

From the analysis of performances and functioning of species mixtures to their insertion in cropping systems and supply chain

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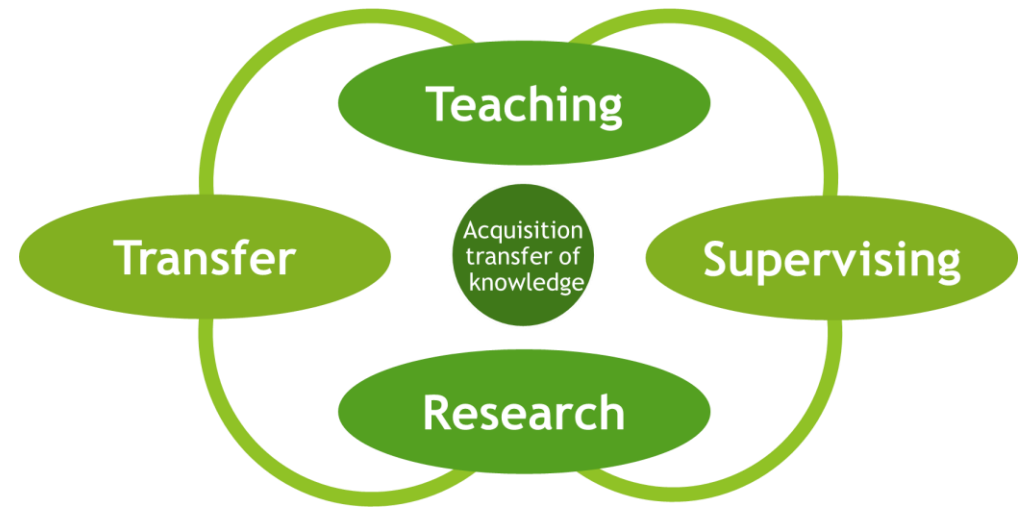
JOURNET Etienne-Pascal, CNRS LIPM, INRA UMR AGIR, Examineur et correspondant



