH_3 concentration

Step 3 : The quantities of NH_3 captured are extracted and quantified by laboratory analysis

2. Calculation of flows by modeling

Flows calculation from NH_3 concentration measurements and environmental data (wind speed and wind direction, NH_3 concentration in ambiant air)

Trial in L'Epine (51) – 2016 - 100 kg N/ha input



Results

ADEME EVAMIN project:

4 wheat trials (2016-2018), 2 maize trials (2016-2017)

Comparison / Ammonium nitrate	Urea	Urea +NBPT	Liquid UAN	Liquid UAN +NBPT
%N volatilized	+13.1**	-0.5^{NS}	+9.4**	+1.6^{NS}
	6 trials		4 trials	

Fertilizers sensitivity to volatilization is confirmed:
Ammonium nitrate < liquid UAN < Urea

39 wheat trials (2013-2018)

ACOLYANCE, ARVALIS, SOUFFLET & VIVESCIA

Comparaison / Ammonium nitrate	Urea	Urea +NBPT	N solution	N solution +NBPT
N recovery coefficient (%)	-3.6**	+1.7^{NS}	-10.1***	-5.4***
	39 trials		25 trials	

Statistical test in comparison to Ammonium nitrate reference (comparison of paired means):
Significant difference at the 5% (**) and 1% (***) level
NS : non-significant difference

Liquid UAN less sensitive to ammoniacal volatilization than urea, but its agronomic efficiency is lower → Effect of physical constitution ?

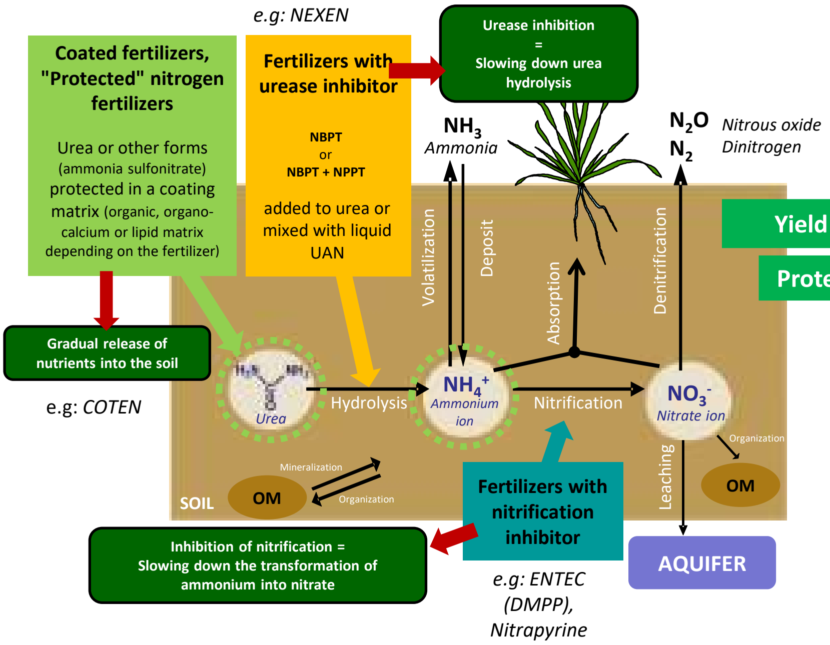
1 wheat trial - Arvalis 2019

Comparison / Ammonium nitrate	Urea	CoteN
%N volatilized	+ 7.0	+ 0.3

Coated ureas efficiency

Performances of different forms of nitrogen fertilizers

Nitrogen cycle and innovative fertilizers


e.g: NEXEN

Coated fertilizers, "Protected" nitrogen fertilizers

Urea or other forms (ammonia sulfonitrate) protected in a coating matrix (organic, organo-calcium or lipid matrix depending on the fertilizer)

Gradual release of nutrients into the soil

e.g: *COTEN*

Fertilizers with urease inhibitor

NBPT
or
NBPT + NPPT

added to urea or mixed with liquid UAN

Urease inhibition = Slowing down urea hydrolysis

NH_3 *Ammonia*

N_2O *Nitrous oxide*
N_2 *Dinitrogen*

Volatilization
Deposit
Absorption
Denitrification

Urea
Hydrolysis
NH_4^+ *Ammonium ion*
Nitrification
NO_3^- *Nitrate ion*
Organization
Leaching
OM
Mineralization
Organization
SOIL
OM
AQUIFER

Fertilizers with nitrification inhibitor

Inhibition of nitrification = Slowing down the transformation of ammonium into nitrate

e.g: ENTEC (DMPP), Nitrapyrine

Comparison of "common" N forms on wheat

Difference with ammonium nitrate

	UREA		LIQUID UAN	
	44 (2012-2019)		34 (2013-2019)	
	Calcareous soils (19)	Non-calcareous soils (25)	Calcareous soils (19)	Non-calcareous soils (15)
Yield	-0.4 q/ha NS	-0.5 q/ha NS	-3.5 q/ha ***	-3.0 q/ha ***
Protein	-0.23 % ***	-0.33 % ***	-0.58 % ***	-0.51 % ***

Summary of 44 trials managed by ACOLYANCE, ARVALIS, CA37, SOUFFLET & VIVESCIA 2012-2019

AMMONIUM NITRATE ≥ UREA > LIQUID UAN

Economic performances (wheat)

Profit (€/ha) from the substitution of ammonium nitrate by urea or liquid UAN

Soil type	Fertilizer	Selling price of fertilizers (€/kg nitrogen)	Hypothesis: Low selling price 2023 (205€/t)	Hypothesis: Medium selling price 2023 (250/t)	Hypothesis: High selling price 2023 (295 €/t)
Calcareous	UREA	**Low 2022 prices** (ammonium nitrate: 1.7, urea: 1.3 and liquid UAN: 1.2)	60	58	56
	LIQUID UAN		13	-3	-18
	UREA	**Prices 2022 high / 2023 low** (ammonium nitrate: 2.3, urea: 1.6 and liquid UAN: 1.8)	111	109	107
	LIQUID UAN		13	-3	-18
	UREA	**High 2023 prices** (ammonium nitrate: 2.9, urea: 1.9 and liquid UAN: 2.3)	162	160	158
	LIQUID UAN		30	15	-1
Non-calcareous	UREA	**Low 2022 prices** (ammonium nitrate: 1.7, urea: 1.3 and liquid UAN: 1.2)	58	56	53
	LIQUID UAN		23	10	-4
	UREA	**Prices 2022 high / 2023 low** (ammonium nitrate: 2.3, urea: 1.6 and liquid UAN: 1.8)	109	107	104
	LIQUID UAN		23	10	-4
	UREA	**High 2023 prices** (ammonium nitrate: 2.9, urea: 1.9 and liquid UAN: 2.3)	160	158	155
	LIQUID UAN		40	27	14

- Calculations for an average dose of 170 kg N/ha (Average of trials 2012-2019)
- Protein effect not taken into account

Performances of urea + urease inhibitors

		UREA + UREASE INHIBITORS	
Number of trials		53 (2012-2019)	
Soil type		Calcareous soil (21)	Non-calcareous soil (32)
YIELD	UREA	+1.8 q/ha ***	+0.9 q/ha**
	AMMONIUIM NITRATE	+1.6 q/ha ***	+0.4 q/ha NS
PROTEINS	UREA	+0.29 % ***	+0.19 % ***
	AMMONIUM NITRATE	+0.05 % *	-0.09 % **

Summary of 53 trials managed by ACOLYANCE, ARVALIS, CA37, SOUFFLET and VIVESCIA 2012-2019

Break-even point of ureas + urease inhibitors / ammonium nitrate or urea (price difference in €/kg N)

Reference fertilizers	Soil type (Number of trials)	Hypothesis: Low selling price 2023 (205€/t)	Hypothesis: Medium selling price 2023 (250/t)	Hypothesis: High selling price 2023 (295 €/t)
Ammonium nitrate	Calcareous (21)	0.19	0.24	0.28
	Non-calcareous (32)	0.05	0.06	0.07
Urea	Calcareous (21)	0.22	0.26	0.31
	Non-calcareous (32)	0.11	0.13	0.16

E4_03_2

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Plant biostimulants: what effects on nitrogen nutrition?

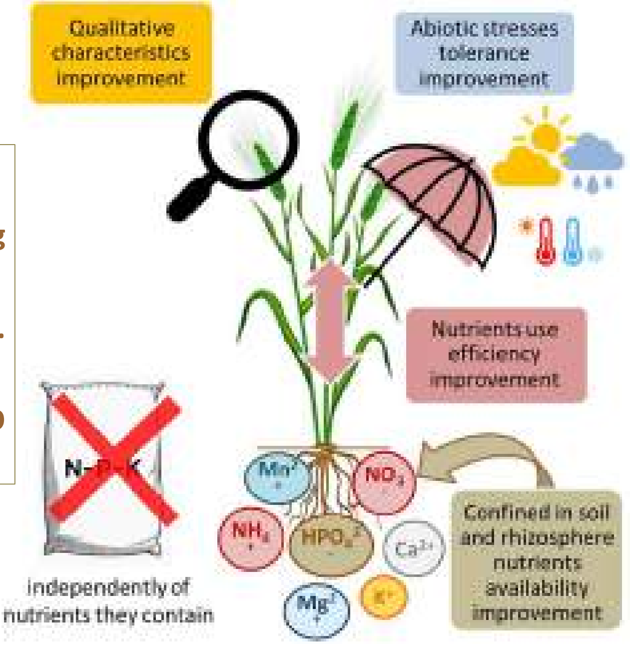
Definition – expected effects

3 ways to improve nitrogen nutrition:

- **Direct supply of nitrogen to the crop: nitrogen-fixing bacteria (e.g. Blue N)**

- **Stimulation of OM degradation and mineralization (e.g. Fertevie Wake)**

- **Improved efficiency of use of absorbed nitrogen (e.g. GO Activ Range)**


Qualitative characteristics improvement

Abiotic stresses tolerance improvement

Nutrients use efficiency improvement

Confined in soil and rhizosphere nutrients availability improvement

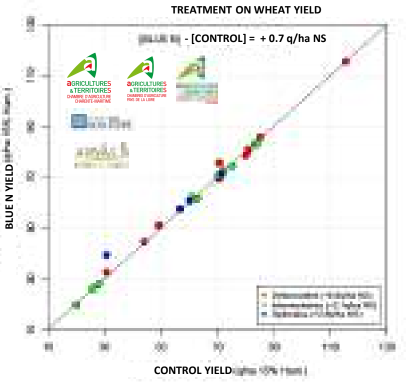
independently of nutrients they contain

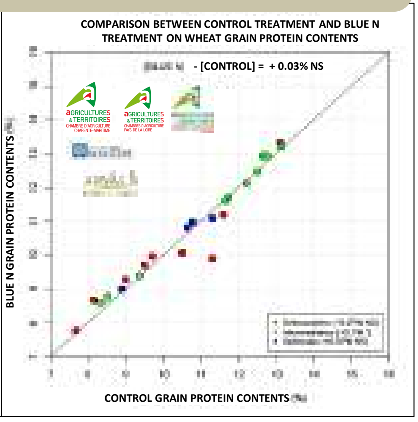
Few results from field trials

Blue N:

Nitrogen-fixing bacteria colonizing leaves

17 trials 2021-2022 on wheat (15 trials), durum wheat (1 trial) and in wheat intercropped with fababean (1 trial), French departments: 17, 18, 21, 27, 32, 51, 52, 60, 68 and 85



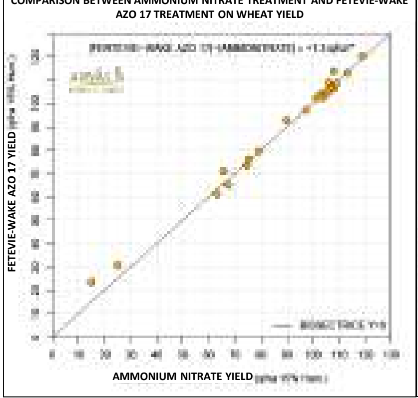


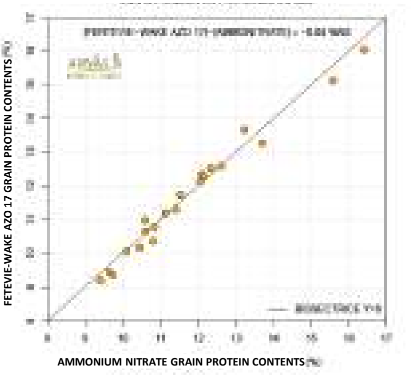
Statistical test compared with untreated control (*** significant difference at 1%, ** significant difference at 5%, * significant difference at 10%, NS: Not significant)

FERTEVIE-WAKE AZO 17:

NS Fertilizer + biostimulant from beer yeast

11 trials 2015-2018 on wheat (9 trials) and durum wheat (2 trials), French departements: 18, 27, 41, 51, 56 and 67

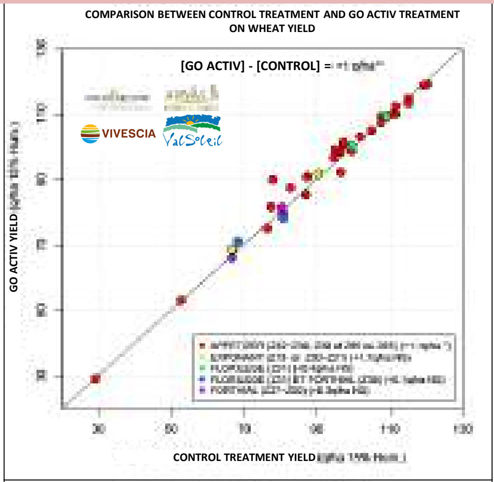


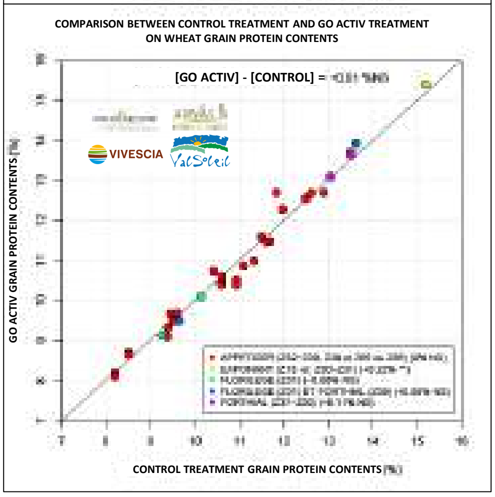


Go Activ Series:

Biostimulants based on algae filtrate

23 trials 2013-2022 on wheat (19 trials) & durum wheat (4 trials), tested biostimulants: Appetizer, Exponant, Florilège, Forthial and Florilège + Forthial



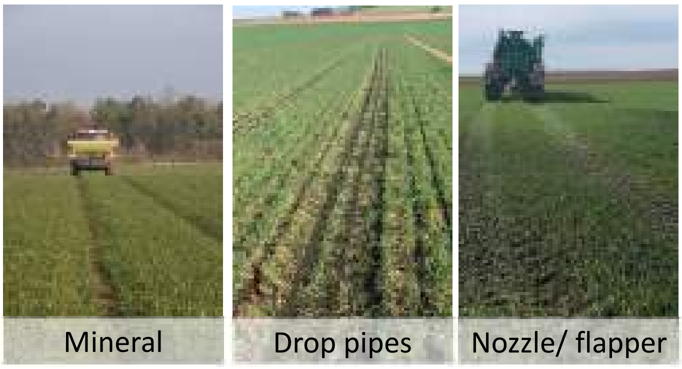


Performances strongly conditioned by climatic context and the state of stress of the crop during application (effect on the stress response often limited in time, specific conditions to guarantee the survival of microorganisms ...).
=> Hard to target the optimal time of application.

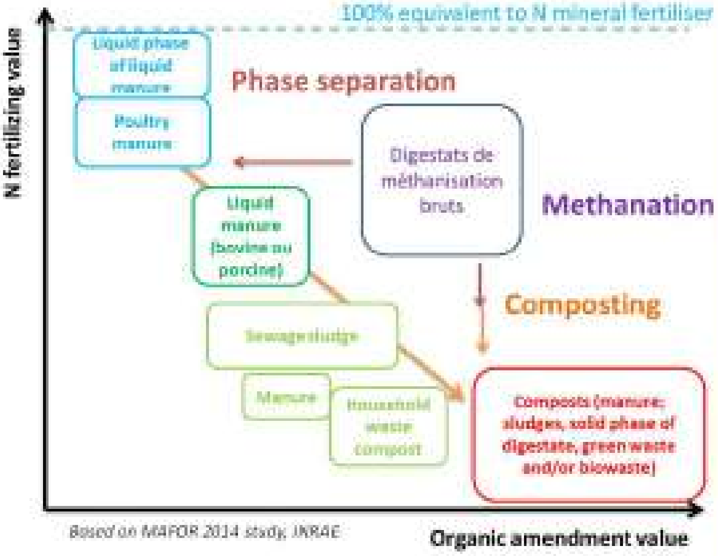
ARVALIS

Digestates: fertilizer and soil improver

Products with both a short-term fertilizing effect (N) and a long-term organic amendment effect (C)


Mineral Drop pipes Nozzle/ flapper

Different input modes are compared to evaluate digestates



Based on MAFOR 2014 study, INRAE

High water-pH and % NH_4 significant → Prone to volatilization risks

P, K, S and trace elements → Significant inputs, more concentrated in the solid phase

Indicator of Residual Organic Carbon (IROC) → Good indicator of the amending effect of the organic product: liquid < raw < solid

- Immediate N effect (rich in ammoniacal N) → Bring the digestate as close as possible to the needs of the crop:
  - ✓ Avoid input during autumn
  - ✓ Incorporate immediately after input

	Period of digestate input
Cereals	At the end of winter
Potatoes	Spring before planting
Sugar beet	Spring before sowing
Rapeseed	Possible at the end of summer at the sowing (low doses) At the end of winter
Maize	Spring before sowing
Energy cover crop	At the end of winter

- The dose is calculated using the NFRV (N fertilizer replacement value):

$$Dose\ (t/Ha) = \frac{Needs(kg/ha)}{Content(kg/t) * NFRV}$$

Source: COMIFER nitrogen fertilization brochure		**Late spring crop e.g: maize**			**Autumn crop** *e.g: cereals*		
Input period:		***late summer***	***autumn***	***spring***	***late summer***	***autumn***	***spring***
Cattle manure		0.10	0.10	0.25	0.05	0.10	
Pig slurries	**Incorporation within 24 hours or vegetation**	0.05	0.05	0.50	0.05	0.05	0.60
	Immediate incorporation	0.05	0.05	0.70	0.05	0.05	
Raw digestate (farm inputs)*	**On the soil**	**0.00**	**0.05**	**0.50**	**0.05**	**0.05**	**0.65**
	Immediate incorporation	**0.00**	**0.05**	**0.90**			

*NFRV for digestates are under revision

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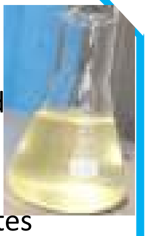
Recycling derived fertilisers

Ammonium salts



Dissolving N with acidic solution, from air (scrubber water) or liquid manure (stripping-scrubbing)

Liquid fraction of manure, digestates
Or air from stables

in kg/tonne of raw product	**Ammonium nitrate**	**Ammonium sulphate**
Total N	86 to 198	30 to 86
N-NH$_4$	43 to 109	30 to 86
N-NO$_3$	43 to 89	0
Total SO$_3$	0	150-250
Water-pH	5.3 to 7.9	2 to 7

No organic matter, no P, no K

N effect is equivalent to a N mineral fertiliser

Prone to volatilisation (low pH)
Crop burning risks

Application the closest as possible to crop needs, same as mineral fertiliser

Struvites

Precipitation of ammonium and phosphate with a magnesium salt
Powder or granulates

Sludge, urine, digestate or animal manure

in kg/tonne of dry matter	**Struvite from swage sludge**	**Struvite from potato factory waste water**	**Struvite from animal manure**
Total N	**58** (18 to 106)	**53**	**8**
P$_2$O$_5$	**260** (115 to 293)	**206**	**135**
K$_2$O	**<10**	**11**	**58**
MgO	**153** (83 to 193)	**161**	**133**

Low P-solubility in water, but OK in acid
Equivalence betweenn 40 to 100% with triple super phosphate

Slow release P fertiliser, not suitable as starter fertiliser

Urino-fertilisers

From phase separation
Various post-treatment process: storage, nitrification, concentrate, alcalinisation, acidification, mixed with organic matter

Human urine or liquid fraction of animal manure

Element in kg/m^3 of raw product	**Human urine**	**Pig urine**
Total N	5 to 8	3 to 6
P2O5	1 to 2	0.01 to 1
K2O	1.5 to 2.5	3.2 to 4.68
Water pH	6.5 to 6.9	7.6 to 9.26

NFRV in field condition from 70 to 85%

Possible presence of pharmaceutical residues
High volatilisation risk, up to 1/3 of N

N quickly crop-available, to be spread as urea or N liquid solution

Biochars

Not one, but MANY biochars!

An organic amendment, not a fertiliser!

Different kind of processes:
Pyrolysis (350 à 700°C); gasification (>700°C); hydrothermal carbonisation (200°C)

All organic materials (green waste, biowastes, sewage sludge, wood etc…)

From 25 to 95% of the dry mater is C
P and N possible in low amount
Trace elements possible depending on inputs

Main claims: water and nutrient retention, soil structure improvment, soil carbon storage.

Infield evaluation are scarce, observed effects are contrasted.
No degradation in soil, attention to product choises and quality

Application between 3 to 20 t/ha
More often used in horticulture or arboriculture than in arable crop productions

NUTRIMAN
Interreg North-West Europe ReNu2Farm
ARVALIS
E4_04_2

Reduce ammoniacal nitrogen volatilization during the organic products' application

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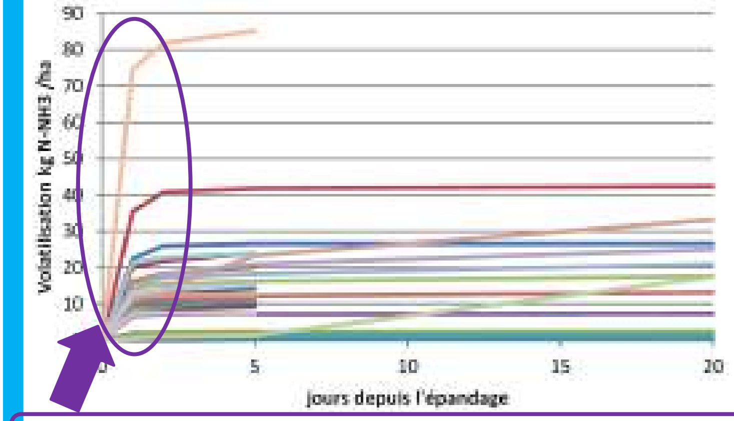
Evaluate and understand volatilization

Kinetics of cumulative ammoniacal nitrogen volatilization (Experimental results from EvaPRO Project - 2016-2017)



- Nitrogen losses due to ammoniacal volatilization range from 0.3 to 85.2 kgN/ha
- Losses for surface inputs:
  - Solid products: between 30 and 90% of the total lost within 1 day
  - Liquid products: between 60 and 80% of the total lost within 1 day

The volatilization of ammoniacal nitrogen takes place **within hours after application of** organic products

Effect of application method on volatilization

Nozzle/ flapper

Nozzle/ flapper

Drop pipes (Source: Arvalis)

Burier (source : INRAE)

+ risks of volatilization

- risks of volatilization

An equipment that allows the incorporation of organic products makes it possible to limit volatilization, especially since the incorporation is made close to the spreading.

Effect of the fertilizer

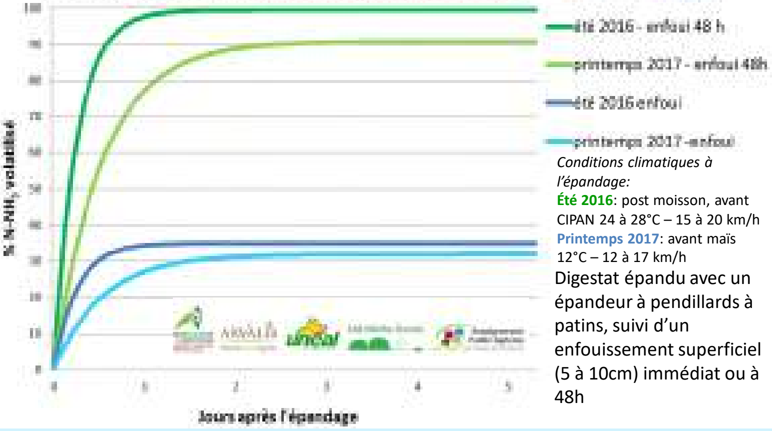
Volatilization losses also depend on the products:

- Composition in $N\text{-}NH_4$
- Water pH
- %DM

Equivalent volatilization kinetics regardless of the product and the mode of supply: everything happens within hours after application.