Université
de Toulouse

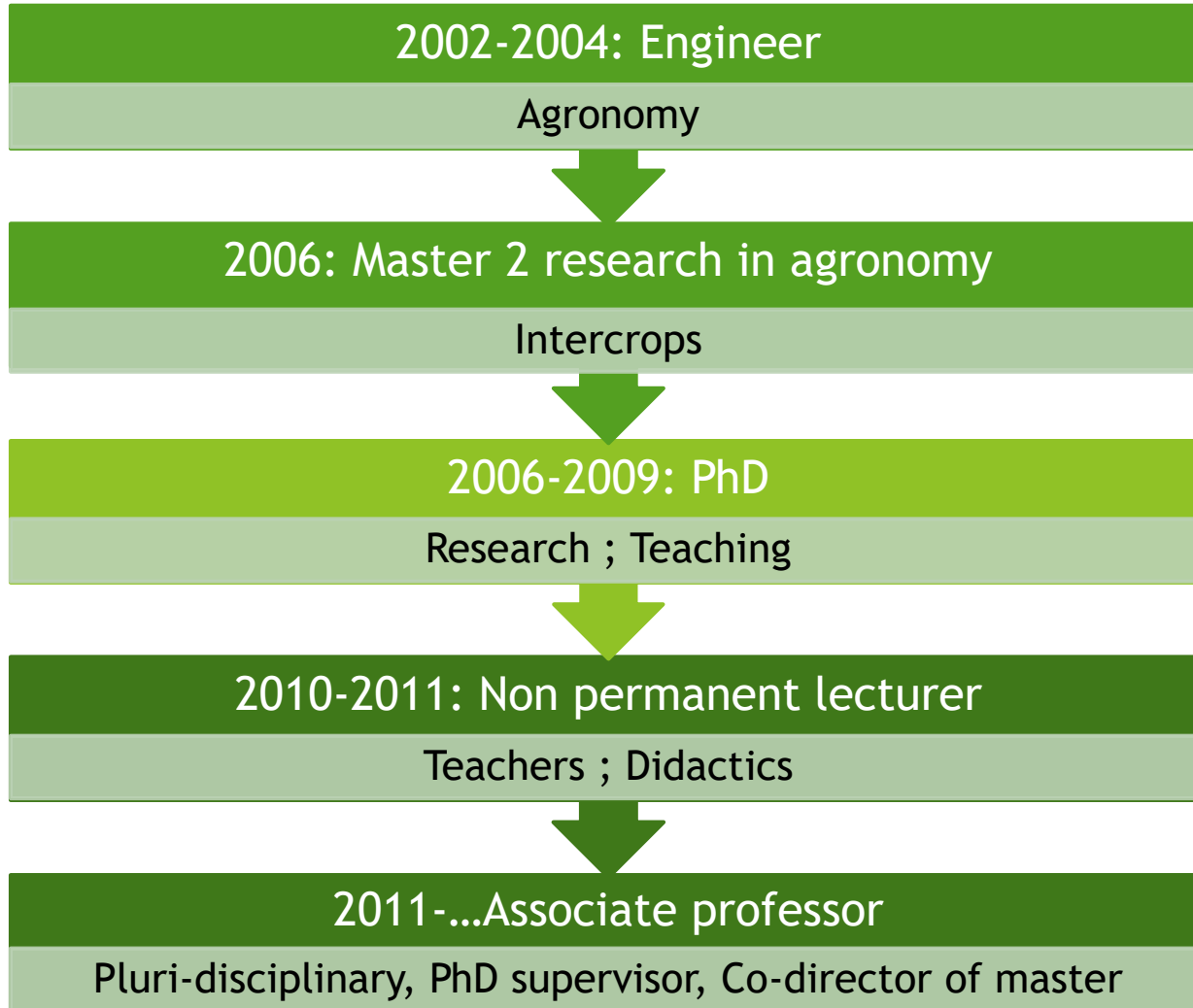
Structuration of my presentation

- ▶ Overview of my background and professional experience
- ▶ Some results to evaluate the functioning and efficiency of intercrops
- ▶ **Project-Axis 1: Tracking on-farm innovations and agricultural machinery**
 - ▶ On-farm tracking
 - ▶ Economic efficiency depends on harvest and grain separation
- ▶ **Project-Axis 2: Increase and stabilize the production and the nutritional quality**
 - ▶ Intercrops stabilize the production against hazards
 - ▶ Intercrops stabilize the production by reducing pests damages
 - ▶ Intercrops modify the nutritional quality of grains