And for digestates?

Cinétiques de volatilisation de $N\text{-}NH_3$ Essai de Valhuon



Conditions climatiques à l'épandage:

Été 2016: post moisson, avant CIPAN 24 à 28°C – 15 à 20 km/h

Printemps 2017: avant maïs 12°C – 12 à 17 km/h

Digestat épandu avec un épandeur à pendillards à patins, suivi d'un enfouissement superficiel (5 à 10cm) immédiat ou à 48h

The risk of volatilization can be reduced by:

- Choice of application period → avoid windy and very hot periods, prefer inputs just before moderate rains
- Soil preparation → prefer application on a cloddy soil
- Choice of spreading equipment and incorporation → ~10 cm, mixing with soil

Optimizing spreading conditions helps to keep nitrogen for crops and preserves air quality.

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E4_04_3

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CHN: A french mechanistic model with application perspectives


Genetic - varieties

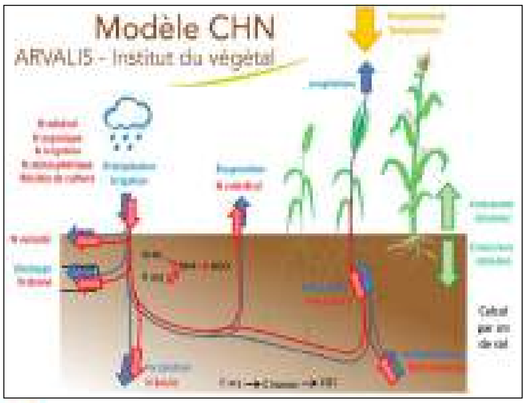

Climate


Mineral nitrogen


Soil

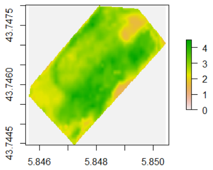

Organic materials

Input data
(field information + databases)

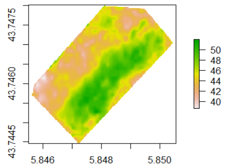



Satellites

LAI



C_{AB}

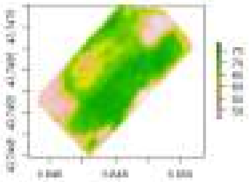


Crop model

Simulations

Decision rules

Advice



Recommended application

60 KgN

A dynamic approach to optimize nitrogen use efficiency

The decision rules depend on a targeted path of nitrogen nutrition index, defined thanks to soil, climatic context and variety information, but also on the level of climatic risk that we want to take

CHN benefits

- Avoid the use of a forecasted N rate, highly
- based on an historical yield
- Valorize all satellite images
- Spatializing fertilization advice
- Simplifying the logistics of advice delivery
- Maximizing the N efficiency in an uncertain

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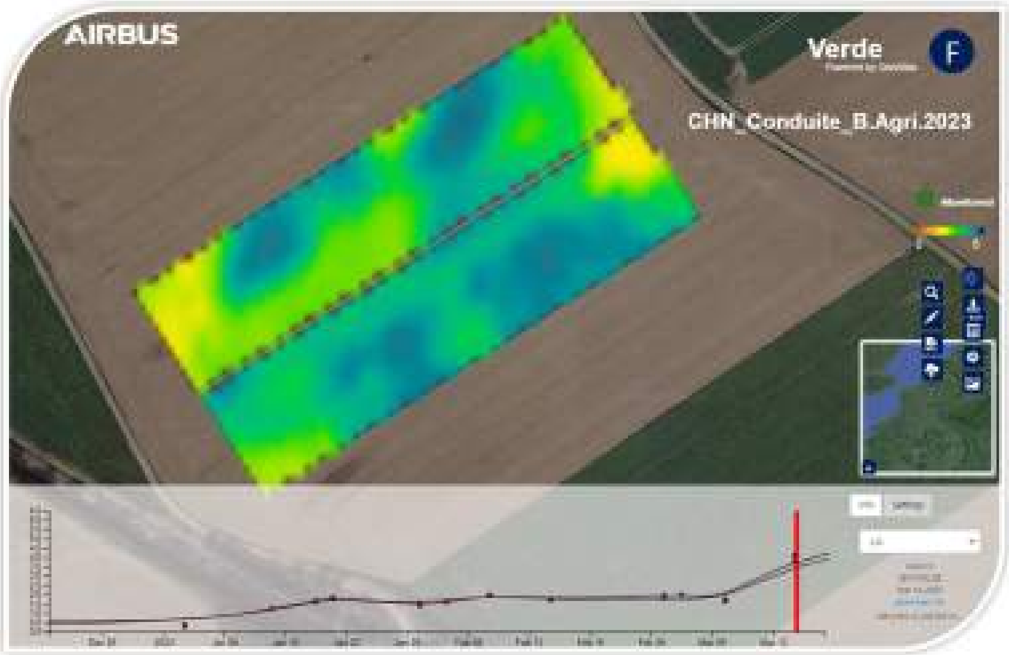
Space imagery: an opportunity for global diagnosis in real time

Valorization of SENTINEL 2 images

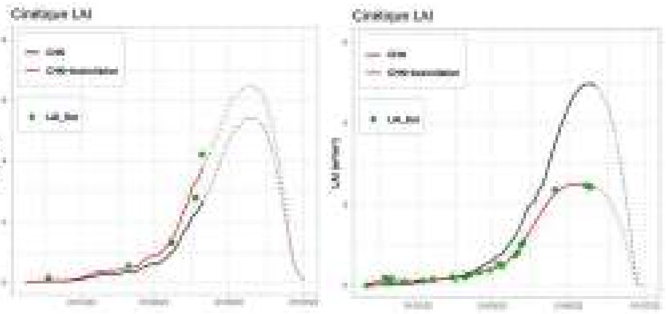
- Observe the field in near real time
- Fine kinetics of growth and nutrition
- Access to intra-plot heterogeneity



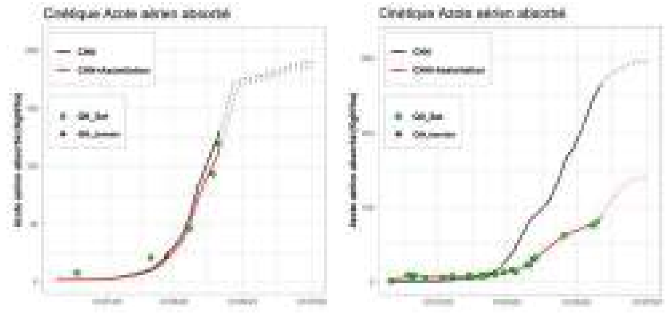
CHN_Conduite_B.Agri.2023

Integration of information into the CHN model

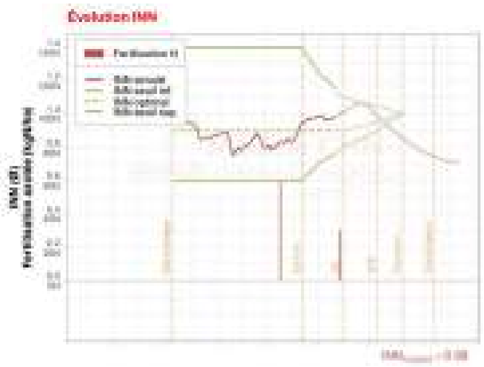
Diagnosing the "year" effect...



Identify the limiting factor(s)...



... to adjust practices to actual yield potential



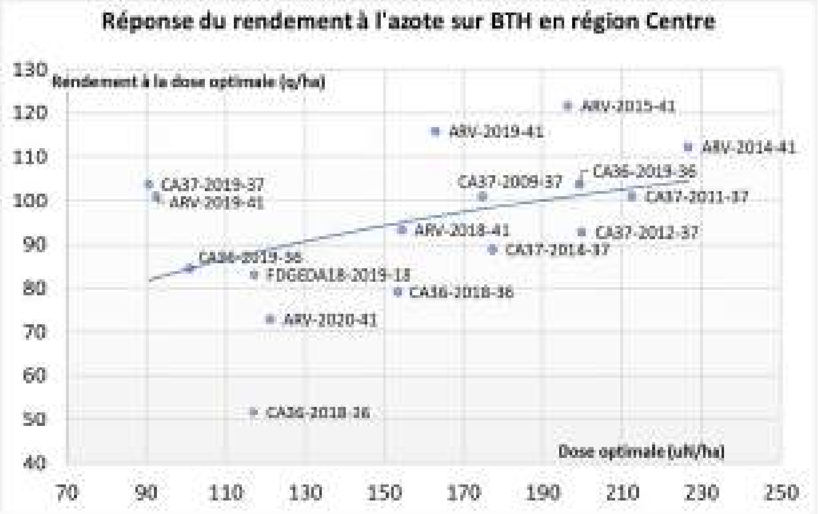
Reasoning on the basis of nitrogen nutrition index (NNI) : a way to optimize nitrogen use efficiency

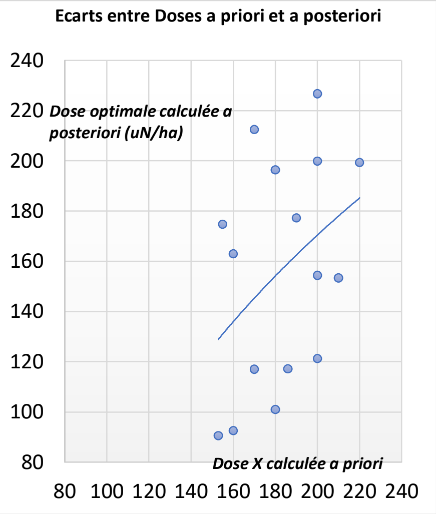
ARVALIS

An average advice to face contrasting climatic and agronomic years?

Variability in optimal N rate and yield potential…

Trials carried out in Beauce / Gatinais / Champagne Berrichonne





Highly variable optimal N rates for equally variable yields -> Need for better adaptation to the field

… but an average advice on nitrogen splitting

According to total N rate :
2nd input bis 1N : ~40u
(splitting of the Ear1cm input if N rate >100-120 kg/ha)

3rd input (Flag leaf stage)
Management : N rate depends on crop's nutrition level and year's potential
Consideration of protein issue
Reserve between 40 and 60 kgN/ha for winter bread wheat, between 40 and 80 kgN/ha for protein-rich wheat and durum wheat

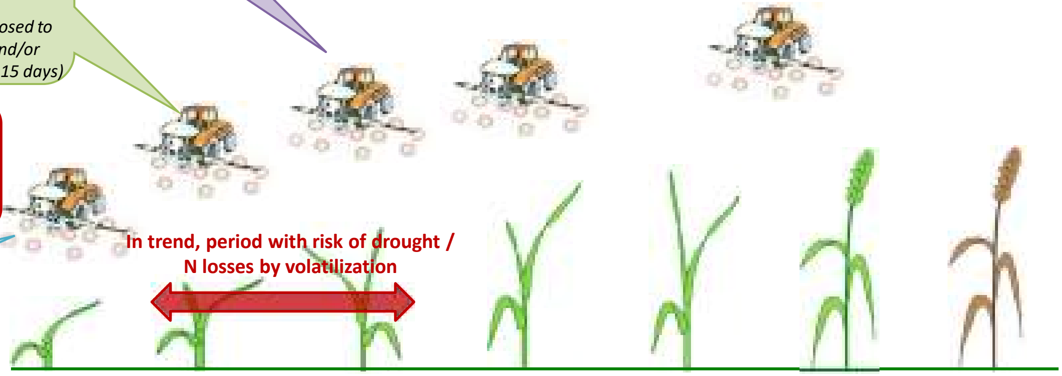
Positioning of the possible complement for proteins between Flag leaf stage and flowering

+0.15% protein per 10 kg/ha

+0.25-0.3% protein for 10 kg/ha

2nd input Ear1cm +/- 10 days depending on weather conditions
(min. 80 kgN) : splitting if
N rate > 100-120 KgN/ha
Slow valorization if N rate is too high, exposed to losses by volatilization in case of wind and/or drought (rainfall target : 15mm in the next 15 days)

Splitting to be reasoned according to regional legislation



In trend, period with risk of drought / N losses by volatilization

1st input: 40-50 kg/ha
Favourable conditions for growth at the end of winter. An excessive N rate would maintain excess stems that would not produce spikes. (luxury consumption)

Wheat growth stages
End of tillering
Ear at 1cm
1 node
2 nodes
Flag leaf
Boot stage
Heading
Flowering
Maturity

Probability of accumulating more than 15mm of rain (%) 2011-2020

Climate often dry during the period Ear1cm to 1-2 nodes

Integral management of nitrogen fertilization with CHN-conduite

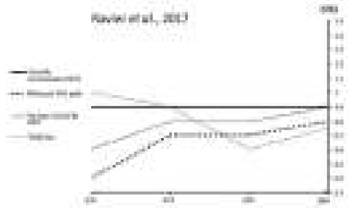
Principle of integral management

1. Use of the CHN crop model for diagnosis – prognosis during the fertilization period

Adaptation of advices to the context of the year (nitrogen stocks and growth potential)

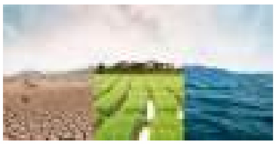
2. Reasoning of nitrogen requirements based on a minimal trajectory of Nitrogen Nutrition Index

Adjustment of a tolerable deficiency threshold

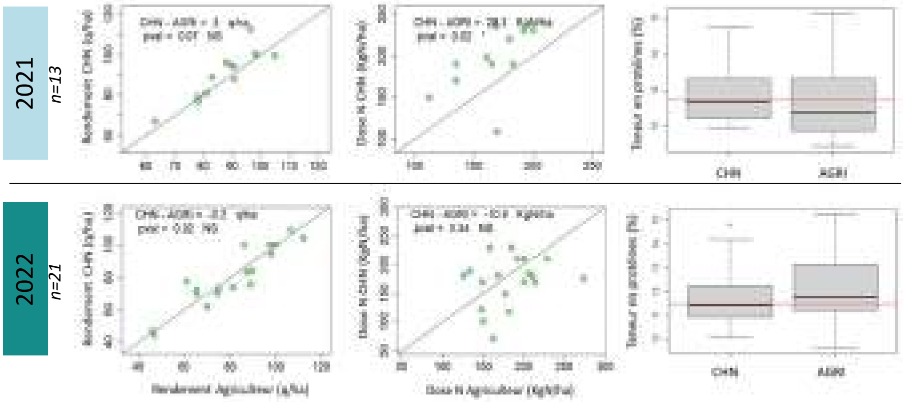


3. Climate risk management integrated into the tool

Optimization of valorization conditions



Techno-economic results



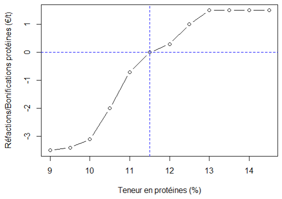
What impact on the margin?

scenarios with different prices

	2022A	2022B	2023
N fertilizer price (€/kg)	1.3	2.3	2.7
Grain selling price (€/t)	300	300	300

×

Protein payment



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Average nitrogen margin gains*

	2022A	2022B	2023
Network 2021	+83 €/ha	+57 €/ha	+47 €/ha
Network 2022	+5 €/ha	+16 €/ha	+20 €/ha

* *(Sales – fertilizer expenses)*

User feedback

« I recommend it 100% »

Points of surprise

« Triggers a little later than usual practice»

« Demand for organization and responsiveness »

« Additional splitting »

Strengths

« Evolve my practices »

« Nitrogen saving and adaptation to the year's potential »

« Technical and economic interest »

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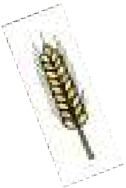
First carbon references on real farms - Results on cereal farms

Results obtained within the framework of the **CarbonThink project by Agrosolutions**

Project objective: Calculate the carbon performance of 100 farms in the Grand-Est region.



30 mainly **cereal farms** diagnosed by their advisor with Carbon Extract, **15 of which have defined a low-carbon transition project**

Identity cards of the farms

186 ha in average

27 % of them in conservation agriculture

In average **7 arable crops** in the rotation

11 % of leguminous crops in the rotation

Wheat yield : **76 q/ha**

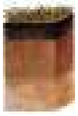
145 kg of mineral nitrogen per ha

Initial carbon balance of the 30 farms

Green house gas emissions :

2,94 $t_{eq}CO_2$/ ha/ year

including 90% from mineral and organic fertilizers



Variation of carbon storage in soils :

-0,70 $t_{eq}CO_2$ / ha/ year

current trend is carbon emission from soil

Net balance (emissions - storage) **:**

3,64 $t_{eq}CO_2$/ ha/ year

Soil carbon storage is added to the GHG emissions

Key messages

- Levers most selected = farmers with soils that emit more than the average choose practices that contribute to soil carbon storage
- **Antagonism between carbon storage in the soil and GHG emissions observed >** GHG reduction levers can lead to soil carbon emission and vice versa
- **Cost of the transition** not 100% covered by the sale of carbon credits > other financial mechanisms to be mobilized
- **What about conservation agriculture?** Lower net balance of the farms (2.76 teqCO2/ha/year) because soil carbone storage practices already used more than an average farm

Transition projects of the 15 farmers

Levers mainly implemented in the farms :

- Increase the biomass and the surface area of cover crops
- Integrate more leguminous crops in the rotation
- Reduce the volatilization of mineral and organic nitrogen

Levers' impact on the carbon balance :

- Variation of GHS :
  - 0,28 $t_{eq}CO_2$/ ha/ year (**- 10%)**
- Variation of carbon storage in soils :
  + 0,70 $t_{eq}CO_2$/ ha/ year
- Variation of the net balance : - 0,98 $t_{eq}CO_2$/ ha/year **(-23%)**

- Average cost of the projects = **71 € /ha /year**
- Potential carbon credits = **0,81 carbon credits/ha /year** (after applying discounts)
- Potential compensation = **32 € /ha /year** (with 40 € the carbon ton)

agrosolutions
Édifier un monde durable

E4_06_1

Carbon credits : Which levers to prefer? Example on 10 Representative Farms

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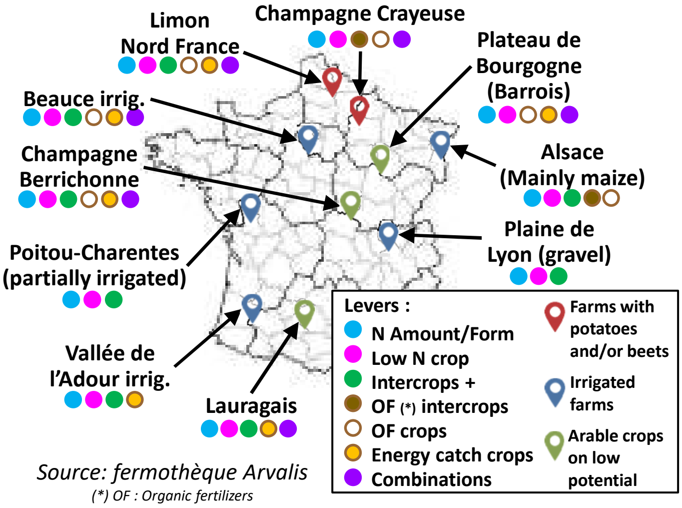
LABEL BAS CARBONE Grandes Cultures

METHOD: IMPLEMENTATION OF LOW-CARBON LEVERS TO HIGH-PERFORMANCE REPRESENTATIVE FARMS

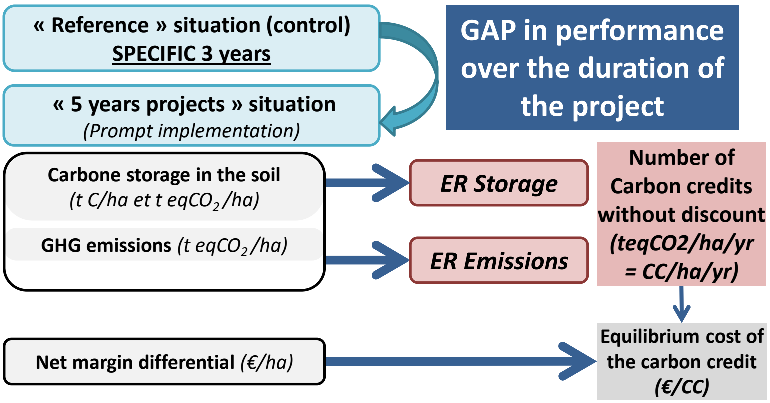
Representative farms studied and levers implemented



Source: fermothèque Arvalis

(*) OF : Organic fertilizers

$$Emissions\ Reduction = ER_{emissions} + ER_{storage} + (RE_{downstream})$$



« Reference » situation (control)
SPECIFIC 3 years

« 5 years projects » situation
(Prompt implementation)

GAP in performance over the duration of the project

Carbone storage in the soil *(t C/ha et t eqCO$_2$/ha)*

GHG emissions *(t eqCO$_2$/ha)*

ER Storage

ER Emissions

Number of Carbon credits without discount *(teqCO2/ha/yr = CC/ha/yr)*

Net margin differential *(€/ha)*

Equilibrium cost of the carbon credit *(€/CC)*

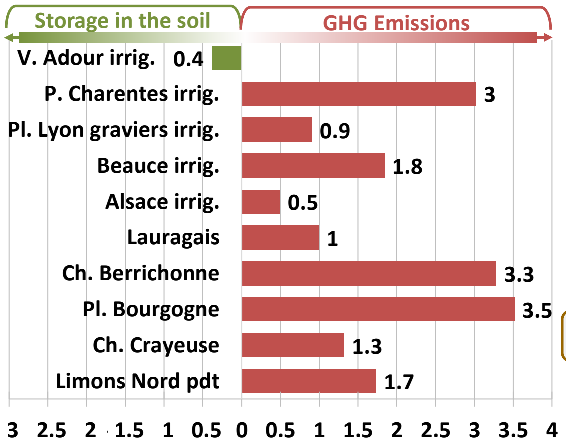
+ Co-benefit calculations pulling time (h/ha) et treatment frequency indicator (/ha)

Modèle CHN   carbon extract   SYSTERRE

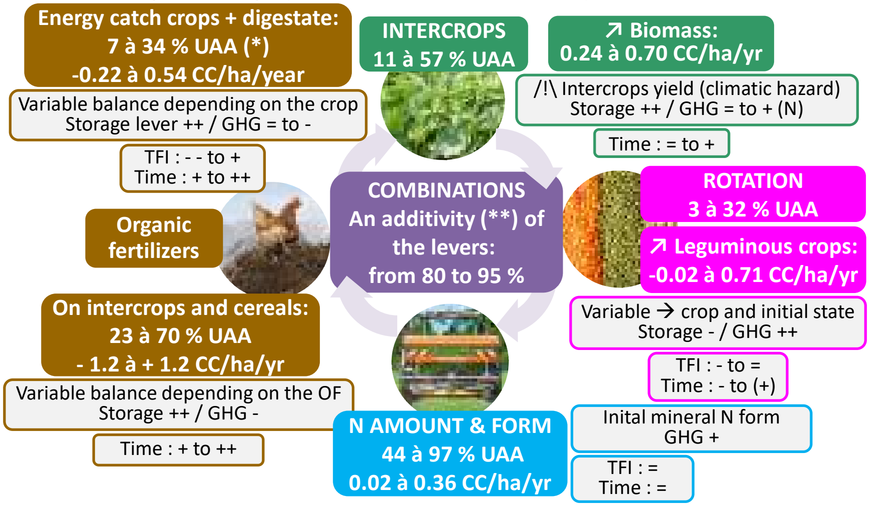
INITIAL CARBON BALANCE AND AVAILABLE CARBON CREDITS PER LEVER

Initial balance before levers' implementation: Net GHG-emitting farms

Expressed in teqCO$_2$/ha/year



Scenarios generating up to 1.2 Carbon credits/ha/year (before discount)



Energy catch crops + digestate: 7 à 34 % UAA (*) -0.22 à 0.54 CC/ha/year

Variable balance depending on the crop
Storage lever ++ / GHG = to -

TFI : - - to +
Time : + to ++

INTERCROPS 11 à 57 % UAA

↗ Biomass: 0.24 à 0.70 CC/ha/yr

/!\ Intercrops yield (climatic hazard)
Storage ++ / GHG = to + (N)

Time : = to +

Organic fertilizers

COMBINATIONS
An additivity (**) of the levers: from 80 to 95 %

ROTATION 3 à 32 % UAA

↗ Leguminous crops: -0.02 à 0.71 CC/ha/yr

Variable → crop and initial state
Storage - / GHG ++

TFI : - to =
Time : - to (+)

On intercrops and cereals: 23 à 70 % UAA - 1.2 à + 1.2 CC/ha/yr

Variable balance depending on the OF
Storage ++ / GHG -

Time : + to ++

N AMOUNT & FORM 44 à 97 % UAA 0.02 à 0.36 CC/ha/yr

Inital mineral N form
GHG +

TFI : =
Time : =

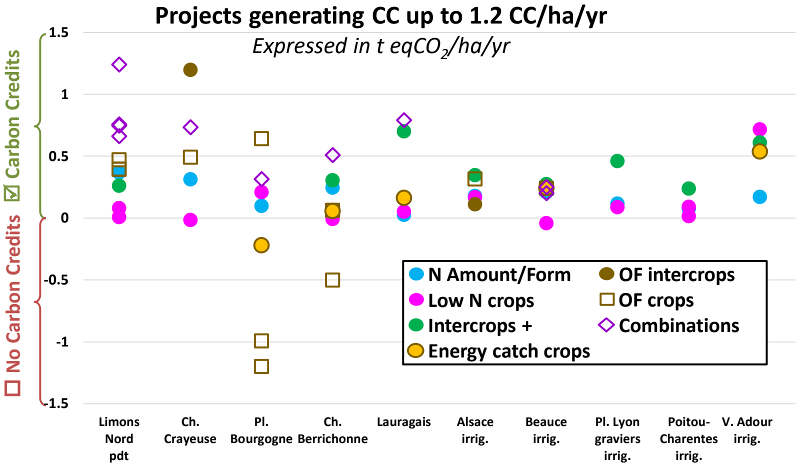
(*) UAA: utilized agricultural area

(**) Levers can be combined together in the same project, but ADDITIVITY is not complete.