Overview of my background and professional experience

Background and professional experience



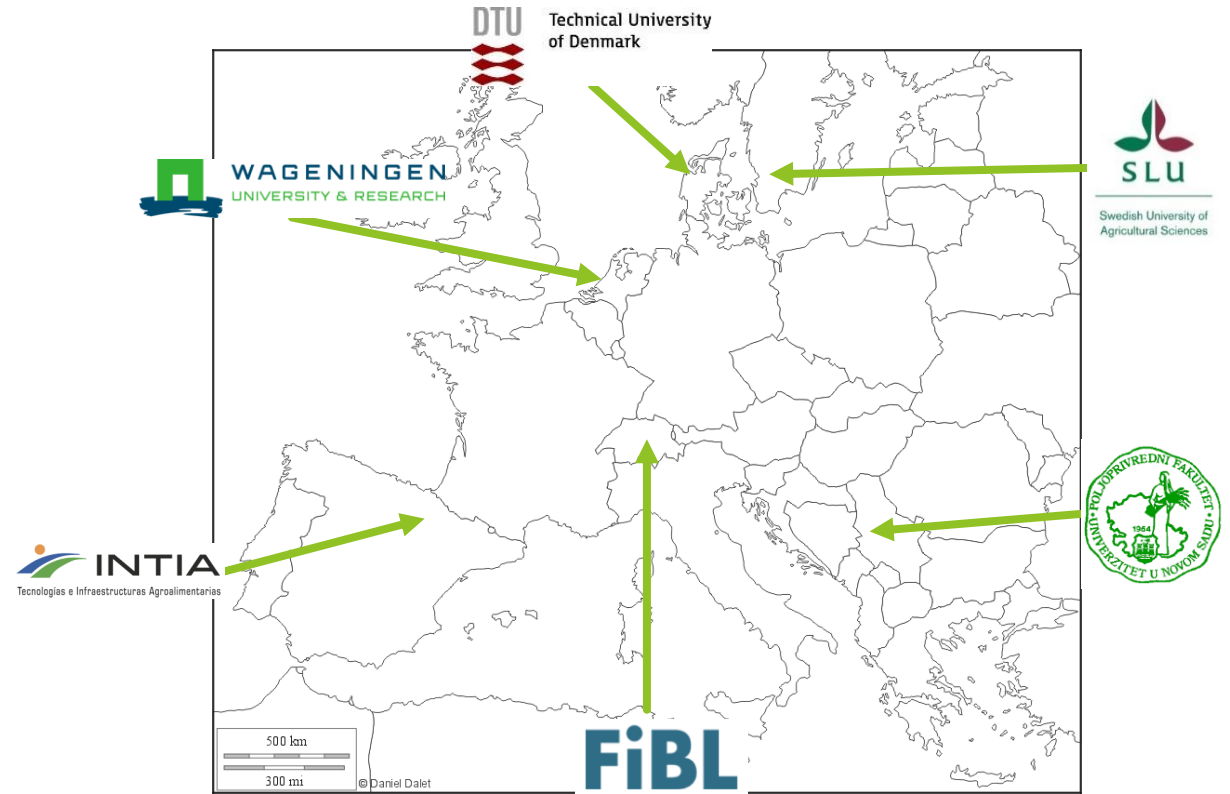
2 * 6 months internship



3 * 64h teaching



No post-doc but many french and overseas collaborations



► And also...



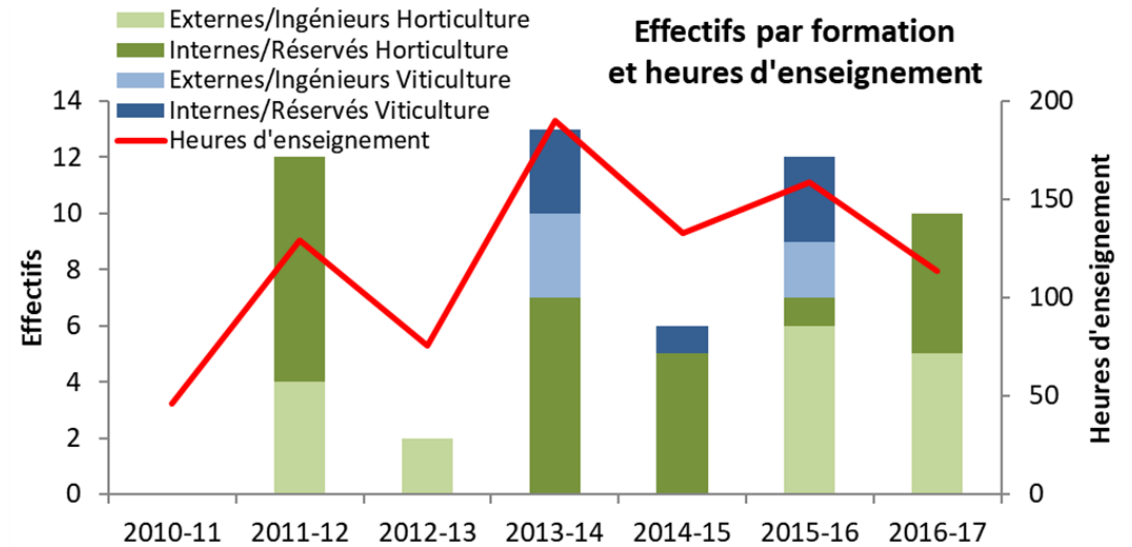
Overview of my activities: training teachers and Master