CARBON CREDITS PER REPRESENTATIVE FARM

Projects generating CC up to 1.2 CC/ha/yr

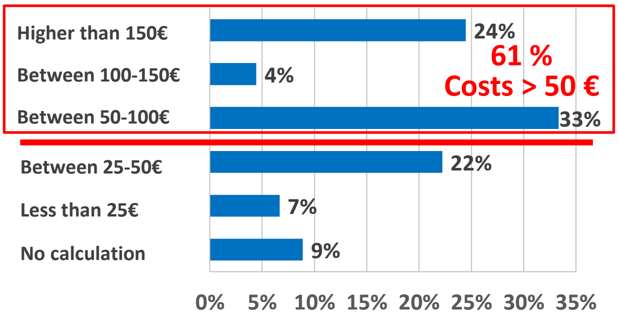
Expressed in t eqCO$_2$/ha/yr



EQUILIBRIUM COST OF THE CARBON CREDITS

Breakdown of projects by equilibrium cost* of the Carbon credits

(% of the 45 projects with CC and negative to neutral margin)



*Equilibrium cost: minimum price at which the farmer would have to sell his CC to pay back the cost of implementing the levers

CONCLUSION

- The levers have to be chosen according to the **initial production system**.
- **Some levers are easier to implement than others** because of their technical nature.
- **Discounts not considered**: an increase of the equilibrium cost must be expected.
- This study is presented with the **specific reference**: work is in progress with the generic reference.

ARVALIS

Source : Arvalis 2022 – Calculs SYSTERRE®, CHN-AMG et Carbon Extract

E4_06_2

Carbon footprint calculation Type-Farm in Beauce

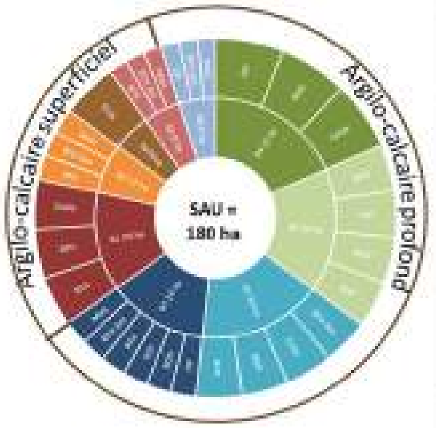
LABEL BAS CARBONE Grandes Cultures

Les Culturales 2023 14-15 juin

Caracteristics of the Type-Farm

References	
% tillage	67
% intercrops	28
N total	178 kg N/ha
N mineral	178 kg N/ha
N organic	/

Crops	Yield (average 16-20)
Winter durum wheat	70 q/ha
Winter bread wheat	78 q/ha
Oilseed rape	42 q/ha
BAF	73 q/ha
Beets	962 t/ha
Maize	130 t/ha
Potatoes	464 t/ha
Winter barley	74 q/ha
Spring barley	74 q/ha
Fallow	/



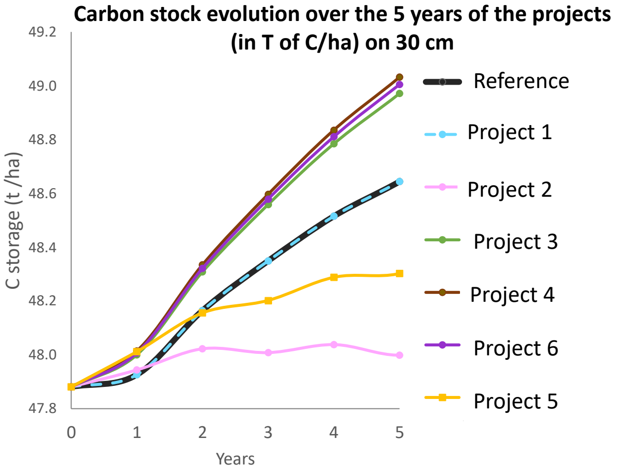
Projects
Project 1 : Reduction of the nitrogen volatilization: replacement of urea or N solution by Nexen or Ammonitrate
Project 2 : Introduction of spring peas (on 15% of the UAA)
Project 3 : Covercrop optimization: Vetch + clover + phacelia + mustard before corn, spring barley, beets and potatoes
Project 4 : Fertilization of the oilseed rape with dried poultry droppings
Project 5 : Introduction of an energy catch crop (rye) before maize with digestate application on the rye (8% UAA)
Project 6 (combined) : Project 1 + Project 2 + **Project 4**

PROJECTS' RESULTS

C storage

Modèle CHN ARVALIS - Institut du végétal

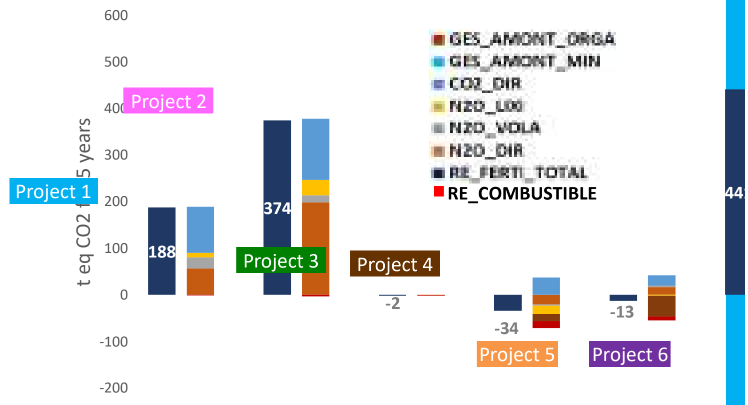
Calculations made with CHN-AMG, AMG-V2 model



Greenhouse Gas Emissions

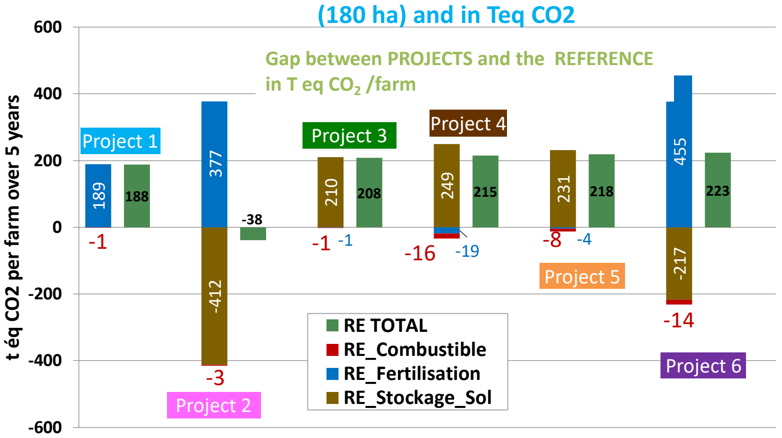
carbon extract

Calculations made with CarbonExtract developped by AgroSolutions
Differences between Projects and Reference in Teq CO_2 /farm



DO WE GENERATE CARBON CREDITS ON THE BEAUCE TYPE-FARM ?

Reductions balance over 5 years at the farm level (180 ha) and in Teq CO2



Economic balance

SYSTERRE

Projects	Number of CC	Number of CC	Margin Gap	Equilibrium cost CC
	5 yr/farm	/ha/yr	€/ha/yr	€/CC
1	188	0.21	-11	51
2	-38	-0.04	-76	-
3	208	0.23	-9	40
4	215	0.24	-42	176
5	218	0.24	+15	Only bonus
6	223	0.25	-113	454

- **The farm level carbon footprints are positive for the projects 1, 3, 4 , 5 et 6 but require important changes**
- **Levers and their interest depend strongly on the initial situation of the farm**
- **The carbon market does not cover the quilibrium costs before discounts for all projects**

Source : Simulations Fermothèque
Arvalis October 2022

Please note that discounts are not taken into account in the calculation
Calculations excluding PK Emissions - Excluding RE Storage and RE Downstream

ARVALIS

E4_06_3

Carbon footprint calculation
Type-Farm Champagne Berrichonne

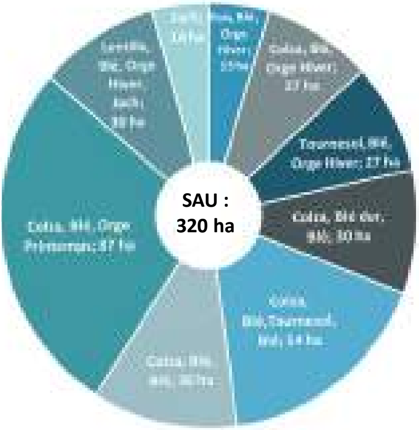
Les Culturales 2023 14-15 juin

LABEL BAS CARBONE Grandes Cultures

Type-Farm characteristics

References	
% tillage	15
% intercrops	10
N total	153 kg N/ha
N mineral	153 kg N/ha
N organic	/

Crops	Area (ha)	Yield (q/ha)
		(average 16-20)
Winter wheat	123	63
Winter OSR	73	29
Winter Barley	33	61
Spring Barley	29	62
Sunflower	22	22
Lentils	10	16
Durum wheat	10	62
Peas	5	35



Projects

Project 1 :
Reduction of the nitrogen volatilization: replacement of urea or N solution by Nexen or Ammonitrate

Project 2 :
Introduction of peas (on 2.8% of the UAA)

Project 3 :
Covercrops optimization (long intercropping before lentils and sunflower, OSR-fababean crop mixture)

Project 4 :
OSR fertilization the with dried droppings from laying hens

Project 5 :
Introduction of energy catch crop (winter rye) before sunflower + application of raw digestate on the rye

Project 6 (combined) :
Project 1 + Project 2 + Project 3

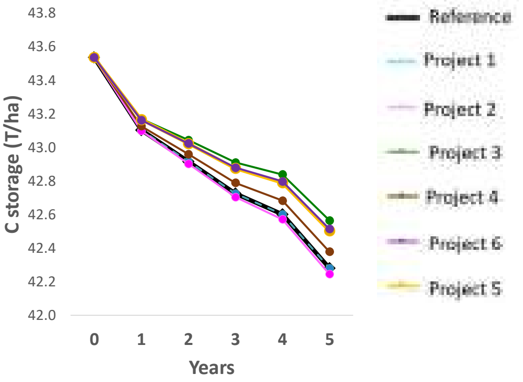
PROJECTS' RESULTS

C storage

Modèle CHN

Calculations made with CHN-AMG, AMG-V2 model

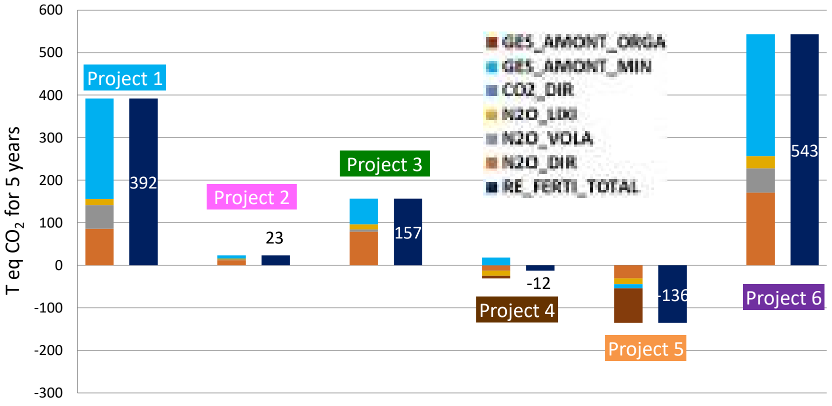
Carbon stock evolution over the 5 years of the projects (in T of C/ha) on 30 cm soil depth



Greenhouse Gas Emissions

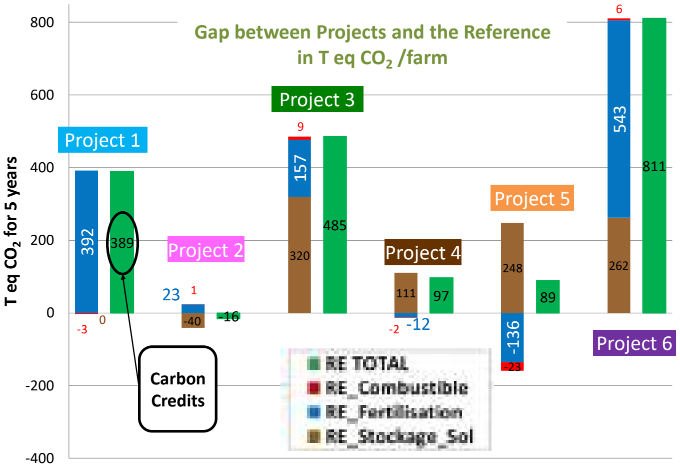
carbon extract

Calculations made with CarbonExtract developped by AgroSolutions
Difference between Projects and References in T eq CO_2 /farm



DO WE GENERATE CARBON CREDITS ON THE CHAMPAGNE BERRICHONNE TYPE-FARM ?

Reduction balance over 5 years at the farm level (320 ha) in Teq CO2



Economic balance

SYSTERRE

Projects	Number of CC	Number of CC	Margin Gap	Equilibrium cost CC
	/5yr /farm	/ha/yr	€/ha/yr	€/CC
1	389	0.243	-26	108
2	-16	-0.01	1	-
3	485	0.3	1	Bonus
4	97	0.06	-36	592
5	89	0.06	-37	662
6	811	0.51	-22	44

- ➢ **The farm level carbon footprints are positive for the projects 1, 3, 4, 5 et 6 but require important changes**
- ➢ **The current carbon market cannot cover equilibrium costs even before discounts for implemented projects**

Source : Simulations Fermothèque Arvalis
September 2022

Please note that discounts are not taken into account in the calculation
Calculations excluding PK Emissions - Excluding RE Storage and RE Downstream

ARVALIS

E4_06_4

Les Culturales 2023 14-15 juin

High prices for nitrogen fertilizers: Should I adjust my application rates?

WHEAT case study

Current high nitrogen fertilizer prices ➔

Need to integrate fertilizer prices and crop selling prices in the decision-making process of nitrogen fertilization.
→ Approach by the **« yield» technical optimum** notion

How can I find my optimum "yield" rate from my forecasted rate?

The forecast nitrogen X nitrogen rate is calculated by integrating a quality objective through the **bq** :

Nitrogen rate at the « yield » technical optimum = X nitrogen rate - **complementary protein requirement (bc x yield objective)**

For example, if X nitrogen rate is 200 kgN/ha, for a complementary bc requirement of 0.2 kgN/q and a yield objective of 80 q/ha, then the nitrogen rate at the technical optimum would be 184 kg N/ha (i.e. 200 - 0.2 x 80).

Nitrogen rate difference (in kg/ha) between technical optimum and technical-economic optimum as a function of wheat price and nitrogen price without protein payment

Average 2017-2021
(N : 0.8 €/kg N, wheat : 180€/t)
Technical-economic optimum >> technical optimum (ratio : 2.25)

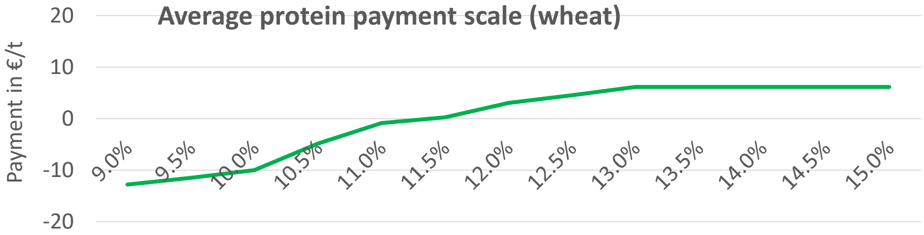
Nitrogen bought 2.00 €/kg, Wheat price at 230 €/t :
Reduce the nitrogen rate by about *10* kg N/ha to target the technical-economic optimum
(ratio : 1.15)

Nitrogen bought 2.50 €/kg, Wheat price at 200 €/t :
Reduce the nitrogen rate by about *40* kg N/ha to target the technical-economic optimum
(ratio : 0.80)

Nitrogen costs (€/kg N)	Wheat price (€/tonne)							
	170	190	210	230	250	270	290	310
0.80	23	27	30	33	35	37	39	40
1.00	13	18	22	26	29	31	33	35
1.20	4	10	15	19	22	25	28	30
1.40	-5	2	7	12	16	19	22	25
1.60	-15	-7	0	5	9	13	16	19
1.80	-24	-16	-8	-2	3	7	11	14
2.00	-34	-24	-16	-9	-4	1	5	9
2.20	-42	-32	-23	-16	-10	-5	0	4
2.40	-51	-40	-31	-23	-16	-11	-6	-1
2.60	-60	-48	-38	-30	-23	-17	-11	-7
2.80	-69	-56	-45	-37	-29	-23	-17	-12
3.00	-78	-64	-53	-43	-35	-28	-22	-17

Nitrogen bought 2.00 €/kg, wheat price at 295 €/t :
Don't modify the nitrogen rate to target the technical-economic optimum
(ratio : 1.48)

Non-valued protein


Average protein payment scale (wheat)

Protein payment

Nitrogen rate difference (in kg/ha) between technical optimum and technical-economic optimum as a function of wheat price and nitrogen price with an average protein payment scale

Average 2017-2021
(N : 0.8 €/kg N, wheat : 180€/t)
Technical-economic optimum >> technical optimum (ratio : 2.25)

Nitrogen bought 2.00 €/kg, wheat price at 230 €/t :
Don't modify the nitrogen rate to target the technical-economic optimum
(ratio : 1.15)

Nitrogen bought 2.50 €/kg, Wheat price at 200 €/t :
Reduce the nitrogen rate by about *20* kg N/ha to target the technical-economic optimum
(ratio : 0.80)

Nitrogen costs (€/kg N)	Wheat price (€/tonne)							
	170	190	210	230	250	270	290	310
0.80	42	44	46	47	48	49	50	51
1.00	33	36	38	40	41	43	44	45
1.20	24	28	31	33	35	37	38	40
1.40	16	21	24	27	29	32	33	35
1.60	7	13	18	20	24	27	28	30
1.80	-1	4	9	14	18	21	23	26
2.00	-9	-3	2	7	11	15	18	21
2.20	-17	-9	-4	1	5	8	12	16
2.40	-26	-17	-11	-5	-1	4	8	10
2.60	-36	-26	-17	-11	-6	-2	2	6
2.80	-46	-34	-25	-17	-12	-7	-3	1
3.00	-55	-43	-33	-25	-17	-12	-8	-4

Nitrogen bought 2.00 €/kg, Wheat price at 295 €/t :
Increase the nitrogen rate by about 20 kg N/ha to target the technical-economic optimum
(ratio : 1.48)

To be validated using a final input control tool

ARVALIS

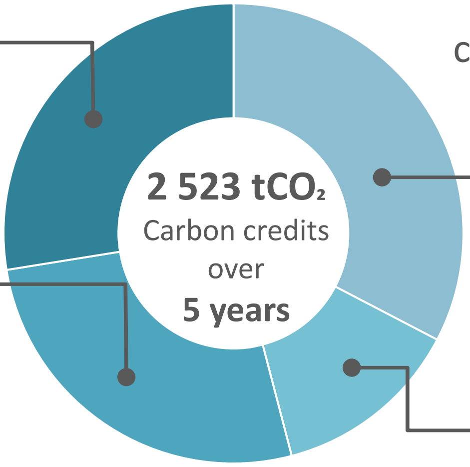
Commitment to a low-carbon project

Department : Marne
Project area : 316 Ha
Target sector : Arable crops

Barley
Sugar Beet
Wheat
Rapeseed

Main low-carbon levers to be activated

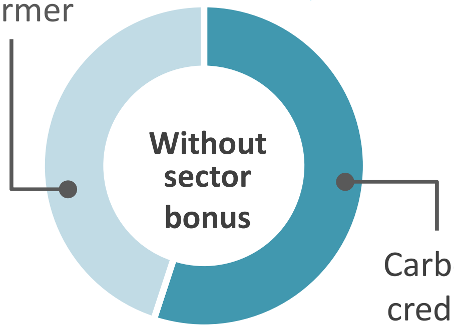
Estimated costs of levers (€/ha/yr)

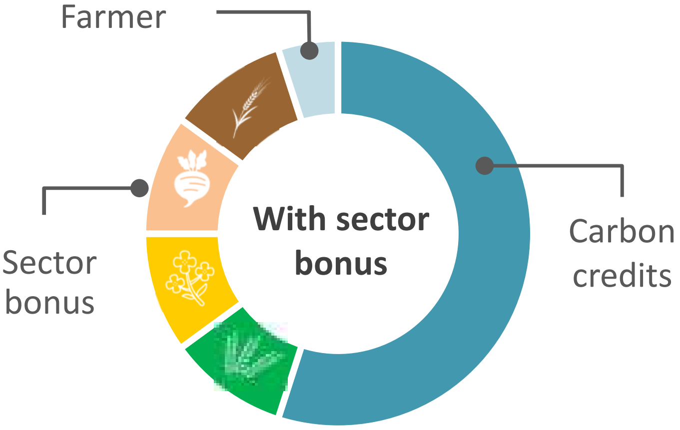


Co-benefits

Biodiversity
Soil quality
Air and water quality

Project financing *(based on a price of €45 per carbon credit)*





Conclusion

The cost of some projects can only be partially covered by the sale of carbon credits. In such cases, provided a better valorization of products derived from "low-carbon" raw materials, establishing a sector bonus should facilitate the agroecological transition of farms.

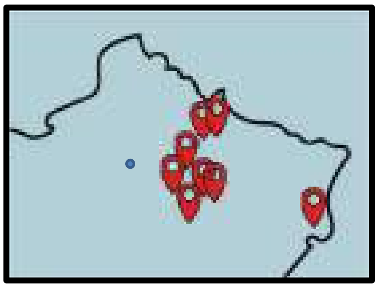
Les Culturales 2023 14-15 juin

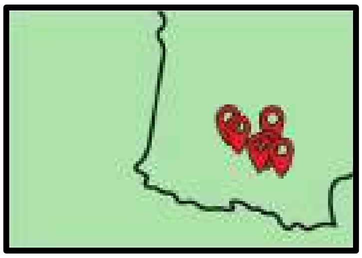
How do French institutes support the low-carbon transition?

The low-carbon transition is a major challenge facing our systems in the years ahead, and an essential key to mitigating and adapting to climate change.

To support farmers in this transition, French agricultural technical institutes (ITA) rely on technical cooperation (inter-ITA actions, regional projects, European projects) to work in concert with numerous French and European specialists in order to find out sustainable and economically viable solutions.

➢ The European project ClieNFarms (2021-2025)





Coordinator : INRAE
Number of partners : 33
Number of countries involved : 13

General objective: **Develop and disseminate solutions to achieve climate neutrality and sustainability in response to climate change.**

ITA's objectives:

- ✓ Make the Label Bas Carbone Grandes Cultures® method known at European level and compare it with other calculation methods.
- ✓ Identify the main levers for effectively storing carbon and reducing greenhouse gas emissions through farms monitoring.
- ✓ Organize 40 demonstration days on the Carbon theme to disseminate the most effective solutions.

➢ The PPDAR – Climate change mitigation (2022-2027)

Cross-disciplinary action between the animal, plant and arboricultural institutes, with the aim of sharing our work on :

- assessing and supporting the implementation of levers to **improve carbon balances**
- **improving methods and tools** in collaboration with and for the **benefit of farmers**: interoperability, reliability of quantification and assessment methods

➢ The European projects ClimateFarmDemo (2022-2029) and ClimateSmartAdvisors (2023-2030)

By taking part in these 2 new European projects on the carbon theme, coordinated respectively by IDELE and ILVO (Belgium), the French ITA seek to increase their expertise on the carbon theme, in order to better support the low-carbon transition of French farmers.

The allocated budget will be used to finance a number of technical days, so stay tuned!

Funded by the European Union

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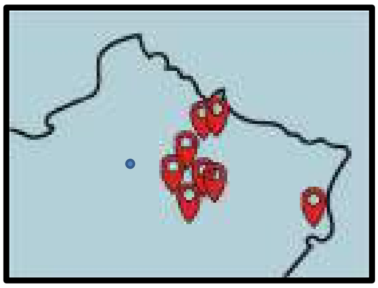

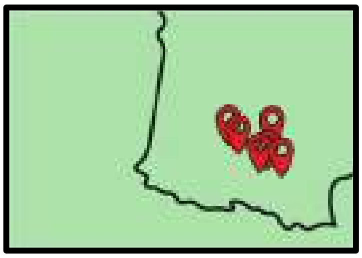

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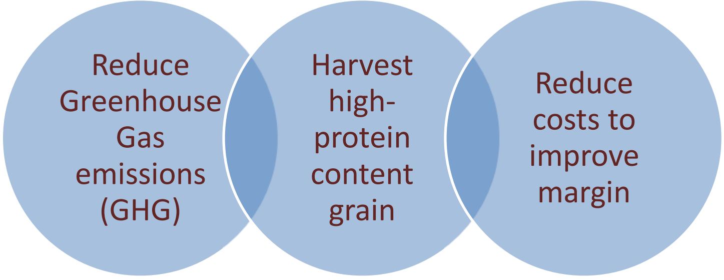
E4_06_7

A guaranteed improvement of the farms' carbon balance by increasing the proportion of grain legumes

+15 to 20% grain legumes for triple benefits

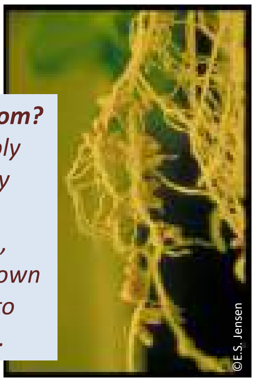

Reduce Greenhouse Gas emissions (GHG)

Harvest high-protein content grain

Reduce costs to improve margin

Where did it come from?

= the nitrogen supply service provided by legumes for the productive system, combined with their own autonomy thanks to symbiotic fixation.


©E.S. Jensen

Terres Inovia quantifies the reduction in net emissions for a project increasing pea, fababean or soybean, by 15-20% of the UAA, with or without the inclusion of an additional wheat as following crop.

On the basis of representative case study*

*the average reality of the 6 pedoclimatic regions

In the case of the Grand Est region, the reductions obtained with eight type-farms are summarized in Figures 1&2.

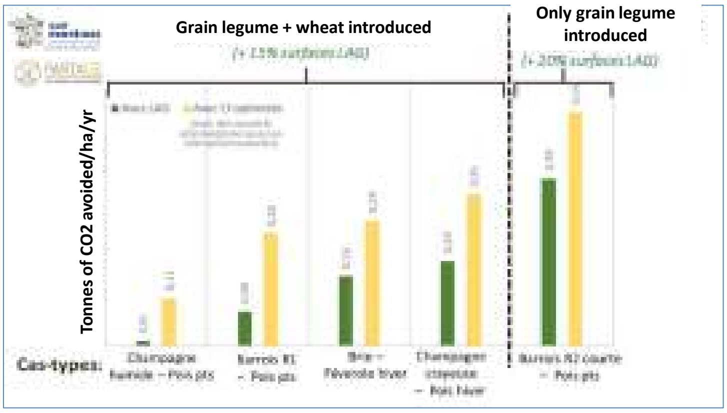


Figure 2 : Net balances (after discounts, i.e. directly valorizable as carbon credits) of emissions reductions made possible by the lever "insertion of grain legumes" possibly combined with "optimization of intercropping covercrops" according to the Label bas carbone- Grandes cultures method in several representative cases in the Grand Est region. (M. Campoverde et al., Terres Inovia 2022).

A significant contribution

Grand Est farmers = an average of 0.7teqCO2 avoided per hectare per year (CarbonThink).

Modulation: additional reduction of **10 to 20%** if the farmer obtains a better yield from the legume or takes advantage of the effects on the following wheat (-N or/and + Rdt).

Significant base: high potential, as only 7% of current dominant rotations include grain legumes.

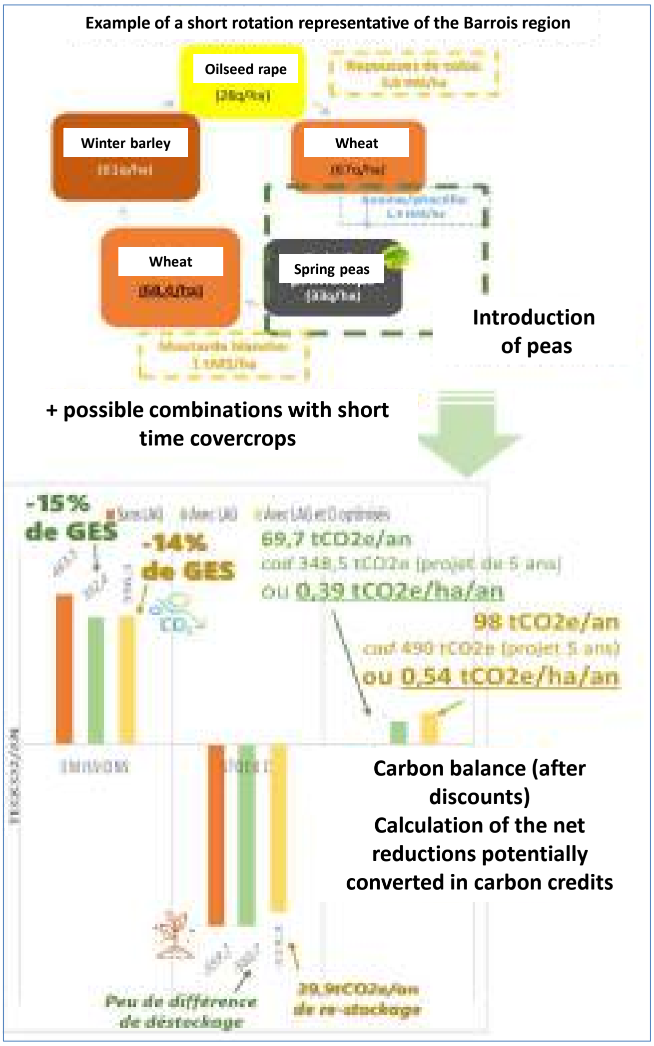
Co-benefits : air quality, preservation of biodiversity, etc. arguments for negotiating up the sale price of carbon credits.

15% of the GHG emission avoided

For example, the project in the Barrois type-farm brings net reductions of 69.7teqCO2/year only linked to the insertion of a pea in the initial oilseedrape-wheat-wheat-barley rotation, i.e. 0.4teqCO2/ha/year and (0.5teqCO2/ha/year with additional insertion of 2 covercrops, discount included).

Figures confirmed by other data

- **Grand Ouest** : 0,6 teqCO2/ha/an with peas or soybean (AgroSolutions);
- **Occitanie** : 0,7teqCO2/ha/an with soybean (Arvalis)



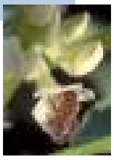
Introduction of peas

+ possible combinations with short time covercrops

Carbon balance (after discounts)
Calculation of the net reductions potentially converted in carbon credits

Figure 1 : An example of a system evolution project with legumes

Anne Schneider
a.schneider@terresinovia.fr
Terres Inovia l'agronomie en mouvement



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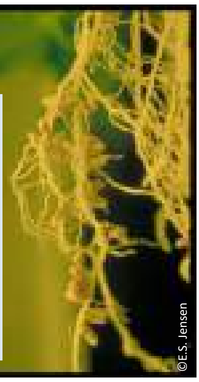
©E.S. Jensen

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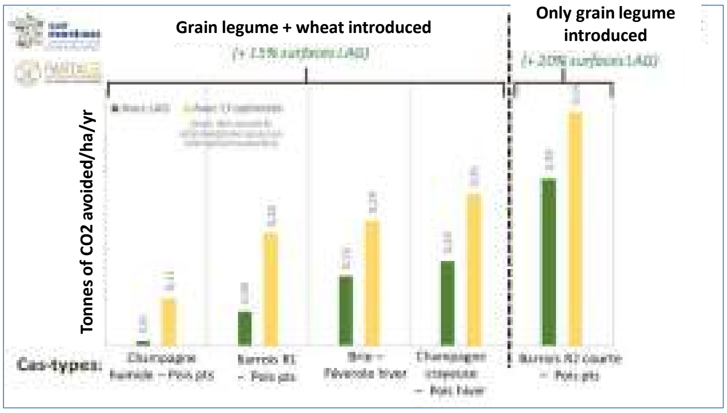

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For example, the project in the Barrois type-farm brings net reductions of 69.7teqCO2/year only linked to the insertion of a pea in the initial oilseedrape-wheat-wheat-barley rotation, i.e. 0.4teqCO2/ha/year and (0.5teqCO2/ha/year with additional insertion of 2 covercrops, discount included).

Figures confirmed by other data

- **Grand Ouest** : 0,6 teqCO2/ha/an with peas or soybean (AgroSolutions);
- **Occitanie** : 0,7teqCO2/ha/an with soybean (Arvalis)

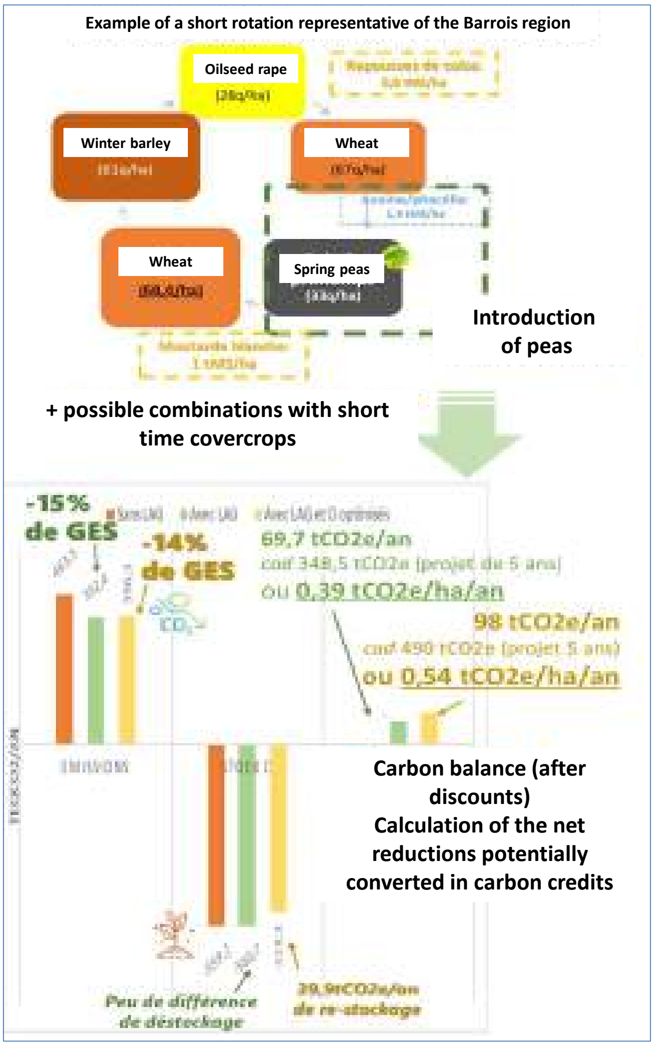
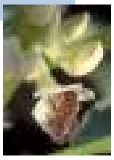


Figure 1 : An example of a system evolution project with legumes



Terres Inovia l'agronomie en mouvement

Anne Schneider
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Find the “perfect" cover crop

Les Culturales 2023 14-15 juin

1. Following crop and crop rotation

Sources :
ARVALIS, ITB, Terres Inovia, UNILET

		Nematode-resistant white and brown mustard	Nematode-resistant fodder radish	Other radish	Oilseed rape	Other brassicas	Phacelia	Linen	Sunflower	Niger	Buckwheat	Rye, Triticale, Canary grass	Common oat, Bristle oat	Foxtail millet	Sorghum	Italian Rye Grass	Faba bean, Lupin	Peas	Fenugreek, BC, CC, R-Aphano Vetches	Other vetches, Lentil, Grass pea	Birdsfoot trefoil, sainfoin, R-Aphano WC and RC	Lucerne, other WC and RC
Following crop	**Winter wheat after a wheat**	🟩	🟩	🟩	🟩	🟩	⬜	⬜	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Following crop	**Other winter cereals**	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Following crop	**Spring barley**	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Following crop	**Maize**	⬜	⬜	⬜	⬜	⬜	🟢	⬜	⬜	⬜	🟧	⬜	⬜	⬜	⬜	🟨	🟩	🟩	🟩	🟩	⬜	⬜
Following crop	**Sugar beets** (Heterodeta schachtii)	🟢	🟩	🟥	🟥	🟥	⬜	⬜	⬜	⬜	🟥	⬜	⬜	⬜	⬜	🟧	🟢	🟩	🟩	🟩	🟥	🟥
Following crop	**Potatoes**	⬜	🟩	🟩	⬜	⬜	🟩	⬜	⬜	⬜	🟥	⬜	🟩	⬜	⬜	🟧	🟩	🟩	🟩	🟩	⬜	⬜
In crop rotation	**Peas, Beans, Lentil**	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟨	⬜	⬜	⬜	⬜	⬜	⬜	🟥	⬜	🟥	⬜	🟥
Following crop	**Canned peas, Beans**	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	⬜	⬜	⬜	⬜	🟧	🟥	🟥	🟥	🟥	🟥	🟥
Following crop	**Protein peas, Lentil**	🟨	🟨	🟨	🟨	🟨	⬜	⬜	⬜	⬜	🟥	⬜	⬜	⬜	⬜	🟥	🟧	🟥	🟧	🟥	🟥	🟥
Following crop	**Faba bean, Lupin**	🟨	🟨	🟨	🟨	🟨	⬜	⬜	⬜	⬜	🟥	⬜	⬜	⬜	⬜	🟥	🟥	🟧	🟧	🟧	🟥	🟥
Following crop	**Sunflower**	⬜	⬜	⬜	🟧	⬜	⬜	🟧	🟥	🟥	🟥	⬜	⬜	⬜	⬜	🟧	🟩	🟩	🟩	🟩	⬜	⬜
In crop rotation	**Linen**	⬜	⬜	⬜	🟧	⬜	⬜	🟥	🟧	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
Following crop	**Linen**	⬜	⬜	⬜	🟧	⬜	⬜	🟥	🟧	⬜	🟥	⬜	⬜	⬜	⬜	🟥	⬜	⬜	⬜	⬜	🟥	🟥
In crop rotation	**Oilseed rape (with clubroot)**	🟥	🟥	🟥	🟥	🟥	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜
In crop rotation	**oilseed rape (without clubroot)**	🟨	🟨	🟨	🟨	🟨	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜

🟩	Beneficial impact of cover crop
🟢	Fairly beneficial impact of cover crop
⬜	No impact of cover crop
🟨	Slight risk due to cover crop
🟧	Risk due to cover crop
🟥	Cover crop not advised

BC: Berseem clover
CC: Crimson clover
WC: White clover
RC: Red clover
R-Aphano: varieties resistant to Aphanomyces

2. Sowing and destruction periods

- Summer cover crop
- Overwintering cover crop
- Long-term association
- Companion plants
- Living mulch

3. Sowing and destruction techniques

4. Objectives of cover crops

- Fast soil coverage
- Harvesting as fodder
- Maintaining biodiversity
- Crop protection
- Increase chemical fertility
- Soil protection

To discover on (only in french):
www.choix-des-couverts.arvalis-infos.fr

Choix des couverts

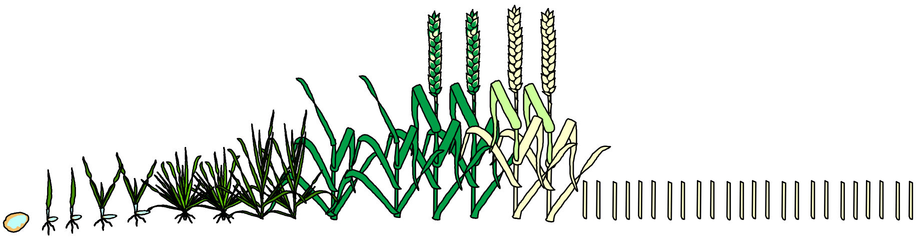
In a few clicks, choose from more than 200 pure species or mixtures!

ARVALIS

E4_07_1

Cover crop:
various sowing strategies

Many techniques and dates of sowing



Sowing with or in a young crop

+ Soil moisture, early sowing
- Weeding, Access to light

Broadcast sowing before harvest

+ Soil moisture, early sowing
- Sowing management

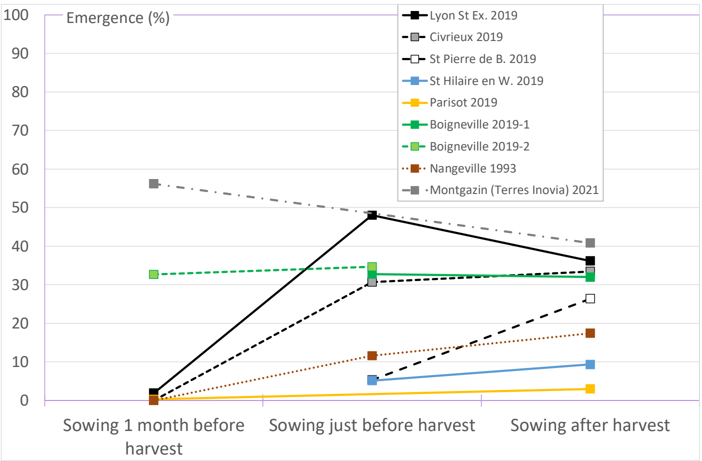
Direct drilling after harvest

+ Soil moisture, early sowing
- Straw management

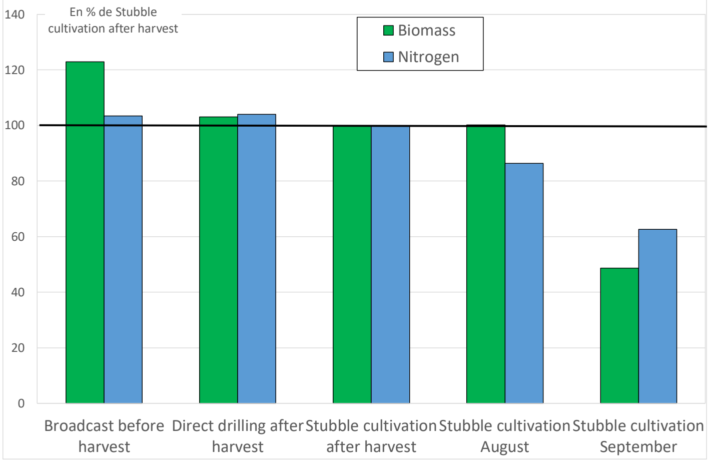
Delayed sowing

+ Easy sowing, Emergence after dry summers
- Late sowing, Soil moisture

Broadcast seeding before harvest



- Emergence close to those obtained after harvest, with adapted species (cruciferous, flax, buckwheat, phacelia, sorghum, foxtail millet, niger, clovers)
- Important water context: do not export straws, increased risk of seedling drying in case of early sowing before harvest



Post-harvest sowing

Direct seeding with disc drill:
Quick sowing after harvest
Seed to soil contact sometimes poor

Direct seeding with fine-toothed seeder:
Quick sowing after harvest
Improved seed to soil contact / discs

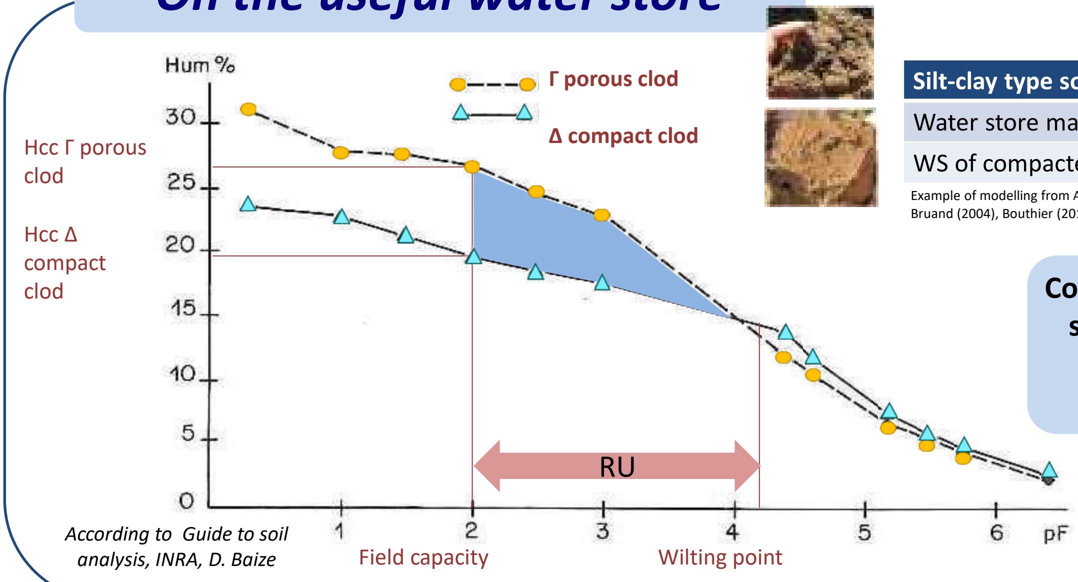
Traditional seeder on superficial tillage:
Versatility but expensive seeding

Broadcast seeding on stubble cultivator:
Good results in case of rain
Favor the covering of seeds (except small seeds such as clover) and soil consolidation

Consequences of soil compaction

Les Culturales 2023 14-15 juin

On the useful water store



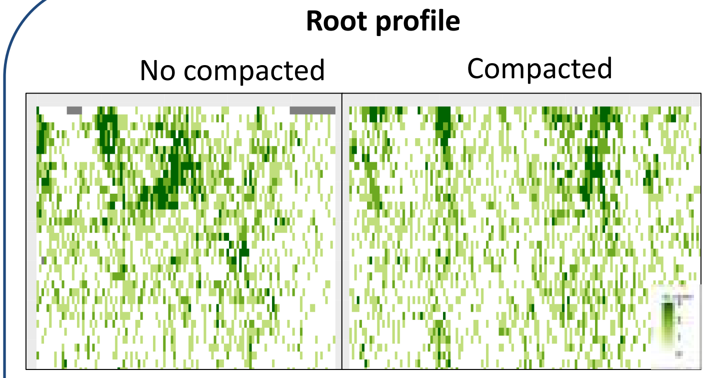
According to Guide to soil analysis, INRA, D. Baize

Silt-clay type soil (on 100 cm)	
Water store max	123 mm
WS of compacted soil	111 mm

Example of modelling from ARVALIS pedotransfer function adapted from Bruand (2004), Bouthier (2014)

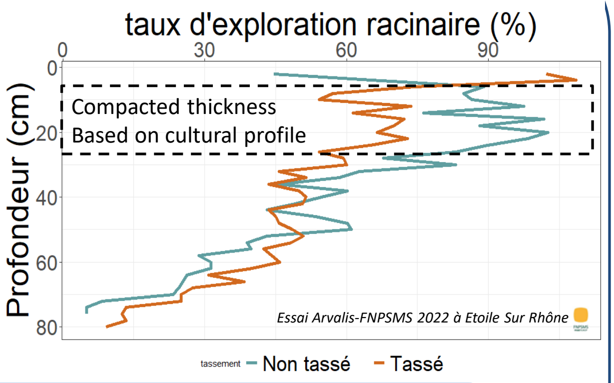
Compacted clods and soils have a lower water storage capacity

On rooting



Root counting at harvest on the Arvalis-FNPSMS 2022 trial in Etoile Sur Rhône

Less well explored areas in compacted situations



Soil compaction slows rooting: smaller volume explored, maximum rooting depth limited (maize) or reached later (wheat)

On production

Crop	Indicative yield losses
Wheat	**Limitées, sauf excès d'eau ou sécheresse**
Maize - **Silage** - **Grain&Seed**	**Eviter en priorité une rupture de densité entre deux horizons** **30 à 35%** **15 à 25%**
Alfalfa	**10 % à 30% sous les roues;** **1 à 3% à l'échelle de la parcelle (selon la taille du matériel)**
Potato	**30 % sous les passages de roues** **5 à 15% à l'échelle de la parcelle**

The shorter the crop cycle, the greater is the impact of compaction

Wheat, grain maize, seed maize: Arvalis trials in Boigneville (91), La Jaillière (44) and Montesquieu Lauragais (31). Maize seed: Arvalis-FNPSMS trials in Etoile sur Rhône. Potato: Sol-D'Phy trial. Luzerne: Beaudoin and Thiébaud, 2007; INRAE – Fodder.