Teaching
≈ 238 hours/year
Teacher training
Co-director of Master AFC

- ▶ Mostly didactic
- ▶ Little agronomy
- ▶ Not easy to establish links with my research

- ▶ Multidisciplinary program
- ▶ 3 mains courses (Agronomy, Economy and Ecology)
- ▶ Designed around projects to develop autonomy



Overview of my activities: a linear research path...in appearance

1st trial in 2006

- ▶ Durum wheat:
 - ▶ Important supply chain
 - ▶ Adapted to climate but intensive
- ▶ Grain legumes:
 - ▶ About 70% of protein deficit
 - ▶ No need for N fertilizer but sensitive to pests
- ▶ Is intercropping an option to:
 - ▶ Produce sustainable durum-wheat?
 - ▶ Increase legume production?

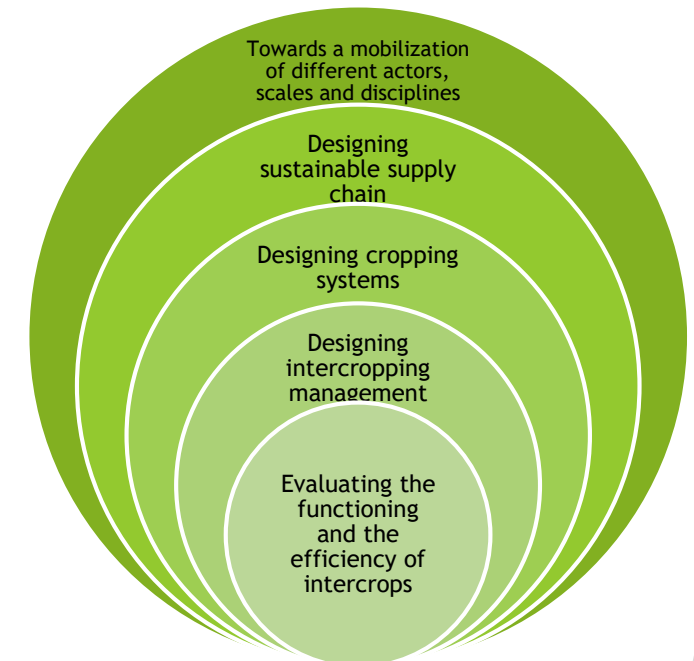


Teaching
≈ 238 hours/year
Teacher training
Co-director of Master AFC

Research
15 articles and 5 chapters
39 talks and 19 posters
Only few articles reviews

10 years later...

- ▶ Large range of practices
 - ▶ Conventional and organic
 - ▶ Species, Cultivars, Densities, Fertilization,...
- ▶ Different aims and multi-actor approaches



Overview of my activities to transfer knowledge



Transfer
12 articles in technical reviews
9 in innovations agronomiques
Farmers and advisors training days

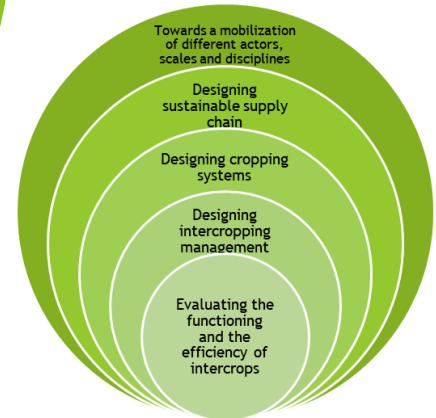
Teaching
≈ 238 hours/year
Teacher training
Co-director of Master AFC

Supervising
13 internship: 1*L3, 2*M1, 7*M2
2 PhD students: B. Kammoun (CDI Arvalis), L. Viguier (Post Doc ESA)