But also:

Overconsumption of fuel, lower efficiency of fertilizers, greenhouse gas emissions, less infiltration therefore risk of flooding and runoff…

ARVALIS

Restructuring a compacted soil

Les Culturales 2023 14-15 juin

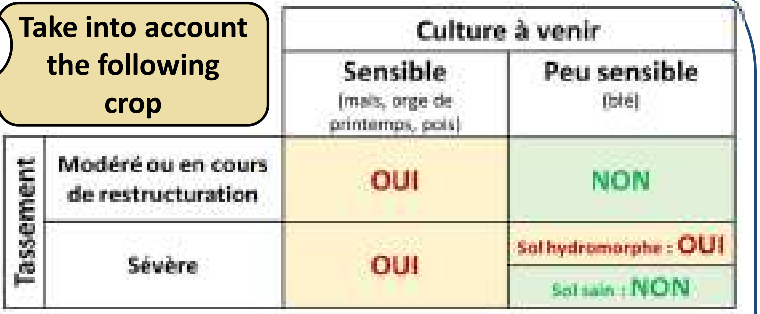
Should we restructure? With which material?

1 Diagnosing to decide on an intervention

Spade test

Cultural profile

2 Take into account the following crop



		Culture à venir	
		Sensible (maïs, orge de printemps, pois)	**Peu sensible** (blé)
Tassement	Modéré ou en cours de restructuration	OUI	NON
	Sévère	OUI	Sol hydromorphe : OUI Sol sain : NON

3 Choose the material according to the depth of the accident

Compaction depth	"Leveled" surface	« Rutted" surface
0 – 10 cm	**Superficial tillage :** *chisels and cultivators*	**Superficial tillage or ploughing:** *chisels, cultivators, plough*
10 – 20 cm	**Deep tillage, pseudo-ploughing or ploughing:** *chisels, heavy or mixed cultivators, décompactors, plough*	**Ploughing:** *plough*
20 – 30 cm	**Plowing or decompaction :** *plough, decompactor*	**Ploughing:** *plough*
> 30 cm	Very expensive mechanical regeneration → **facilitate natural regeneration by setting up a service crop with deep roots present for at least 1 to 2 years (e.g. alfalfa). If surface is rutted, plan to plough before sowing.**	

When to intervene?

Passage of material in FRIABLE consistency

⚠

In poor conditions, decompaction can have a negative effect!

How to choose your decompactor?

Wanted criteria :

- Maximize restructured volume
- Highest possible homogeneity
- Flatness of the ground after passage
- As few clods on the surface as possible
- Not/little mixing of horizons

Oblique tooth ✓

Straight tooth ✓

Curved tooth ✗

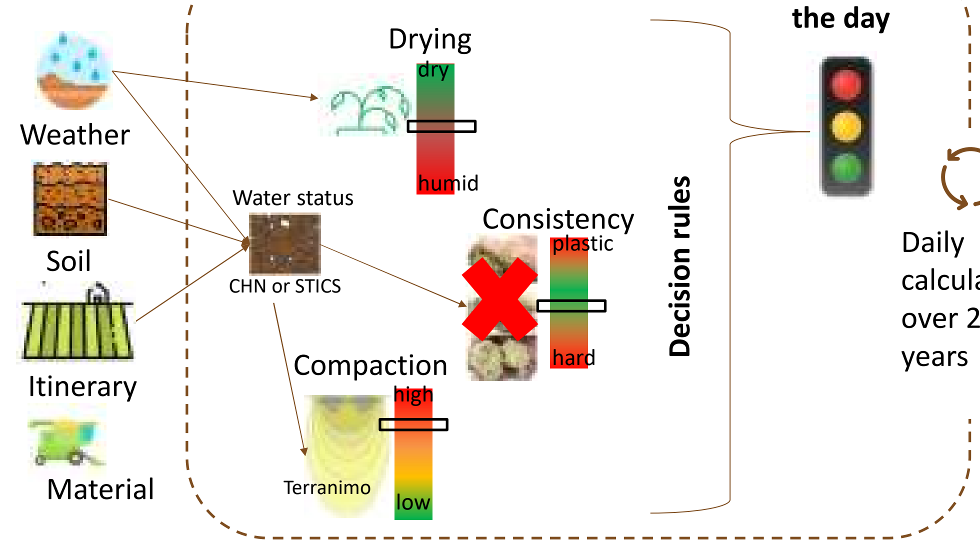
ARVALIS

Les Culturales 2023 14-15 juin

J-DISTAS : Tool for calculating available days

A new tool to take physical fertility into account in your strategic choices

How the tool works:



Input data

Weather

Soil

Itinerary

Material

Calculation of capacity levels

Water status

CHN or STICS

Drying

Consistency

Compaction

Terranimo

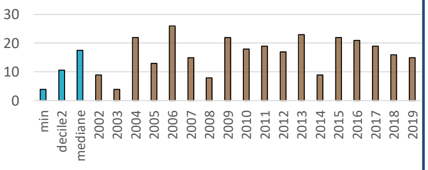
Decision rules

Availability of the day

Daily calculation over 20 years

Summary of results

Number of days available per year, minimum, deciles ...



This tool works for seedbed preparation operations, sowing, mechanical weeding, corn and beet harvesting, destruction of cover.

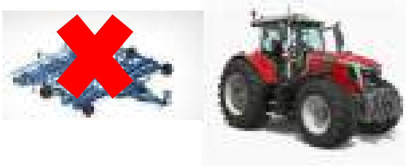
Application on a concrete case: the purchase of a stubble

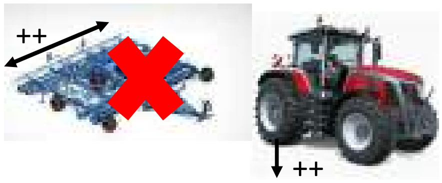
Case study : UniLaSalle Beauvais experimental farm, 40 ha of cover to be destroyed between 1 and 10 November. 5h traction / day

Option A: 4m

⇩

4,8 ha/h
190 hp are enough
6.2 t on the rear axle



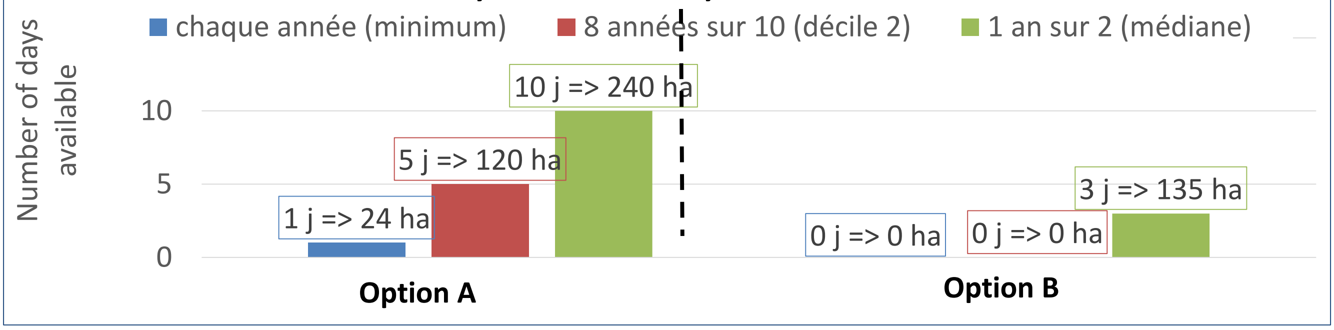


Option B: 6m

⇩

9 ha/h
245 hp required
8.3 t on the rear axle

Number of days available to rely:



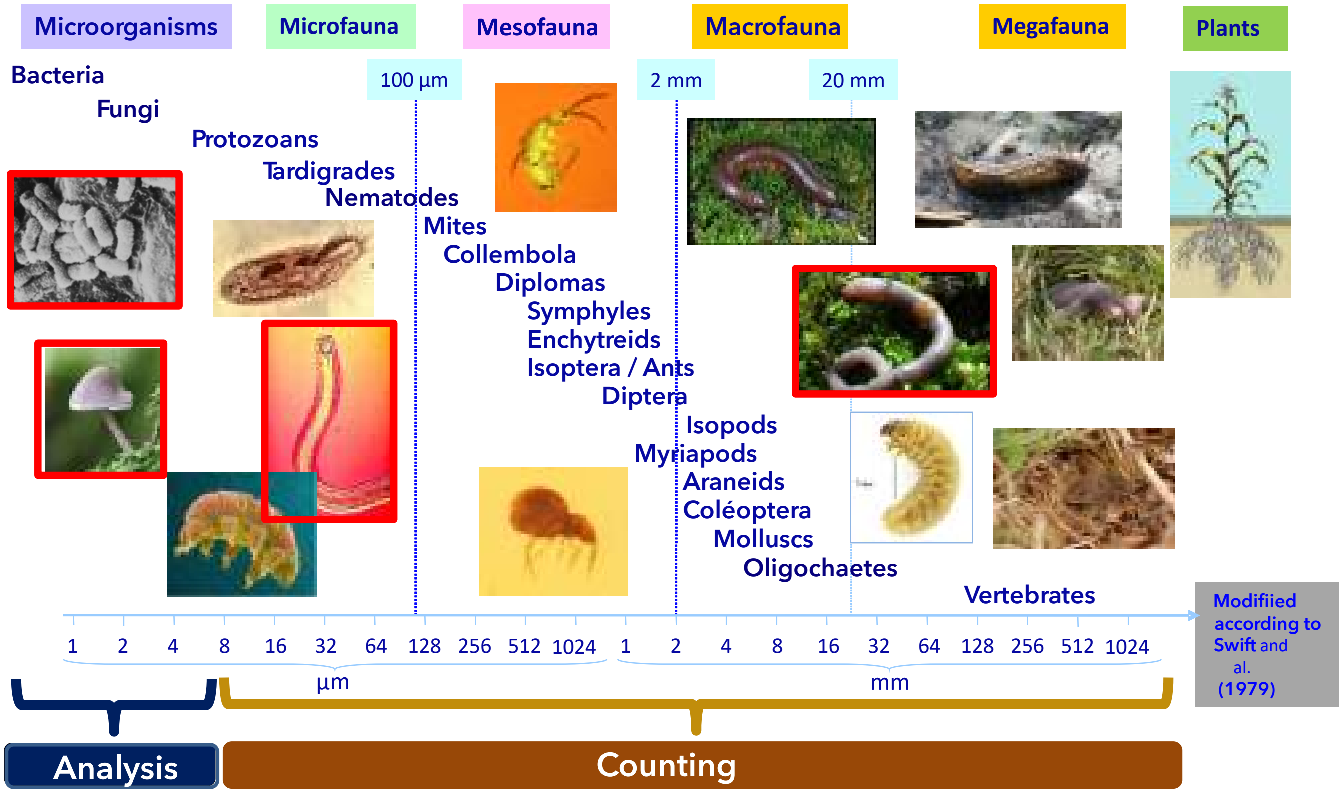
In this situation, the 4m stubble is more suitable: it requires less power, so a lighter tractor that generates less compaction and will be able to enter in the field more often.

J-Distas ARVALIS INRAE UniLaSalle ITB
with the financial contribution of CASDAR managed by Agriculture ministry

Biological functioning of the soil: how to evaluate it?

Les Culturales 2023 14-15 juin

A diverse ecosystem



Microorganisms
Microfauna
Mesofauna
Macrofauna
Megafauna
Plants

100 µm
2 mm
20 mm

Bacteria
Fungi
Protozoans
Tardigrades
Nematodes
Mites
Collembola
Diplomas
Symphyles
Enchytreids
Isoptera / Ants
Diptera
Isopods
Myriapods
Araneids
Coléoptera
Molluscs
Oligochaetes
Vertebrates

1 2 4 8 16 32 64 128 256 512 1024
µm
1 2 4 8 16 32 64 128 256 512 1024
mm

Modifiied according to Swift and al. (1979)

Analysis
Counting

New methods of analysis and quantification

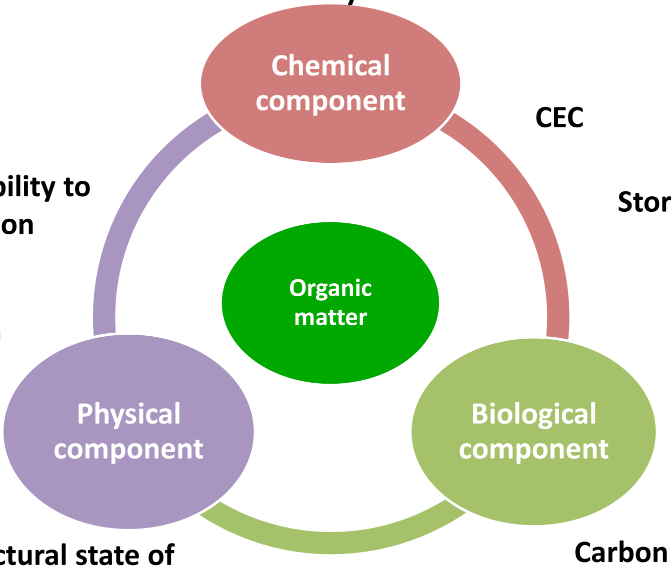
	Type of indicator	Method	Level of maturity
Organic status	Quality of organic matter	**·Particle size fractionation of organic matter**	Standard method, laboratory repositories
		·Microbial carbon by fumigation-extraction	Standard method, laboratory repositories
		·Carbon oxidizable at KMnO4	Current referencing
		·Biologically mineralizable nitrogen	Current referencing
		·Potentially mineralizable nitrogen	Current referencing
		C and N mineralization by aerobic incubation	Standard method, laboratory repositories
Abundance	Microbial abundance	**• Total microbial DNA**	Several existing methods, including INRAE Dijon, with RMQS repository
		• Relative abundance of fungi (18S rDNA) and bacteria (16S rDNA) (F/B ratio)	Several existing methods, including INRAE Dijon, with RMQS repository
	Abundance and diversity of earthworms, carabids and springtails	**Identification by morphological analysis**	Standard method (sampling) Researcher repositories
		Molecular diversity of soil fauna	Not yet done
	Abundance and diversity of nematodes	**Identification by morphological analysis**	Standard method ELISOL repository
Activity	Microbial activity	**Enzymatic activities (N, C, P, S)**	Standard method Several laboratories including INRAE UMR Ecosys with INRAE/RMQS repository
Diversity	Diversity of bacteria and fungi	**Taxonomic diversity by high-throughput DNA sequencing**	INRAE Dijon method with RMQS reference system

ARVALIS

Evaluate the fertility of your soil, and more!

Les Culturales 2023 14-15 juin

Why is it important?



Bioavailability of elements

CEC

Storage of mineral elements

Susceptibility to erosion

Root exploration

Chemical component

Organic matter

Physical component

Biological component

Nitrogen mineralization

Structural state of the soil

Air and water porosity

Carbon Storage

How to evaluate it:

Criteria	Tests and indicators	Advantages	Disadvantages
Availability and content of mineral elements	Soil analysis: pH, CEC, PK, OM levels...	Standardized and accurate measurement	Delays
Abundance, diversity and microbial activity	Soil analysis : Corg, Coxydé, ABM, B-GLU...	Standardized measurment	Referencing in progress to link to functions
Structural state of the soil	Cultural profile	Direct observation of all prospected horizons	Difficulty of execution and destructive measure
	3D Profile	Easy to do	Surface soil horizon
	Spade test (ISARA)	Easy to do	Surface soil horizon
	Penetrometer: Resistance to penetration (kPa)	Fast Extrapolation of unrepeatable observations	Very sensitive to moisture Indirect measurement of structure
Infiltrometry	Beerkan test: Infiltration speed	Simple and minimally destructive	Depending on the texture of the soil Long in some soils (>1h)
Sensitivity to beating	Slake test : Structural stability	Simple, fast and minimally destructive	Depending on the texture of the soil

Auger sampling

Cultural profile

Beerkan test

Penetrometer

Fertility

Ability of a soil to produce sustainably under a climate and for a cropping system

Quality

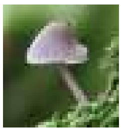
Ability of soil to perform its functions to enable production, maintain water and air quality, and support human health

ARVALIS

Soil diagnosis: interpretation of the new indicators

What do these indicators mean about soil functioning?

- ✓ Referencing of soil microbiology indicators
- ✓ Search for repeatable indicators, reactive over time and relevant for advice



Lien indicateur / fonction	
Relation forte	■
Relation faible à moyenne	▨
Lien non identifié	

		Indicateurs du menu Microbioterre	Recyclage des nutriments		Transformation du carbone			Structure du sol		
			Fourniture N	Perte N	Transformation MO	Minéralisation MO (CO2)	Augmentation MO	Erosion Battance	Porosité	Stockage eau
Statut organique		C org	■	■		▨	▨	▨	▨	▨
		Carbone labile KMnO4		■		■		■	■	▨
	Fractionnement granulométrique de la MO	C 0-50 µm					■			
		C 50-200 µm				■		■		
		C 200-2000 µm			▨	■				
		N 0-50 µm								
		N 50-200 µm	▨							
		N 50-2000 µm								
		N total	■							
		ABM (mg/kg)	■	■				■		
Abondance		Carbone microbien (biomasse microbienne)				▨		■		
		ADNr 18S (biomasse fongique)						▨		
Activité		Activité enzymatique : LAP	▨							
		Activité enzymatique : ARYLN	■							
		Activité enzymatique : Protéase	■			■		■		
		Activité enzymatique : B-Glu (nmol/min/g)	■			▨		■		

Pilote — **Partenaires techniques financés**

Partenaires techniques non financés — **Sous-traitants**

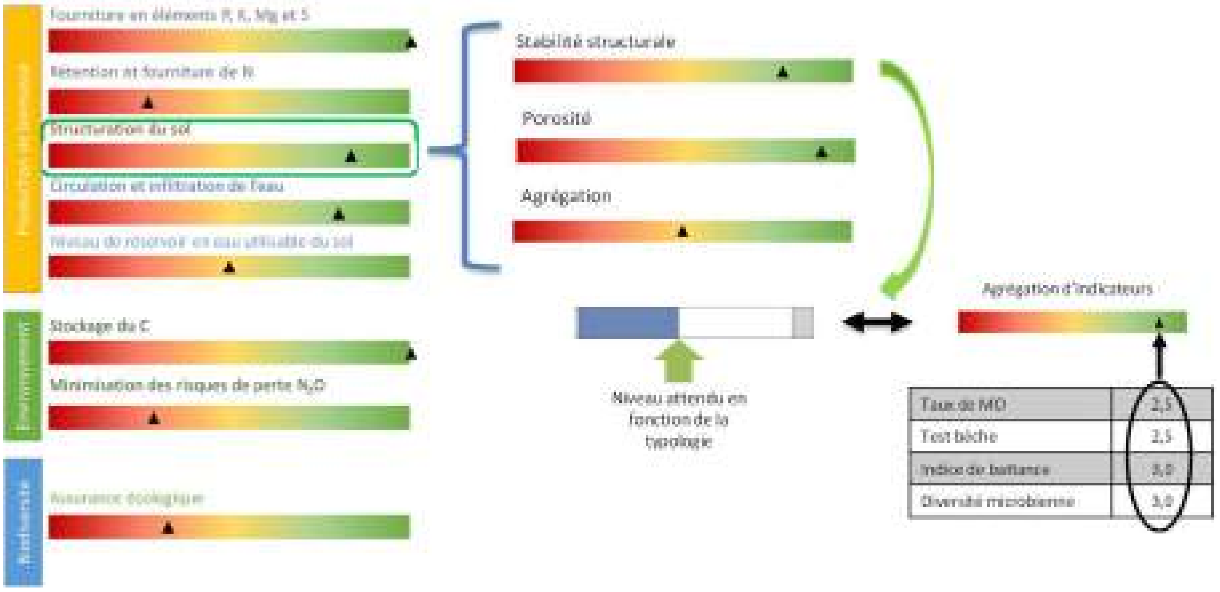
How to move from indicators to diagnosis and advice?

Example of the Agro-Eco Sol interpretation process

1- Definition of a typology of cropping systems and pedoclimate

Wheater — *Soil type* — *Cultivation strategy* — *Fertilization*

2- Diagnosis of function satisfaction and processes based on indicators



Taux de MO	2,5
Test bêche	2,5
Indice de battance	3,0
Diversité microbienne	3,0

3- Advice with setting up levers

Le projet est accompagné par l'ADEME dans le cadre du programme « Industrie et Agriculture éco-efficientes » du programme des investissements d'Aven

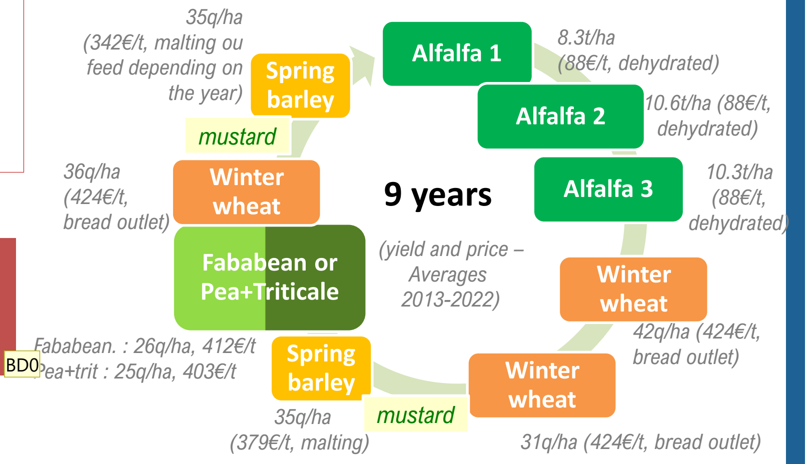
ORGANIC pole

Results of a simulated arable farm in southern Paris

Contexte :

- Surface : 180 hectares
- Soil : Silty-clay, semi-deep to deep,
- No irrigation
- 1 family unit + 0.3 employee

A long and diversified rotation!



Combining the levers is essential!

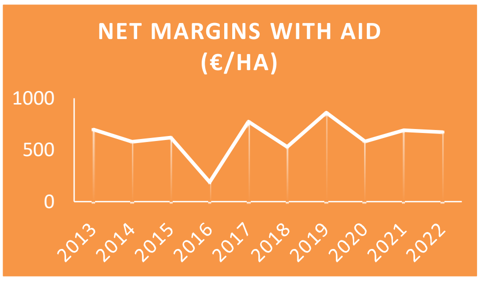
- ➢ **Alternation of winter / spring crops**
- ➢ **N-demanding crops behind legumes**

Which multi-performance ?

Low input costs
High mechanization costs
Overall increase in expenses in 2022

Average 2013-2022	€/ha
Seed cost	103
Fertilizer cost	71
Protection plant cost	0
Mechanization cost	**255**
Employee cost	48
MSA contributions (health, …)	203

Average 2013-2022	
Total working time (h/ha)	3.9
Number of interventions	11
Fuel Consumption (L/ha)	90
Number of phytosanitary treatments	0
Net margin with subsidies (€/ha)	620
Subsidies (€/ha)	400
Greenhouse gas emissions (kgeq.CO_2/ha)	558
Energy production / Energy consumed	21



Economic robustness: an asset for this system

Decreased soil fertility P and K

Average 13-22 (kg/ha)	Per year	At the end of the 9 years of rotation
Total N input	22	223
N balance	-7	-65
Total P_2O_5 input	13	130
P_2O_5 balance	-23	-230
Total K_2O input	38	380
K_2O balance	-61	-611

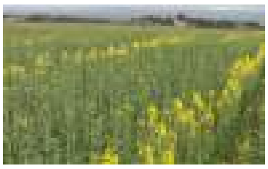
THISTLE MANAGEMENT
Advices

Depletion strategy: intercropping tillage

- **Repeated tillage interventions in dry conditions**
  - In summer and autumn after a winter crop harvested in July
  - From 6-8 leaves of the thistle (compensation point) to exhaust it
- **Ploughing**: if well practiced, it can delay the emergence of thistle in spring
- **Tillage in spring**
  - As soon as new thistle shoots emerge
  - Before a spring crop whose sowing will be delayed
  - No rain forecast in the following days
- **Choice of material:**
  - Teeth equipment preferably with fins (good covering)

Choice of crop succession: alternate!

- **Alternating winter crops / spring crops**
  - To have long intercrops to practice depletion strategy
  - Introducing winter crops decrease the risk
- **Choosing covering crops**
  - to compete with the thistle
  - Rye, winter barley, rapeseed, cereal+grain legumes, ...
  - 3 years of alfalfa (competition + repeated mowing)
- **Choosing stuffy cover during intercrops**
  - Do not save tillage before (depletion strategy)
  - Take care of the implantation to succeed (rain forecast, soil structure, ...)
  - Choose stuffy, high-density species to compete
  - Be careful, if the cover is not competitive enough (little biomass), the thistle grows!.



During crop

- **Hoeing:** to practice in dry conditions
- **Topping :** slight effect

A retenir

Proceed from 6 leaves of the thistle

Always in dry conditions

Repeat tillages

Fostering competition

Avec le soutien du CASDAR

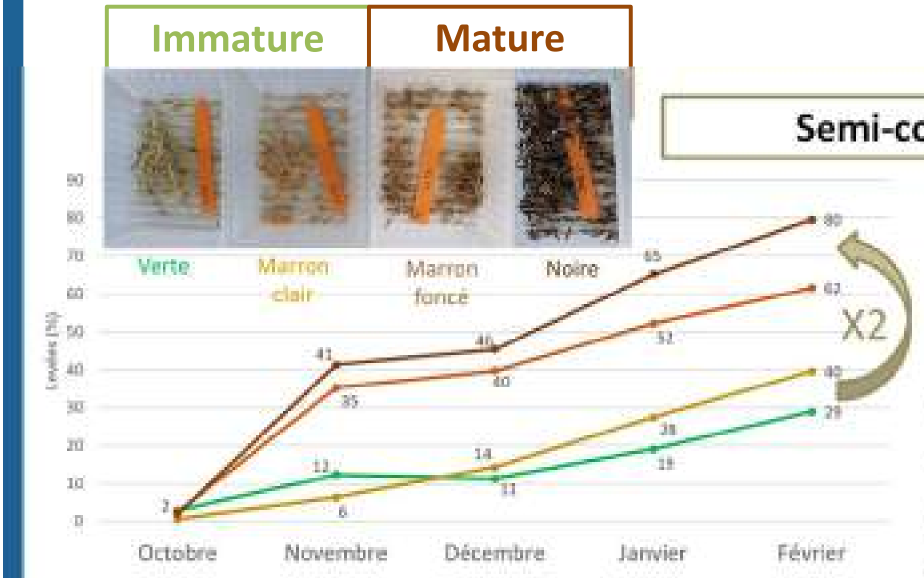
Les Culturales 2023 14-15 juin

Management of wild oats: Biological knowledge and Topping

When ? Which indicators in the field? How to manage fallen seeds?

Semi-controlled testing

- Seed color
- Seeding depth
- Date of topping
- Viability 1 to 2 years after sampling



Levées en fonction de la couleur de la graine
Moyenne d'environ 10 échantillons/couleur - 4 répétitions/échantillons
Diverses localités - Échantillons 2020-2021

Test results

Emergences X2 with dark vs light seeds

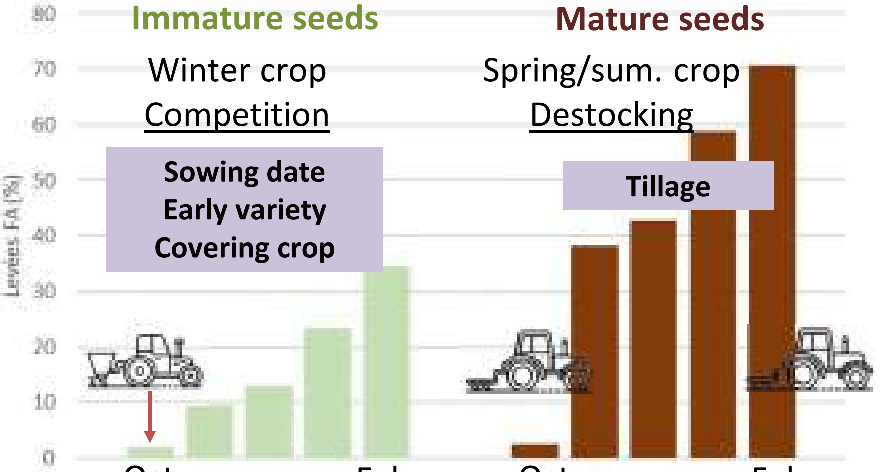
Emergence X2 with a seedling on the surface vs 3cm

Stimulation of germination of mature seeds at 5°C

Light seeds : viable but loss of germination (50% max in the following 2 years)

Dark seeds : 80% emergence in the following 2 years (viability and germination retained)

Combination of levers adapted to the germination capacity of seeds on the ground



Annual rate of mortality ~ 80 %	Autumn + spring emergences
Early topping	**Late topping**
Immature seeds	**Mature seeds**
Winter crop	Spring/sum. crop
Competition	Destocking
Sowing date **Early variety** **Covering crop**	**Tillage**
Oct → Feb	Oct → Feb
Light seeds on panicles	**Dark seeds on panicles**

Limits: staggered emergences and genetic variability

Veg&Lab ARVALIS

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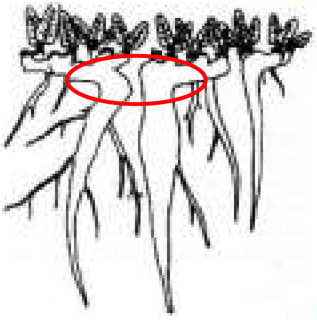
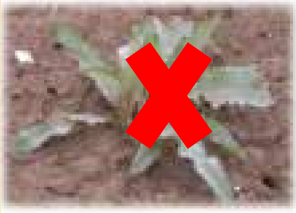
RUMEX MANAGEMENT
Biology and agronomic levers

Biology: Tuberous root

Multi-year
Sexual
multiplication



Collar fragmentation
Vegetative propagation



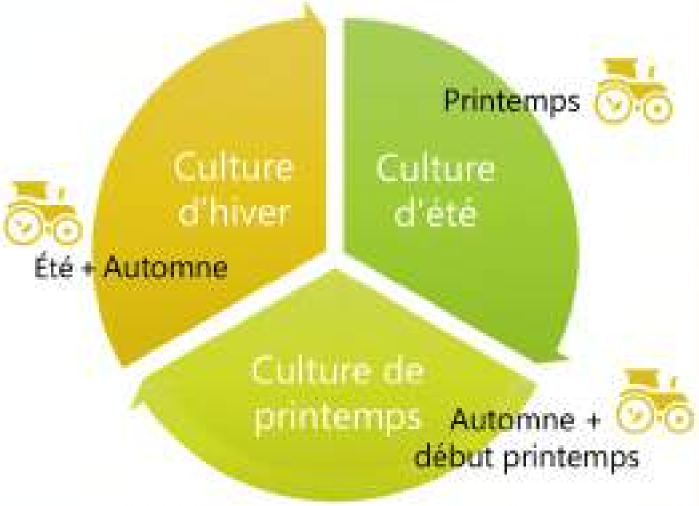
Rumex crispus

Rumex obtusifolius

Printemps	Été	Automne	Hiver
Levées			
	Floraison		
			Dormance

Agronomic levers

- **Intercropping tillage**



→ Adapt your cultural itinerary

→ Alternating long and short intercrops

→ Proceed from 3 leaves

- **Scalp and Extract the collar**

1. Toothed equipment with maximum cover (fins, crow's feet)

2. Straight tooth equipment (vibrator, harrow)

3 to 4 interventions in dry conditions

Combining levers

- **False seedling: spring / autumn**
- **Mowing: summer/autumn, before seeding**
- **Ploughing : partial action on the strains**
- **Compost (manure input): >50°C – 3 weeks**

Manual grubbing

Rolls <-> transplants

Avec le soutien du CASDAR

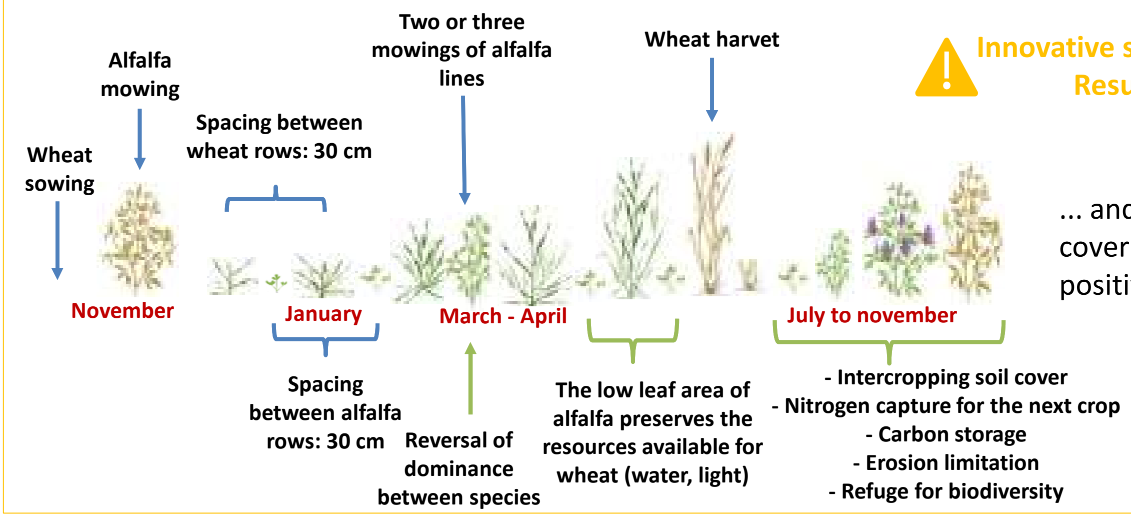
Management of a permanent cover by mowing in a main crop inter-row

Agronomic principle

Separate the crop and the cover crop in the same space to be able to manage them separately.

RTK autoguiding to sow and manage the 2 species

Ecomulch inter-row mower to manage the cover crop



Wheat sowing

Alfalfa mowing

Spacing between wheat rows: 30 cm

Two or three mowings of alfalfa lines

Wheat harvet

November

January

March - April

July to november

Spacing between alfalfa rows: 30 cm

Reversal of dominance between species

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

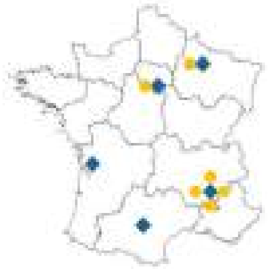
- **Intercropping soil cover**
- **Nitrogen capture for the next crop**
- **Carbon storage**
- **Erosion limitation**
- **Refuge for biodiversity**

Innovative system under test – Results to come

... and so on, as long as the cover crop services are positive

First results

« We learn from our failures ! » → The teams faced the difficulty of implementation. Rigor in equipment setting is essential to succeed!



5 trials – **6 Observatories**

whose objective is to test the feasibility of the practice, the complementarity between species and evaluate the services rendered, and disservices

Equipment setting best practices, some examples
Having the same width between seeder and mower
If sowing guidance errors, reproduce it for other operations
Checking that the RTK setting of the tractor has an accuracy of +/- 2 cm
Use the same seeder for all sowings
Number the seedling and mowing elements and always place them at the same place
Centering the seeder relative to the seeding elements + butt balls
Calibrating the cant corrector between tractors or use the same tractor for sowing and mowing
Allowing between 10 and 20 m for the tractor to take over the reference line

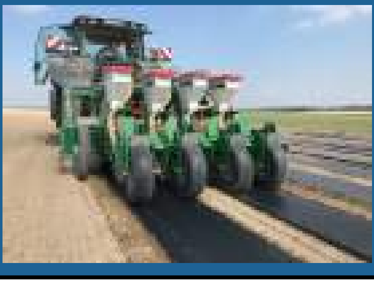
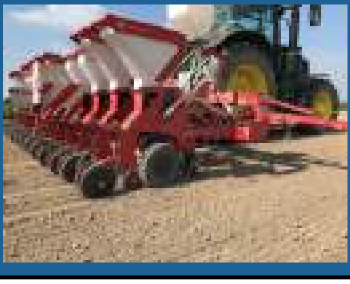
Arvalis - Couverts permanents fauchés Subscribe to follow our work!

Funded Partners:

Unfunded partners:

With the support of CASDAR

Sugar beet set up in organic farming to minimize manual weeding

	Transplanting	Sowing under tarpaulin	Sowing for full hoeing
			
€	• Plants : approx. €1,800/ha (excluding equipment and labour)	• Service : approx. 1300 €/ha (seeds not included)	• Service : approx. 100 €/ha (seeds not included)
Positives ➕	• Vegetation advance • Tolerance to underground pests • Early mechanical weeding	• Vegetation advance • Management of weeds by the tarpaulin	• Hoeing perpendicular to the direction of sowing • Cost
Negatives ⛔	• Cost • Root conformation (split roots)	• Cost • Tarpaulin present at harvest • Weeds in the tarpaulin holes	• Hard-to-achieve alignment • Potentially smaller sown population

Autonomous sowing with the Farmdroid FD20 robot

- Speed: 700 m/h
- Autonomy: 24 h
- Work rate : 4/5 ha/day
- Cost: 100 K€

The position of each seed is referenced thanks to the RTK GPS which allows the intra-row and inter-row hoeing of weeds by the robot.

ITB Institut Technique de la Betterave

Which varieties can be used in organic farming?

• Which varieties in Organic Farming ?

Varieties registered on the French official catalogue for Organic Farming usage

In France: in place since 2011 for soft wheat, in progress for Durum wheat

- **Trials in Organic Farming conditions**
- Quality evaluation on grain produced in organic farming
- **Specific characteristics** useful for OF considered upon registration : covering power, resistance to decay…
- Possible for all species upon depositor request.
- In soft wheat, 17 varieties registered since 2011. Some examples:

Year	2012	2019	2020	2021	2022	2023
Name	Hendrix	Geny, Gwastell	Gwenn	LD Voile, LD Chaine	Chaussy	KWS Eternel, Novic

Also exists in other European countries (Austria, Germany…)

These varieties are adapted to organic farming

Today

Other varieties registered on other lists

Some varieties may be of interest in OF.

Some examples : IZALCO CS, ENERGO, RENAN, APEXUS, LENNOX, TOGANO…
Importance of evaluation under OF conditions = **réseau Expébio**

Today

Post-registration evaluation by the partners network **Expébio**

New rules defined in the new OF Regulation
RUE 2018/848

Organic varieties (adapted to organic production)

= selected under OF conditions (selection method and OF plot) with specific registration procedures. Will be identified in the official list of varieties.

An experimental phase from 01/07/23 for 6 pilot species (including wheat, barley, rye, maize). Many questions still remain on the rules definition : Which heterogeneity? Whole selection in OF ? What are the registration rules?

Tomorrow

Tomorrow

• In addition to varieties, Organic Heterogeneous Material

= Very heterogeneous material produced under OF conditions

It is not a variety, no official description. No registration but a notification.

Its significant heterogeneity can provide an ability to adapt.

Authorized since 01/01/22. No request in France yet.

GEVES Expertise & Performance

Expébio
Le réseau des céréales bio

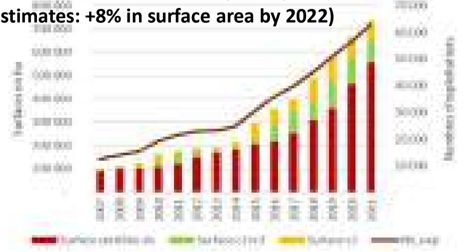
ARVALIS

Les Culturales 2023 14-15 juin

Organic Arable Crops Market

STRENGTHS

Positive arable crops dynamic
(estimates: +8% in surface area by 2022)



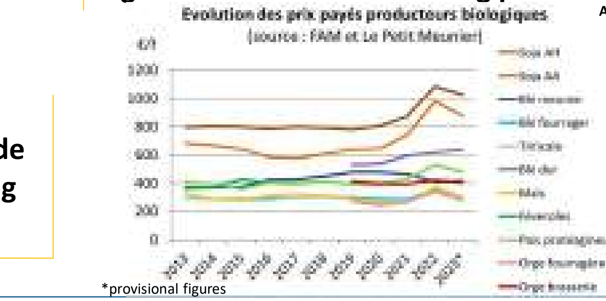
Source : Agence Bio

Meets consumers' desire: environmentally friendly, healthier and local food

69%
of French people are vigilant about production process that respects the environment and animal welfare

Source : Agence Bio

Higher and more stable selling prices



*provisional figures

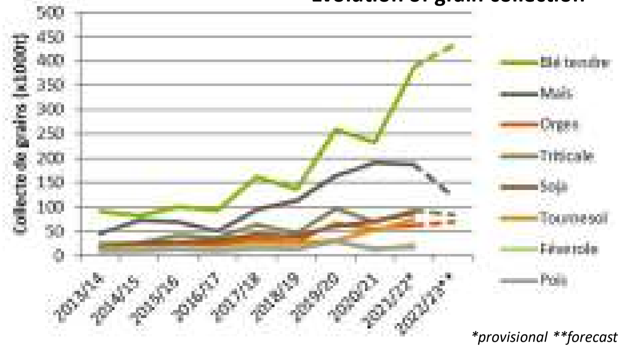
Average price 2013-2022
832
676
425
300
290
566
303
414
412
280
408

Diversified systems mode robust facing hazards

WEAKNESSES

Increasing collection but fluctuating in the face of climatic hazards
→Permanent adjustment of sectors

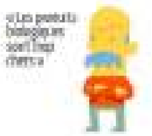
Evolution of grain collection



*provisional **forecast
Source : FranceAgriMer

The main barrier to the consumption of organic products is their "too high" price, remained stable despite inflation

71%



Source : Agence Bio

Divisive communication focused on "pesticide-free" that does not highlight the strengths of organic farming

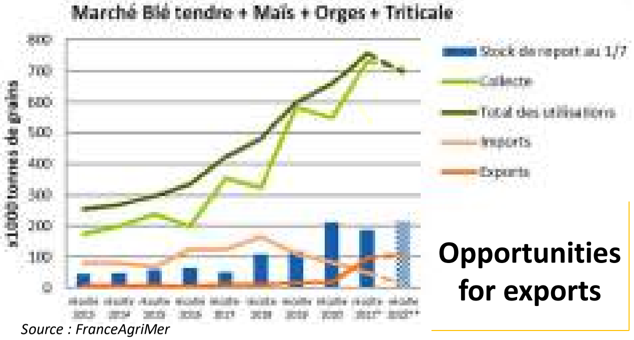
ISSUES
- Restoring consumer confidence
- Boosting consumption in out-of-home catering
- Promoting local organic produce
- Maintainning the sectors

OPPORTUNITIES

Political ambitions, driven by the EU
→ Increase the proportion of organic UAA from 10.5% in 2022 to 25% in 2030

EGalim law : 20% of organic food in collective catering (6% in 2021)

Self-sufficiency in organic cereals



Source : FranceAgriMer

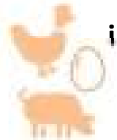
Unmet demand for legume crops

Opportunities for exports

THREATS

-7.8 % fewer organic products sold in supermarkets by 2022

French mistrust of organic labels (+17% compared to 2021)



Animal sectors heavily impacted → Grain uses down

De-certifications, Lower prices → Weakened sectors and producers

57%

Source : Agence Bio

High carry-over stocks of cereals

Uncertainties about the context: long-term or cyclical decline

ARVALIS

Overview of the project PhosphoBio

Les Culturales 2023 14-15 juin

CONTEXT :

-> Increase in organic fields area and limited availability of phosphate fertilizers for use in Organic Farming (OF)
-> Challenge of maintaining sufficient availability of Phosphorus (P) in OF

Action 1 : Make an inventory of the soil P-fertility in OF

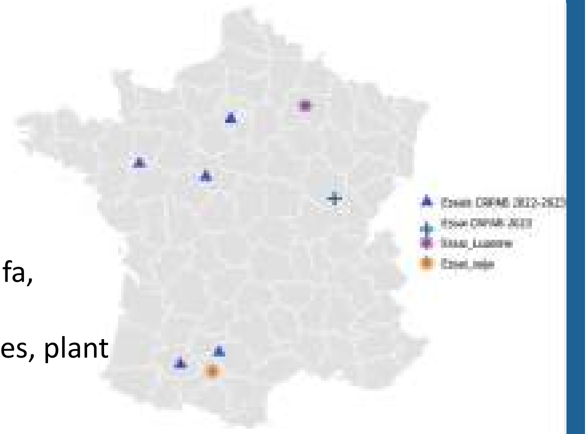
Construction of a "P-fertility" observatory : 201 fields at French organic farmers

Action 2 : Test and adapt diagnostic tools and their references to the OF context

-> Construction of a response curve to the P status of soils in OF from field trials :
- In 2022 and 2023
- 6 trials sites in France : wheat and/or maize (contrasting soil types)
- In O.F. for at least 5 years
- With low Olsen P2O5 soil levels
- 12 fertilization treatments (2 nitrogen and 6 phosphorus rates)

-> Development of nutrition indices adapted to the OF context (alfalfa, soybean)
-> Comparison of P-fertility diagnostic methods based on soil analyses, plant analyses and phosphorus nutrition index (PNI)

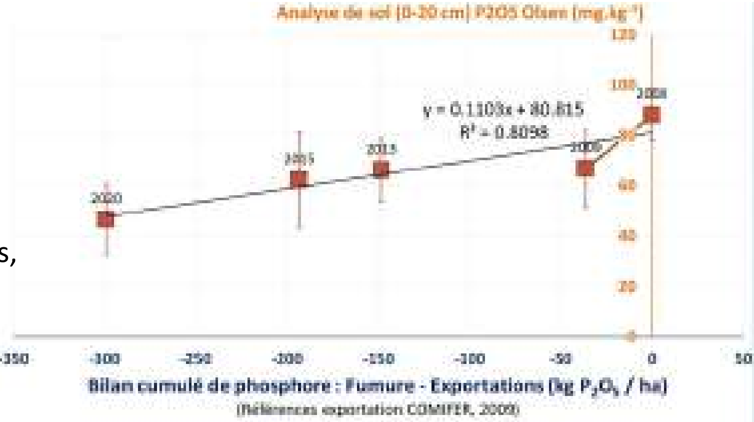
"Action 2 trials" location



Action 3 : Predicting the impact of practices on soil phosphate status

-> Development of P content references in OF (grains, straw)
-> Development of N and P content fertilizers compilation approved for use in O.F.
-> Evaluate the impact of agricultural practices on the availability of P (inputs of organic products, plant cover)
-> Construction of scenarios for the expansion of O.F. at various geographic scales (small agricultural regions, France, etc.) and simulation of their consequences on the P-availability in soils and on yield

Evolution of the cumulative Input-Output balance of P according to the Olsen P2O5 content of the soil
OF crops system without fertilizers in Boigneville (Arvalis trial) – 2008 to 2020



Action 4 : Promote and communicate the project results

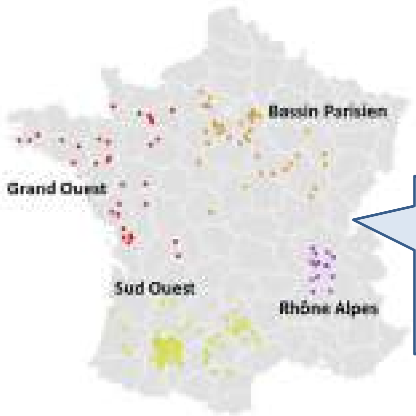
-> Construction of a tool to calculate input-output balances of P at the scale of the plot, adapted to O.F.
-> Development of a diagnostic guide for fertility P and references to predict its evolution according to practices
-> Communication and transfer of project results to farmers and advisors
-> Distribution of Newsletters to all partners and farmers mobilized

Funded Partners:

Other partners associated with the project:

With the support of CASDAR

First knowledges from the observatory PhosphoBio

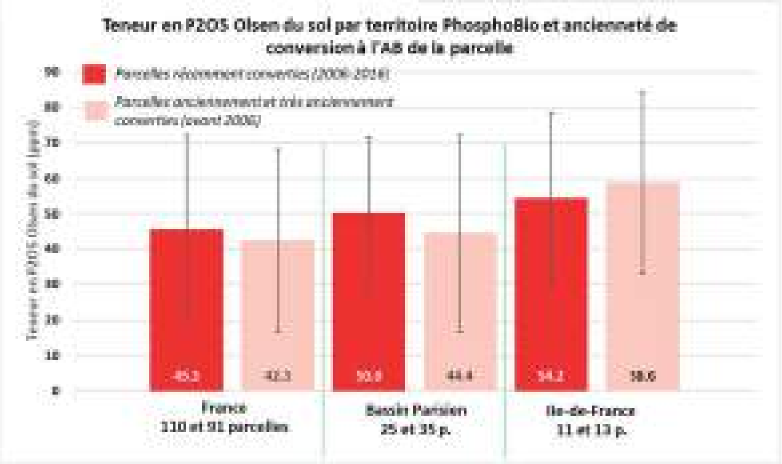


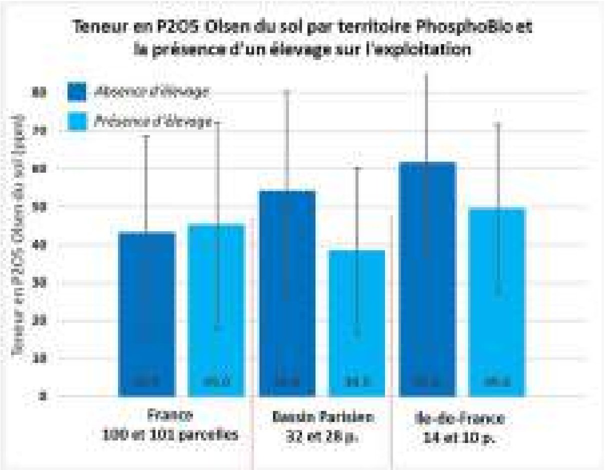
CONTEXT :