Acquisition
and
transfer
of
knowledge

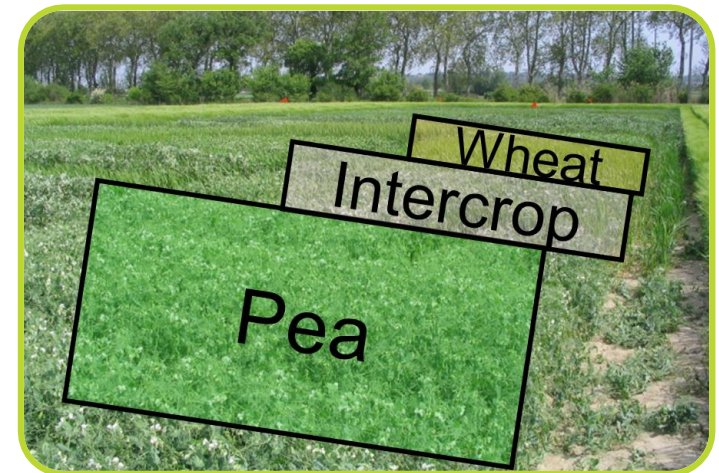
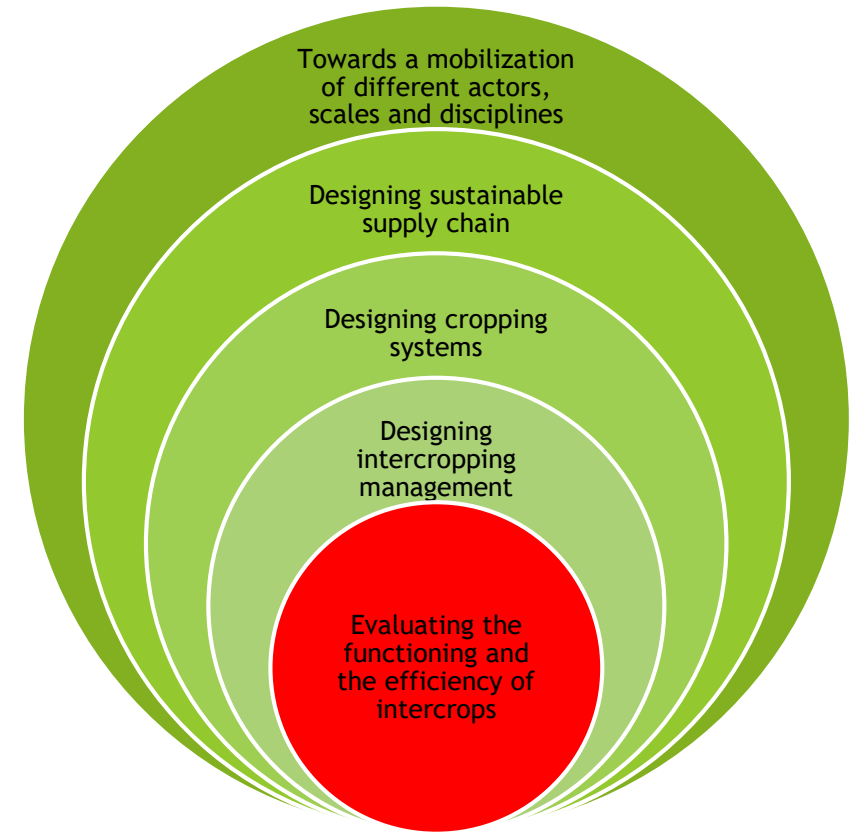
Research
15 articles and 5 chapters
39 talks and 19 posters
Only few articles reviews

20,292
Reads



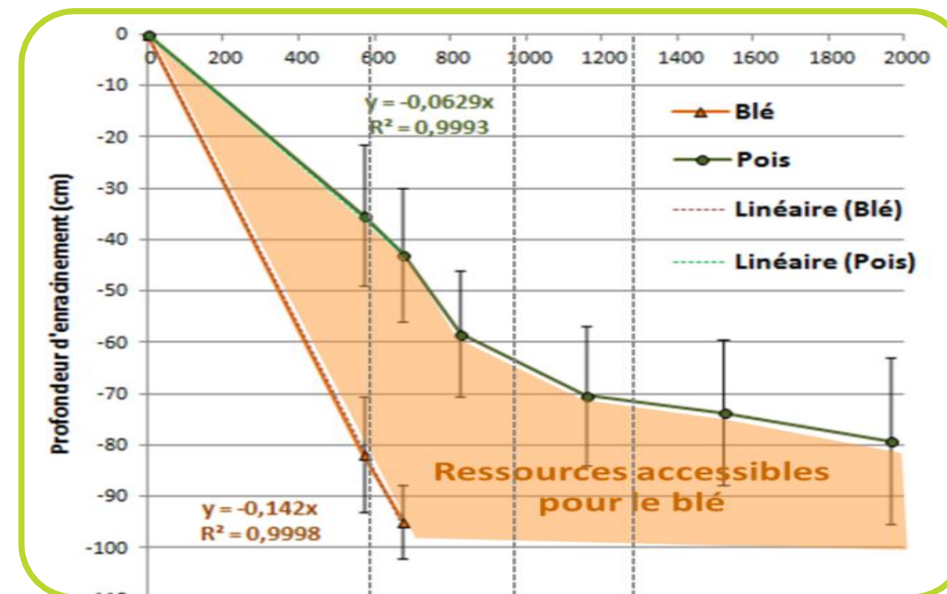
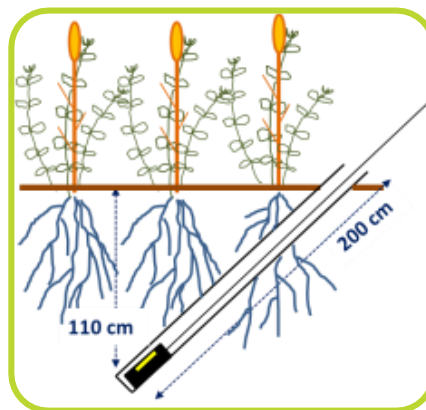
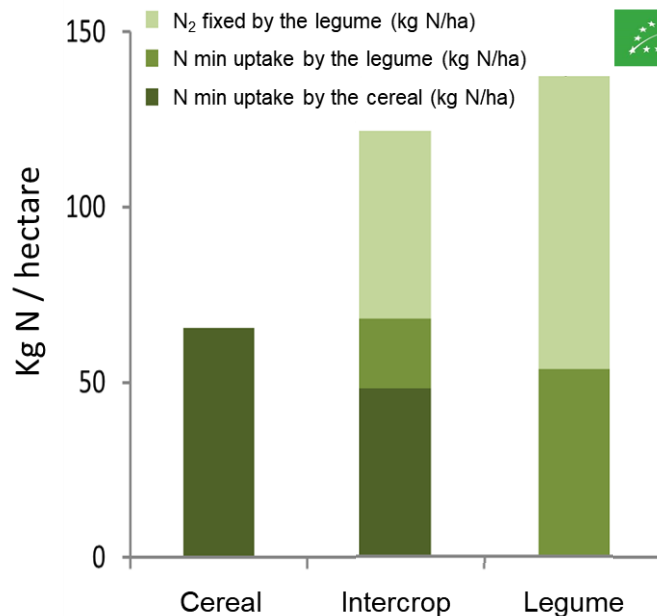
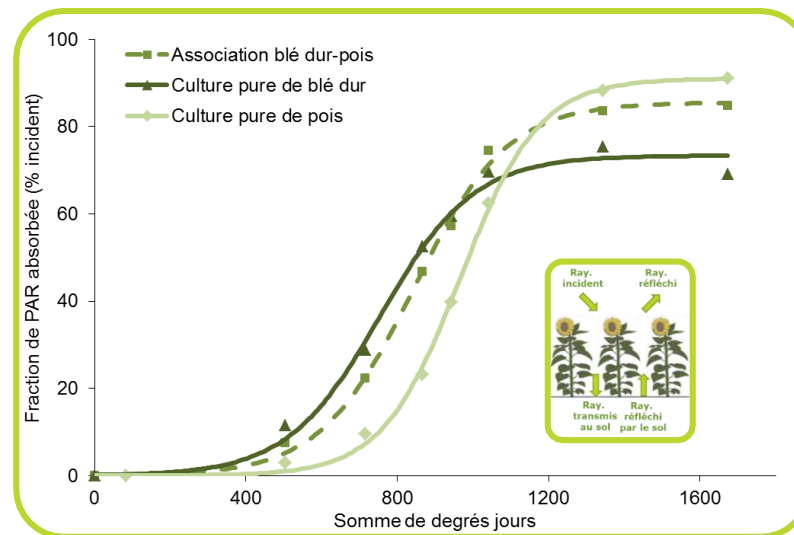
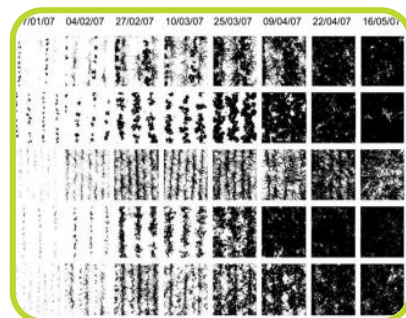
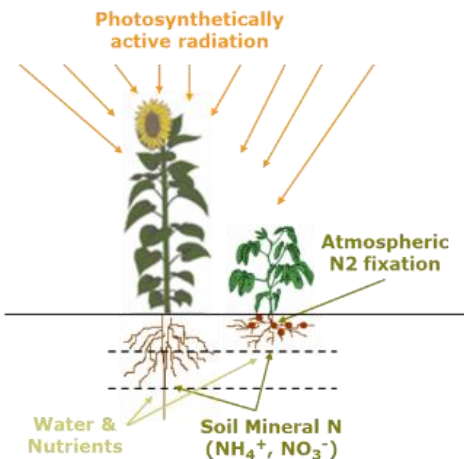
Evaluating the functioning and efficiency of intercrops on experimental fields