Construction in 2021 of an observatory of 201 crop fields (172) and permanent meadows (29) in 157 farmers to monitor soil P-fertility in Organic Farming (OF)

- ✓ 101 fields located on farms with livestock (10 in Île-de-France) vs. 100 without livestock (14 in Île-de-France)
- ✓ 91 fields recently converted to OF (between 2006 and 2016) including 11 to IDF vs. 110 "old" fields (converted before 2006) including 13 to IDF

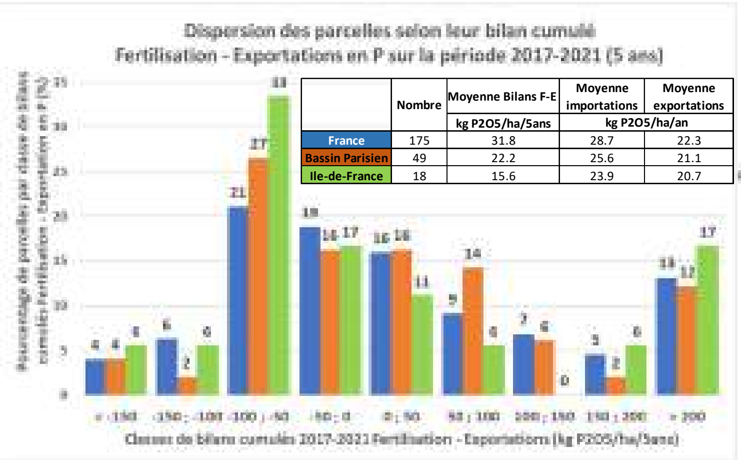
Results of the soil analysis *(Autumn-Winter 2021-2022)*





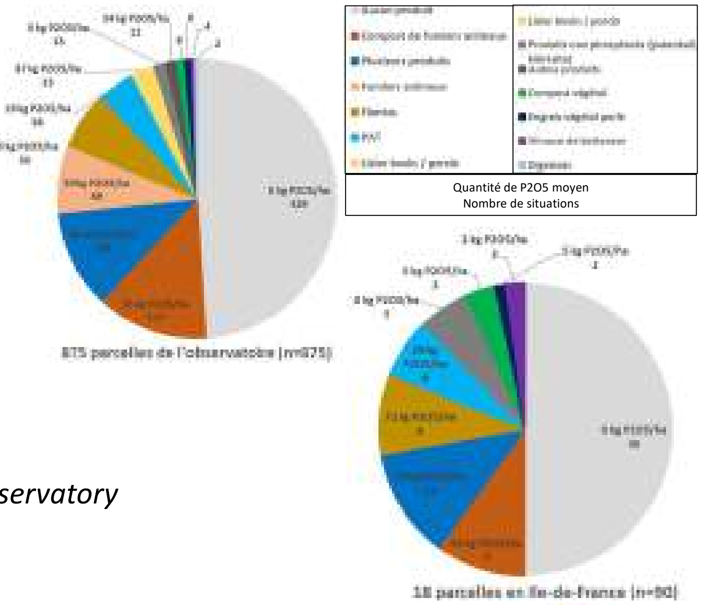
In Île-de-France, average soil levels of Olsen P2O5 higher than in the rest of the France (57 vs. 44 ppm)
→Similar between fields recently (54 ppm) and formerly converted to O.F.(59 ppm)
→Higher for fields of farms without livestock (62 ppm) compared to those with livestock presence (50 ppm) unlike the rest of the France (43 vs 45 ppm) where they are similar

Impacts of cultural practices on the Fertilization- Exports P-balances



	Nombre	Moyenne Bilans F-E	Moyenne importations	Moyenne exportations
		kg P2O5/ha/5ans	kg P2O5/ha/an	
France	175	31.8	28.7	22.3
Bassin Parisien	49	22.2	25.6	21.1
Ile-de-France	18	15.6	23.9	20.7

Distribution of fields according to average annual inputs of P205



In Île-de-France, Fertilization – Exports in P balance :
→Lower than the national average of the PhosphoBio observatory
→Annual exports similar to the national average
→Annual imports lower than the national average

Funded Partners:

Other partners associated with the project:

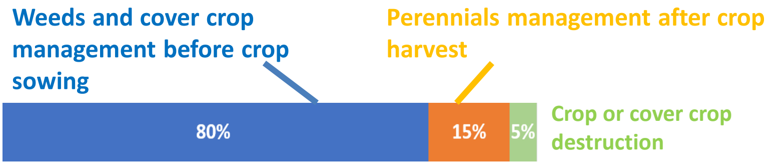
With the support of CASDAR

SOIL CONSERVATION AGRICULTURE pole

Uses of glyphosate in Conservation Agriculture

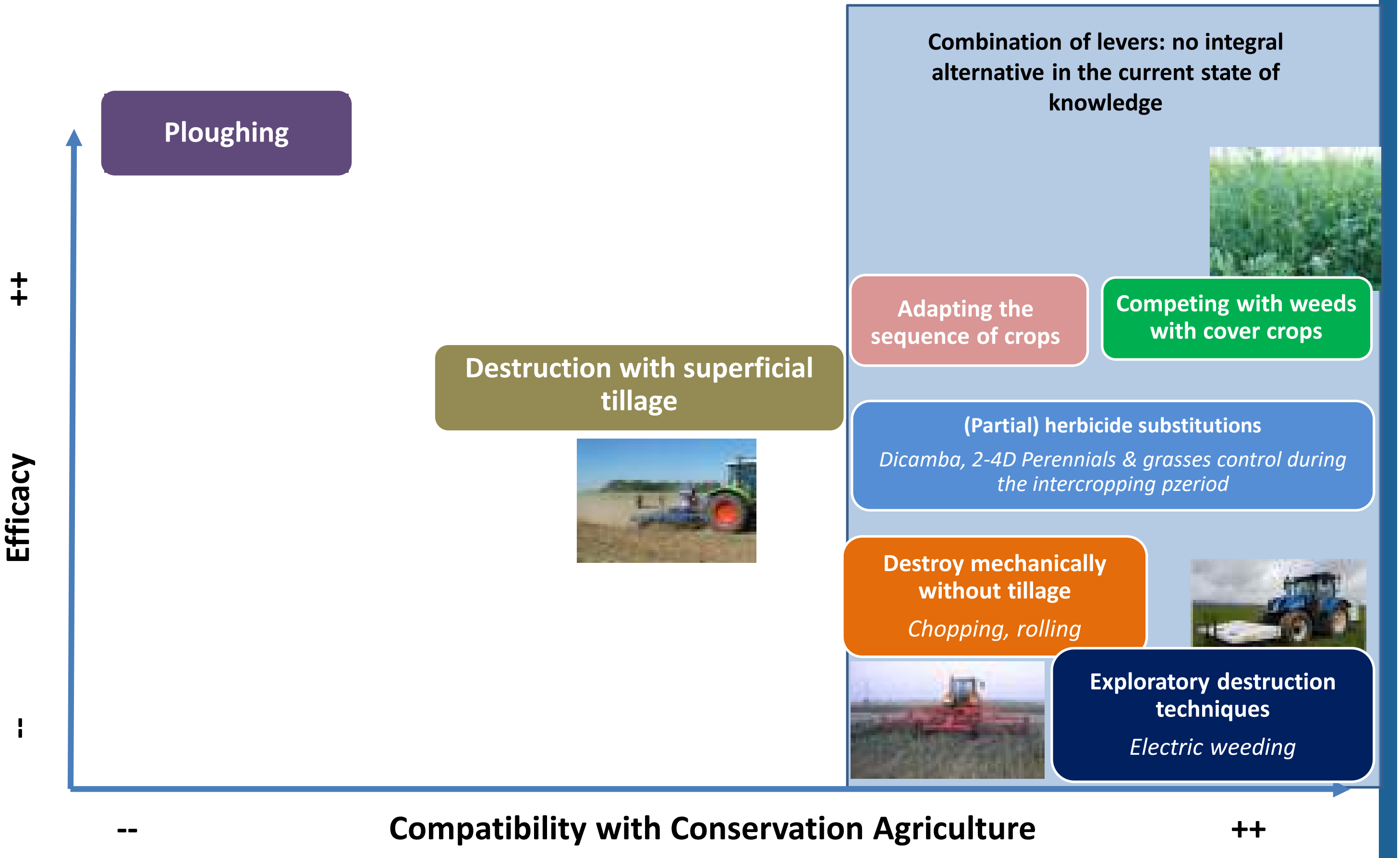
Les Culturales 2023 14-15 juin

What is the situation in France?



Glyphosate : 10 to 30% of the herbicide pesticide treatment intensity (IFT)
On average = 2.2l/ha/year*
1l/ha/year: favourable conditions
3l/ha/year: unfavourable conditions
*APAD survey "SOLutions ACS"
No-till perennials and grasses management

Are there alternatives?



Combination of levers: no integral alternative in the current state of knowledge

Ploughing

Destruction with superficial tillage

Adapting the sequence of crops

Competing with weeds with cover crops

(Partial) herbicide substitutions
Dicamba, 2-4D Perennials & grasses control during the intercropping pzeriod

Destroy mechanically without tillage
Chopping, rolling

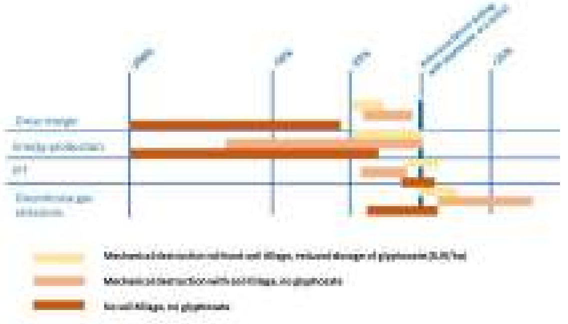
Exploratory destruction techniques
Electric weeding

Efficacy of alternatives to glyphosate

- 🟩 Very good efficacy
- 🟢 Good efficacy
- 🟨 Medium efficacy
- 🟧 Low efficacy
- 🟥 No efficacy

	Chemical methods		Physical methods							Other methods
			Not adapted to conservation agriculture							
	Glyphosate	Other herbicides	Plough	Superficial tillage 0-8 cm (1) drying conditions	Superficial tillage 0-8 cm (1) wet conditions	Superficial tillage 8-15 cm (1) drying conditions	Superficial tillage 8-15 cm (1) wet conditions	Chopping, Knife roller	Heavy roller on frozen weeds (T°<-3°C)	Freeze
Perennials dicots (including roots)	🟢	🟢	🟨	🟧🟥	🟥	🟩🟨	🟧	🟥	🟥	🟥
Perennials grasses (including roots)	🟢	🟥	🟨	🟨	🟥	🟢	🟥	🟥	🟥	🟥
Grasses (1-3 leaves)	🟩	🟥	🟩	🟢	🟢	🟢	🟢	🟥	🟥	🟥 <-15°
Grasses (tillering or stem elongation)	🟩	🟥	🟩	🟢	🟧	🟢	🟧	🟥	🟥	🟥 <-15°
Graminées (heading)	🟩	🟥	🟩	🟢	🟧	🟢	🟧	🟨	🟨	🟨
Dicots (cotyledons to 2-3 leaves)	🟢	🟨	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟥
Dicots (> 3 leaves)	🟢	🟨	🟩	🟩	🟩	🟩	🟩	🟥	🟧	🟥
Cleavers and geranium > 3 leaves)	🟨	🟨	🟩	🟢	🟧	🟢	🟧	🟥	🟥	🟥 <-15°
Fodder radish	🟨	🟨	🟢	🟢	🟨	🟢	🟨	🟧	🟨	🟨 -8 à -13°
Vetch and faba beans at flowering stage	🟨	🟢	🟩	🟩	🟢	🟩	🟢	🟨	🟢	🟢 -5 à -10°
Mustard and Phacelia well developed	🟢	🟢	🟩	🟩	🟢	🟩	🟩	🟩	🟩	🟢 -5 à -10°
Living mulch (lucerne, white clover…)	🟨	🟨🟥	🟢	🟨	🟧	🟢	🟨	🟥	🟥	🟥
Meadow and set-aside destruction	🟢	🟥	🟢	🟨	🟧	🟢	🟨	🟥	🟥	🟥
(1) : superficial tillage of 100% of the soil surface										

Multi-criteria evaluation of technical management with reduced doses or without glyphosate (SOLutions ACS, APAD)



APAD

ARVALIS

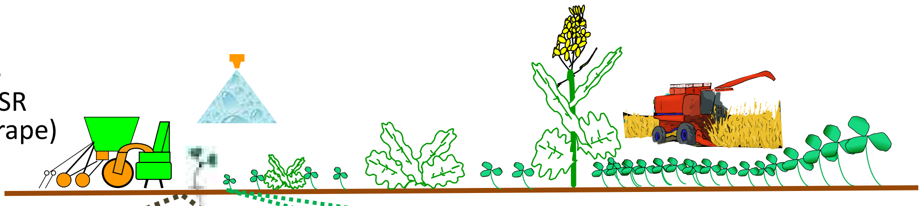
Handling living mulch

Objectives: maximize the services provided by cover crops (CC)

Year 1: anticipate CC establishment under a crop

Low impact on crop except weeding which must be adapted

Example
under OSR
(oilseedrape)



OSR sowing + Legume
Alfalfa or Birdfoot trefoil 6-8 kg/ha
Red clover 5 kg/ha
White clover 3 kg/ha

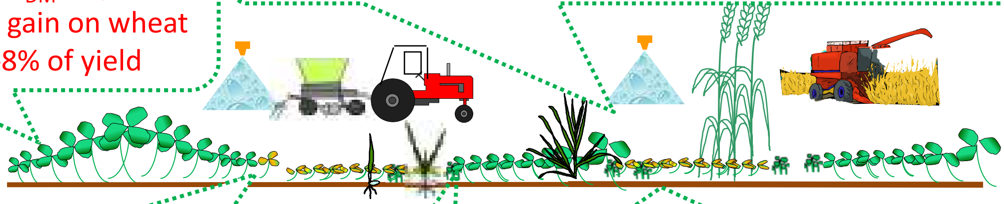
Post emergence reduced doses : Novall, Alabama
Kerb and foliar grass herbicides

Intercrop : CC development (except dry summers)

Year 2 : CC destroyed or kept alive in a winter cereal

Significant CC in autumn
(2 à 5 t_{DM}/ha) →
Average gain on wheat
of 5-8% of yield

Limit CC biomass to 1 t_{DM}/ha in spring (dead or alive),
otherwise average loss of 30% yield



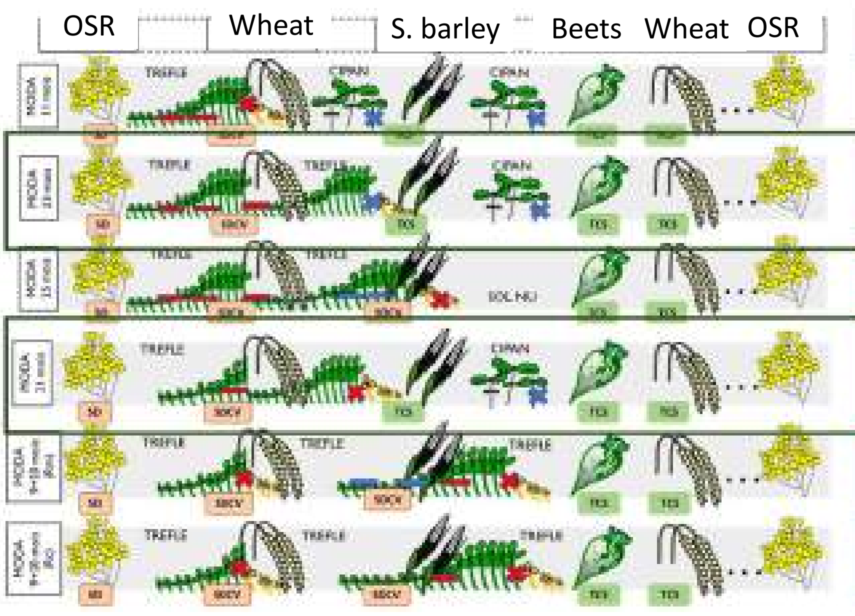
CC suppression and Weeding
(Glyphosate 360 to 540 g/ha)

Autumn weeding (Fosburi
0.5 + Défi 2.5 l/ha)

Clover destruction (Allié 10 g/ha)
Clover suppression (Allié 3 g/ha)
Alfalfa suppression (Allié 5-10 g/ha
then Starane 0.33 l/ha)

Year 3 or more (spring crops or grain legumes): CC destruction is recommanded (complex or impossible CC suppression)

Results 2015-2021, long-term trial in Poix (51)



Yield	N leaching	N release
+	☑	++
++	☑	+++
-	☑	+
+	☒	+
--	☒	-
--	☒	--

A.R.E.P. Association Régionale pour l'Etude des Productions végétales en Champagne-Crayeuse

In the 3 campaigns following the destruction of the CC, beneficial impacts on nitrogen and yield.
But perennial CC are :
-difficult to set up
-to be well suppressed under wheat
-to be destroyed at the end of winter before spring crops (competition + nitrate leaching)

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P2_ACS_2

Fertilization in Conservation agriculture : is needed to split nitrogen inputs on wheat ?

Why ask the question?

Nitrogen mineralization dynamics hypotheses in Conservation agriculture vs conventional

Increased availability (medium-term effects)

Cover crops:

Nitrogen fixation and additional restitution.

Limitation of leaching during the drainage period.

Increase of organic matter levels:

+30 to 50 kg N/ha/year for a gain of 0.5 points of organic matter

Slow availability (short-term effects)

No tillage: slowing of mineralization at the end of winter (-10 to -15 kg N/ha)

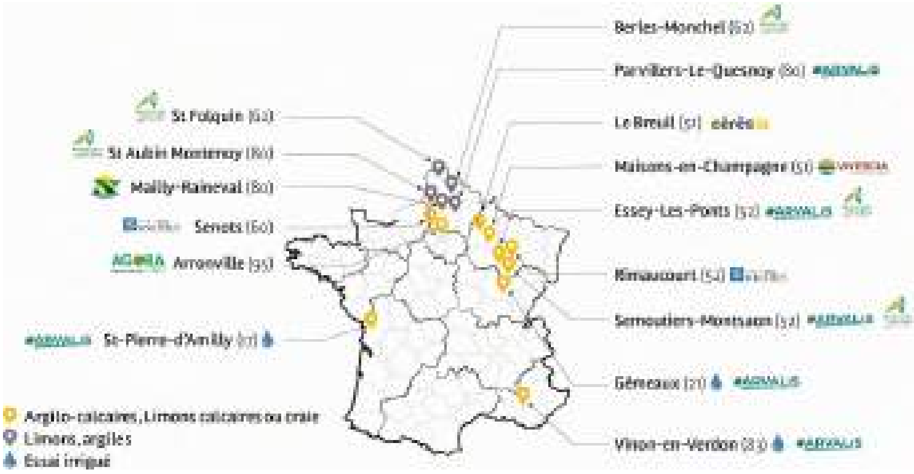
Degradation of plant residues : immobilization of mineral nitrogen by biological decomposition activity.

Increase of mineral nitrogen organization of soil organic matter (Intense biological activity and depending on C/N of crops residues)

Higher ammoniacal volatilization: no incorporation of fertilizers into the soil

Hypothesis : is needed to reduce fertilizers inputs splitting to avoid early nitrogen scarcity on wheat ?

A multi-partner trial network and a first year of results



1st conclusions :

- Splitting is still necessary in Conservation agriculture
- Beware of the absence of nitrogen input during wheat tillering
- Single early N supply: risks of yield losses and quality degradation.

Ongoing (trials 2023):

- Nitrogen forms (urea vs AN)
- Nitrogen with sulphur

VG0

Treatment	Description	Average impact on yield	Average impact on proteins
Classic splitting	Total of N rate « X » split into 3 or 4 inputs	Control	Control
All N before stem elongation	Total of N rate « X » spread in 1 or 2 inputs before stem elongation beginning	-1.1 q/ha *	-0.32% **
Before stem elongation + 40 at flag leaf stage	X-40 kg N/ha before stem elongation beginning then 40 kg N/ha at flag leaf stage	0 q/ha	-0.11% *
Increased tillering N rate	80 instead of 40 kg N/ha during tillering then N rate reduction of 40 kg N/ha at stem elongation beginning	-0.7 q/ha NS	-0.27% **
No N supply during tillering	Tillering N input (40 kg N/ha) postponed at stem elongation beginning or at flag leaf stage	-2.7 q/ha **	+0.25% NS

NS = Not significant
**= significant at 5%
*= significant at 10%

P2_ACS_3

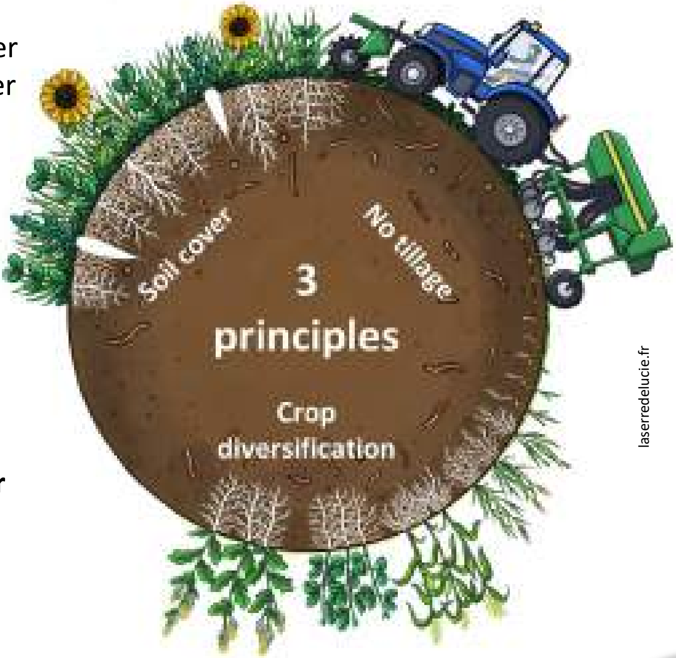
CA – Soil Conservation Agriculture

Principles et expected benefits

SOIL COVER, WITH RESIDUE RESTITUTION:

- ✓ Cover crop plantation whatever the crops sown before and after
- ➔ **Erosion control**
- ➔ **Carbon Storage**
- ➔ **Decreased vulnerability to climatic vagaries**

- ✓ Multi-species cover crops:
- ➔ **Improvement of soil structure by the cover crop roots**
- ✓ Keeping the cover crop alive in the following crop
- ➔ **Fauna nutrition with the cover crop and its residues**
- ➔ **Weed emergence prevention**



laserredelucie.fr

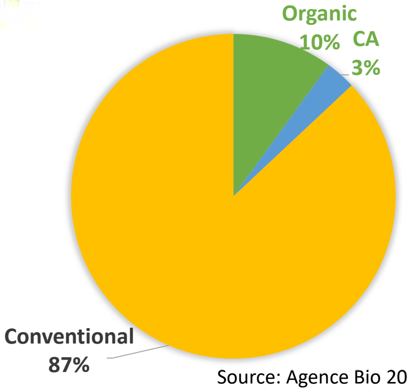
NO TILLAGE:

- ✓ No ploughing, no superficial tillage
- ✓ Direct sowing
- ✓ Chopping roller
- ➔ **Reduced mechanization cost**
- ➔ **Reduced greenhouse gas emissions**
- ➔ **Concentration of the organic matter at the surface of the soil**

CROP DIVERSIFICATION:

- ✓ Longer rotation
- ✓ Alternation of winter crops and summer crops ; alternation of botanical families
- → **Better management of the pest cycles**

- ✓ Introducing leguminous plants
- ➔ **Reduced greenhouse gas emissions**



Source: Agence Bio 2021 and APAD.

Areas of research ARVALIS-APAD

A partnership agreement has been signed in February 2022 between Arvalis and APAD, and a programm to support CA farmers and to promote new CA conversions:

Water management: which water efficiency for the irrigated or rainfed systems, and which recommendations for irrigation monitoring and the crop rotation choice?

Fertilization management: how to optimize the crop nutrition, especially while taking account of the cover crop input and the mineralization kinetic of a non-tilled soil?

Weed management: how to do without the tillage lever and in a context of Glyphosate use restriction?