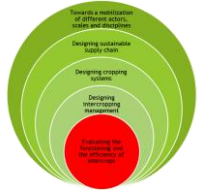
Some results from 12 years experiments





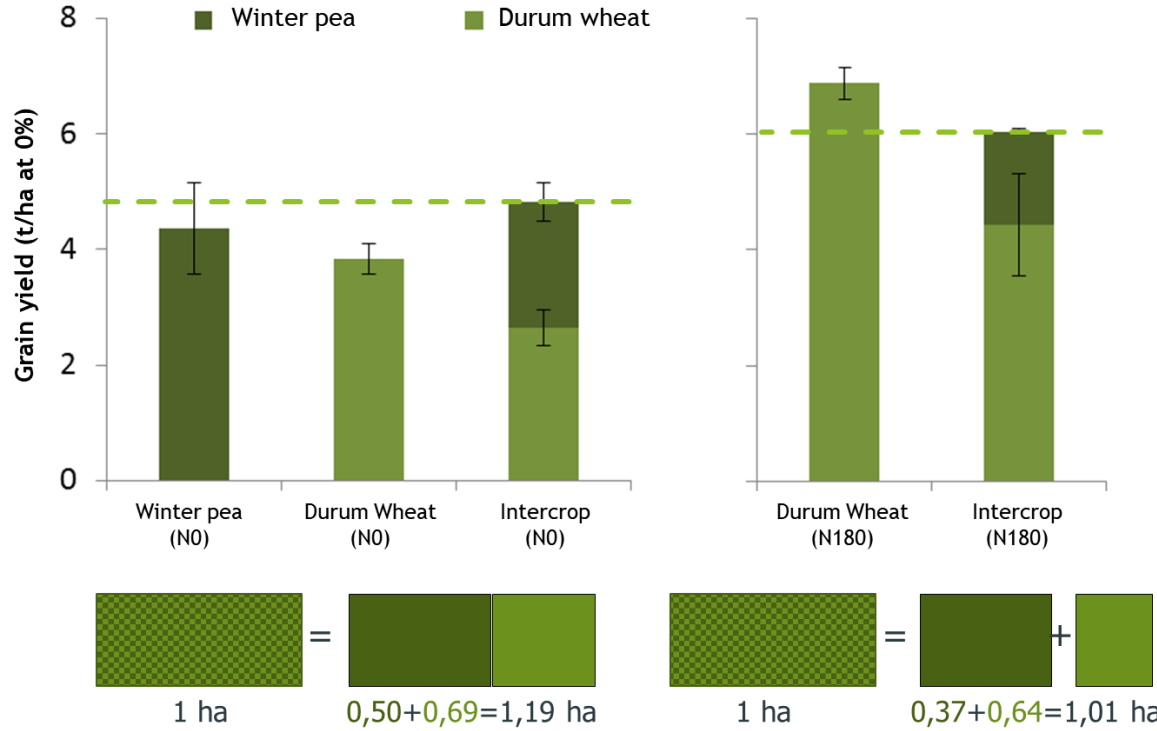
Species complementarity in time and space