Life of the farmer network: geographic representation, trial and farm visits, forum,…

Communication: Farm visits, trial visits, articles, videos…

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Performances de l'ACS : trajectoire de deux fermes sur 10 ans

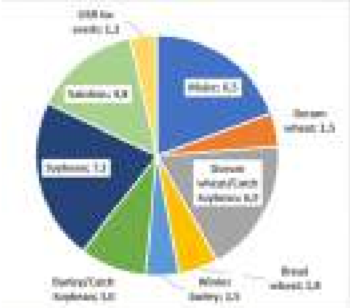
1st Farm: South-East Daniel Brémond

- ✓ UAA = 40 ha ; Labour Units: 0,4
- ✓ Soil: Clay and limestone with few gravels
- ✓ Hot-summer Mediterranean climate (Csa): Hot and dry summers, rainy falls, cold and dry winters
- ✓ Irrigated
- ✓ CA since 2009 (Simplified tillage since 1996)
- ✓ **No Tillage**
- ✓ **Cover crop**: Annual and semi-permanent (sainfoin/alfalfa)
- ✓ Main crops: Durum wheat, sainfoin, maize
- ✓ HRAC 1 and 2 Herbicide tolerant Ray grass

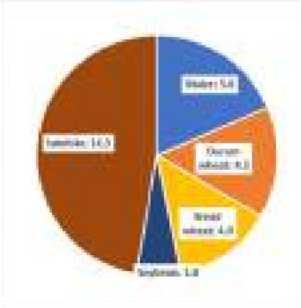
Share of crops and crop rotation example

Maize *(12 t/ha)* → **Legume cover crop** → **Soybean** *(3.4 t/ha)* → **Durum Wheat** *(4.7 t/ha)*

Share of crops 2013-2015



Share of crops 2019-2022



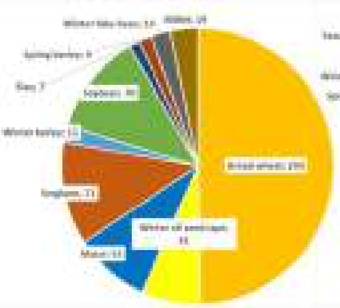
2nd Farm: North-West: Anthony Quillet

- ✓ UAA = 639 ha ; Labour Units = 4,1
- ✓ Soil: sandy-clay loam
- ✓ Oceanic Climate
- ✓ Irrigated
- ✓ CA since 1998
- ✓ **No Tillage**
- ✓ **Cover crop**: Annual
- ✓ Main crops: Bread wheat, soynean, oil seed rape
- ✓ Herbicide tolerant Ray grass

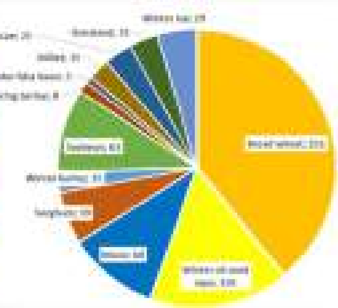
Share of crops and crop rotation example

Bread Wheat *(6.5 t/ha)* → **Cover crop** → **Maize** *(10 t/ha)* → **Bread Wheat** *(6.5 t/ha)* → **Cover crop** → **Soybean** *(3.7 t/ha)*

Share of crops 2017-2019



Share of crops 2020-2022



Technical, economical and environmental results

		Southern France farm (irrigated)			Western France farm (irrigated)		
		2013-2015	2019-2022	Evolution	2017-2019	2020-2022	Evolution
Economy	**UAA**	34	34		639	639	
	Total LUs	0.4	0.4		4.08	4.08	
	Replacement Investment (€/ha)	2683	3167	18%	1521	1989	31%
	Turnover (€/ha)	1335	1665	25%	1065	1387	30%
	CAP subsidies (€/ha)	426	260	-39%	230	193	-16%
	Gross product (€/ha)	1761	1925	9%	1295	1621	25%
	Total input cost (€/ha)	553	527	-5%	359	285	-21%
	Fertilizor cost (€/ha)	137	162	18%	138	56	-59%
	Phytosanitary product cost (€/ha)	86	52	-39%	98	112	14%
	Seed cost (€/ha)	163	101	-38%	80	76	-5%
	Irrigation cost (€/ha)	167	212	27%	34	37	9%
	Gross margin with subsidies (€/ha)	1207	1398	16%	936	1336	43%
	Mechanization cost (€/ha)	331	418	26%	123	182	48%
	Net margin with subsidies (€/ha)	469	546	16%	349	643	84%
Main crops	**Bread wheat average yield (T/ha)**	6.0	4.5	-25%	7.48	5.58	-25%
	Durum or bread wheat production cost (€/t)	287	270	-6%	125	191	53%
	Maize average yield (T/ha)	12.4	13.0	5%	9.52	10.38	9%
	Maize irrigation (mm/ha)	218	360	65%	143	150	5%
Technical indicators	**Total N input (kg/ha)**	134	94	-30%	142	142	0%
	Total Treatment frequency index	2.6	1.8	-29%	3.26	4.07	25%
	Herbicide treatment frequency index	1.2	1.3	8%	2.46	2.69	9%
	Pulling duration per hectar (h/ha)	5.7	5.8	1%	2.2	1.9	-14%
	Irrigation (mm/ha)	172	217	26%	29	30	3%
	UAA / LU	84	82	-3%	156	156	0%
Environment indicators	**Total GHG emissions (kg CO2 eq /ha)**	1985	1553	-22%	2083	2056	-1%
	Toal primary energy consumption (MJ/ha)	34278	37123	8%	14701	15542	6%
	Gross energy production (MJ/ha)	96528	74779	-23%	98164	82888	-16%

Average yields (t/ha):

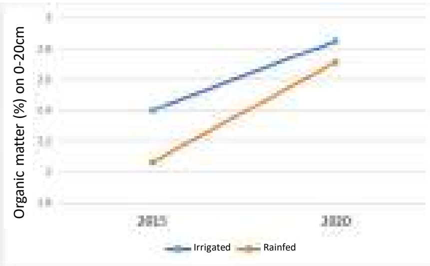
	1st Farm	2nd Farm
Spring oat	**2.6**	
Winter durum wheat	**4.7**	
Winter bread wheat	**5.3**	**6.5**
Spring barley		**4**
Winter barley		**5.6**
Winter rye		**3.5**
Winter OSR	**1.3** (for seeds)	**2.5**
Maize	**12.7**	**10.0**
Sorghum		**5.9**
Winter faba bean	**2.1**	**1.2**
Winter pea	**3**	
Soybean	**3.4**	**3.7**
Grassland		**4**
Sainfoin for seeds	**0.8**	
Flax		**1.8**
Millet		**2.6**
Buckwheat		**1.2**

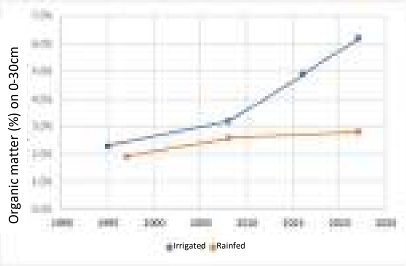
1st farm:

Irrigated: maize-soybean-wheat

Rainfed: sunflower-wheat-faba bean

No exogenous organic matter input





2nd farm:

Irrigated: maize-soybean-wheat

Rainfed: wheat/OSR/wheat/sorghum/wheat

Spreading of sewage sludge and green wastes (6-10T every second year under irrigated fields and every third year on the rainfed fields)

Pros:

- **Increase of margins and cost control despite of inflation.**
- **Soil function improvement (organic matter, less soil sealing, infiltration of water)**

Working points:

- **Fairly technical transition**
- **Herbicide tolerant raygrass**
- **Herbicide treatment frequency index**
- **Uncertain commercial outlet pour certain unusual crops (faba bean, sainfoin)**

Multi-criteria assessment done with the software SYSTERRE

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BIOGAS pole

Les Culturales 2023 14-15 juin

Camelina:
which opportunities ?

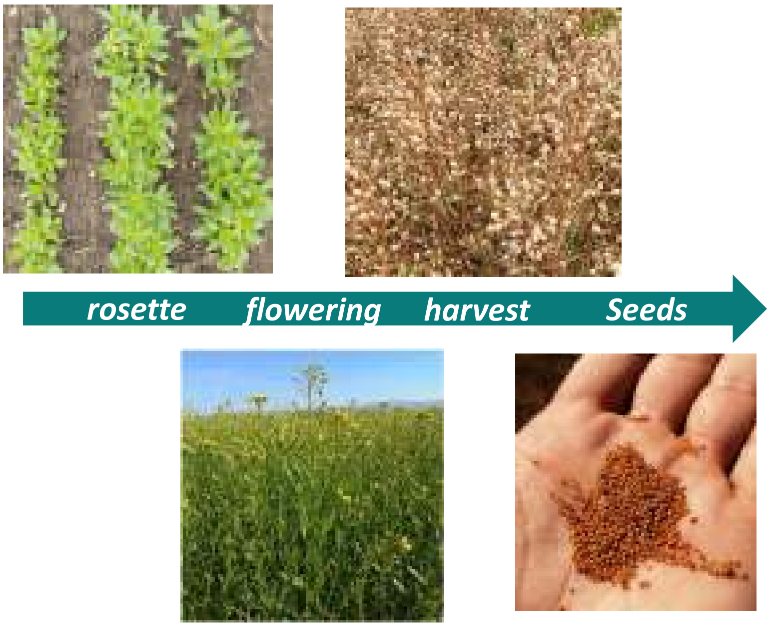
What ?

Family: *Brassicaceae*

Cycle length: *3 to 6 months depending on the sowing date*

Grain yield: *between 10 and 25 q/ha*

Market opportunities *: edible oil, cosmetics and biofuels*



Genetic diversity :
winter / spring, sown in winter

- Less sensitivity to flea beetles
- Autumn sowing before cereals
- An opportunity for grass weed control ?

What for?

Short-cycle genetics, Adaptation to climate change?

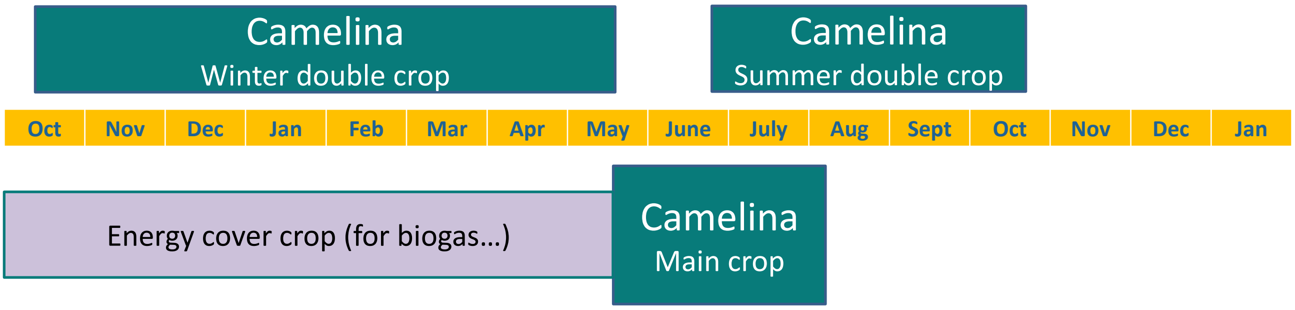
Integrable in sequences of double crops

Strong expectations from the bioenergy sector (jet-fuel, biorefinery)

Few inputs ~150 €/ha

Adapts to many environments

Where to integrate it into double cropping systems?



Camelina
Winter double crop

Camelina
Summer double crop

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan

Energy cover crop (for biogas…)

Camelina
Main crop

Funded by the European Union

P3_METHA_1

Energy cover crop :
How can I optimise my biomass potential?

Les Culturales 2023 14-15 juin

Non food/feed crops grown and harvested **between two primary food/feed** crops in order to produce biomethane and decrease land use competition

01 Choice of species

The choice depends on the rotation.

- Winter cover : Adapt to the risks of pest, lodging, freezing, precocity...
- Summer cover : cost/opportunity ratio.

02 Tillage

Depending on the situation and objectives :

- Soil preparation
- **Weed control**
- **Time between two crops**

03 Sowing

Sowing early to increase yield.

Winter cover : between 15/09 and 10/10

Summer cover: at the earliest until 10/07

04 Fertilization & Irrigation

Fertilization :

- **Well-valued moderate N input** (40 to 100 kg N/ha)
- Beware of valuation in summer
- Good valorization of digestates

Irrigation :

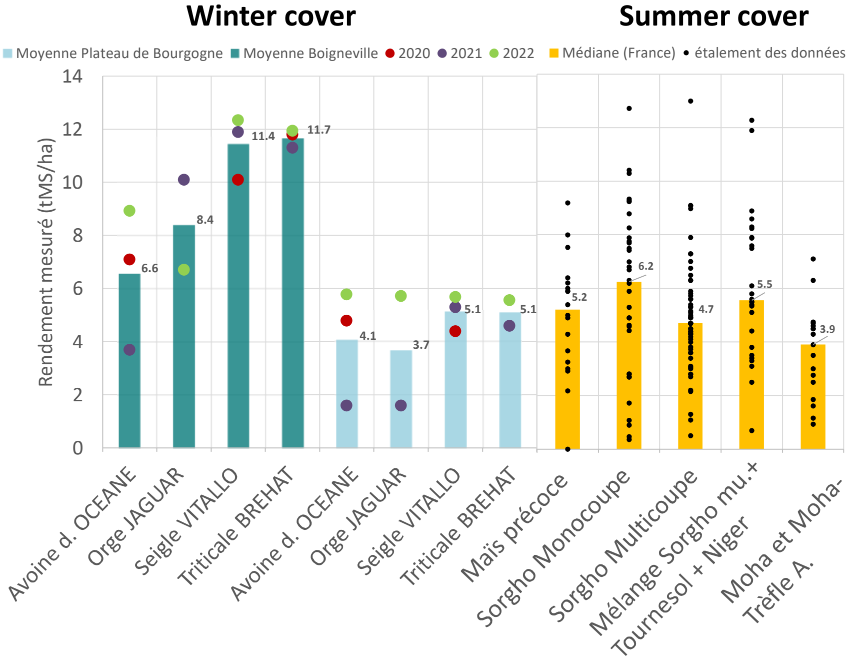
- Ensures summer cover emergence
- **Depends on cost/opportunity ratio**

05 Harvest

The harvest date results from a compromise between biomass production from the energy cover crop and the impact on the yield of the next food/feed crop.

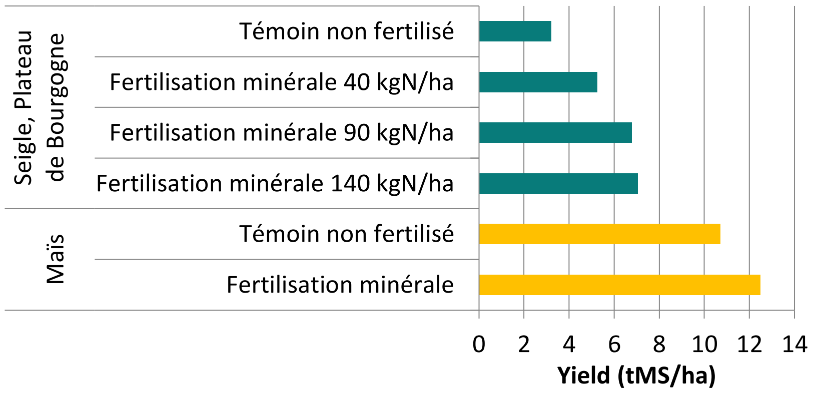
- Winter cover: between 20/04 and 10/05
- Summer cover: between 20/09 and 15/10

Cover Performance, Data Recital

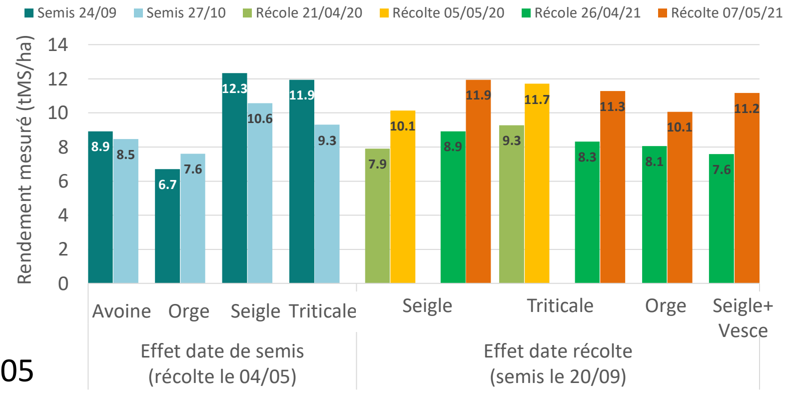


Impact of fertilization on yield

Data OPTICIVE, 2016



Impact of sowing and harvest date on biomass yield, Boigneville, 2019-2022



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P3_METHA_2

Energy cover crop into double cropping system : how much does it cost ?

Les Culturales 2023 14-15 juin

Recital SYSTERRE

• What is a complete cost of production?

Complete cost of production (€/t) = **Inputs** *Seeds, fertilizers, chemicals* + **Machinery and labour cost** *Mechanization, salaried and family costs* + **Other farm costs** *tenant farming, administration cost, electricity…*

→ Energy cover crop into double cropping has to be managed in the whole cropping system : biomass with the same crop management into 2 different cropping systems will not have the same cost of production.

• Ask yourself the right questions:

How to take into account the dilution of variable charges?

Should we consider the impact of the following culture?

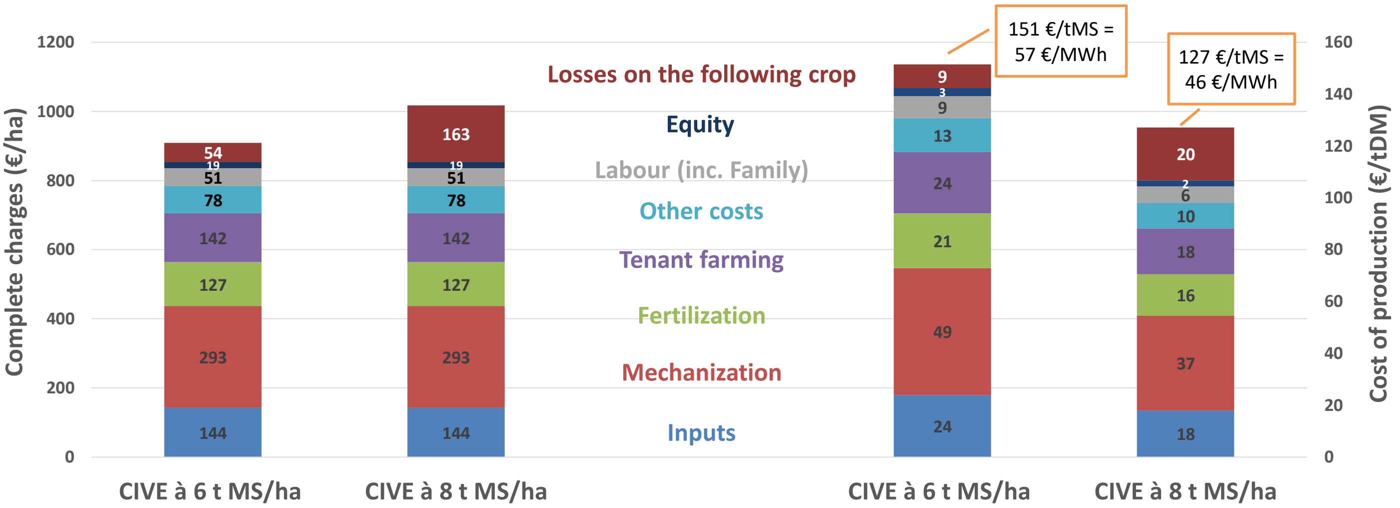
How to account for fixed charges?

What value should be given to digestate?

Who supports the spreading of digestate?

• Do not underestimate the production cost

Cost per hectare (€/ha) and complete production cost (€/tDM) into a crop rotation cover + Sunflower / Durum wheat in the Centre/Île-de-France region



	CIVE à 6 t MS/ha	CIVE à 8 t MS/ha	CIVE à 6 t MS/ha	CIVE à 8 t MS/ha
Losses on the following crop	54	163	9	20
Equity	19	19	3	2
Labour (inc. Family)	51	51	9	6
Other costs	78	78	13	10
Tenant farming	142	142	24	18
Fertilization	127	127	21	16
Mechanization	293	293	49	37
Inputs	144	144	24	18

→Clearly identify all expenses
→Optimize yield decreasing impact on the following crop
→Optimize energy cover crop & crop management to maximize services

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Energy cover crop into double cropping system : When to harvest? Case of the Centre region.

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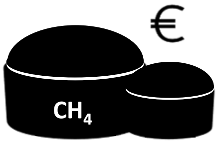
- *Food security*
- *Profitability of crop succession*
- *Regulation*

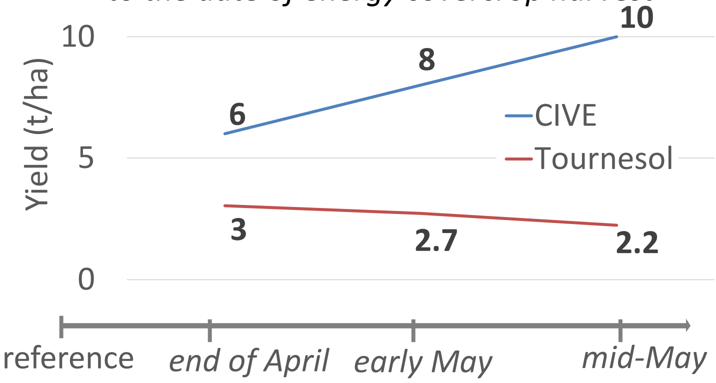
Vs



- *Security of biogas plant supply*
- *Profitability of the biogas plant*

Three harvest dates

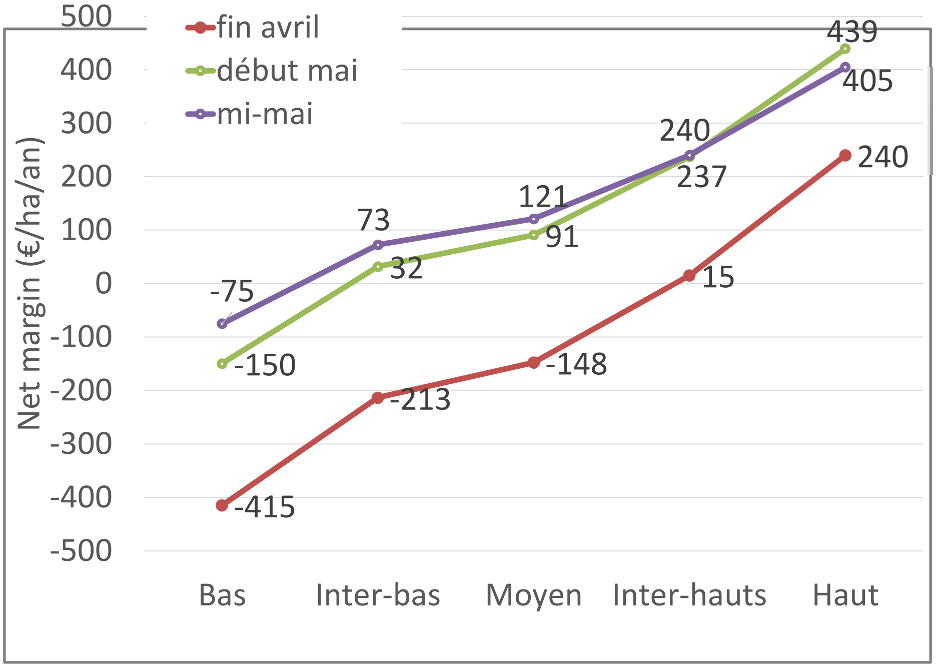
Evolution of sunflower yields according to the date of energy covercrop harvest



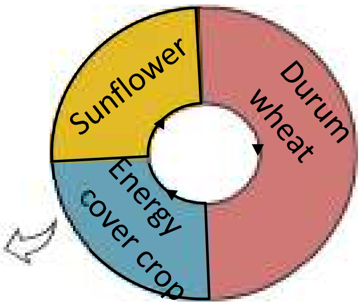
Five food production price scenarios

- From 110 to 220 €/t for cereals
- From 250 to 500 €/t for oilseeds
- No integration of 2022 prices
- Selling price of the biomass : 100 €/tMS

Net margin of the succession : energy cover crop + sunflower



Net margin of the succession according to price scenarios and harvest date (€/ha/year)



Rotation inclung energy cover crop

In intermediate to high price scenarios (€>350/t in oilseeds), important weight of the profitability of food crops.

1st decade of May = the best compromise to harvest :

→Low food price scenarios: possibility of delaying harvest if the cover price is stable

→High food price scenarios: do not delay the harvest of the cover