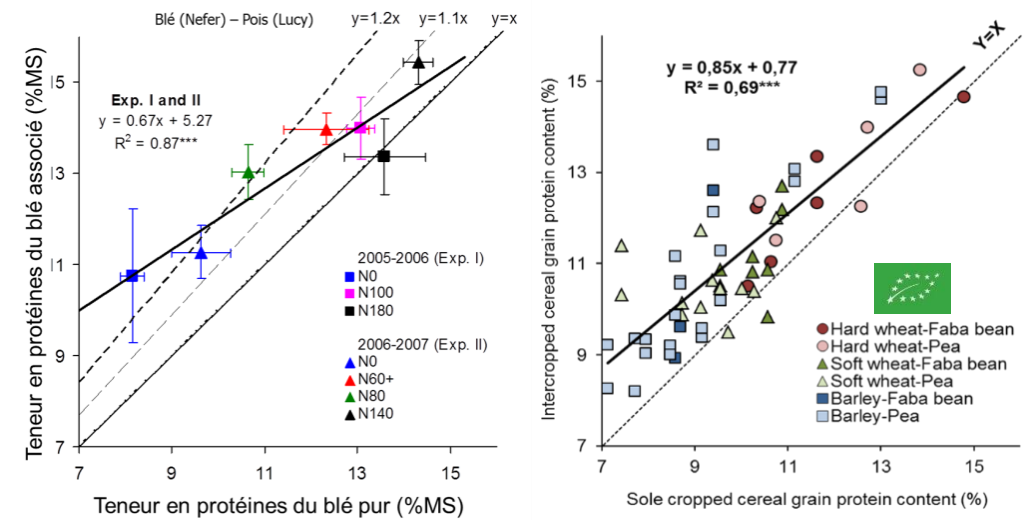
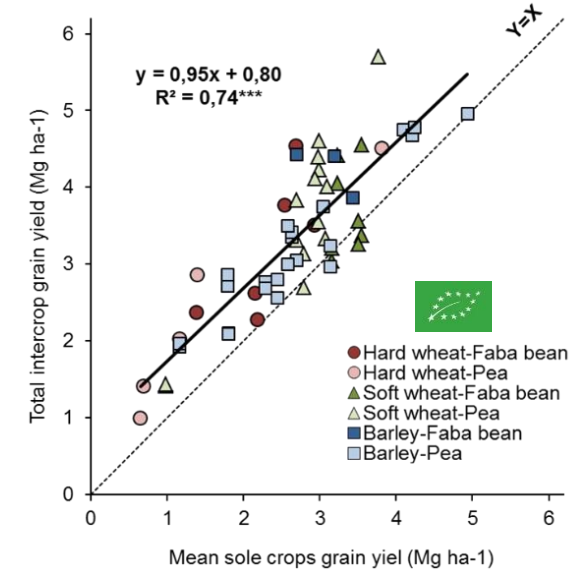


Intercrop efficient for yield and cereal quality...

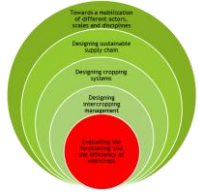
Bedoussac and Justes, Plant and Soil 2010



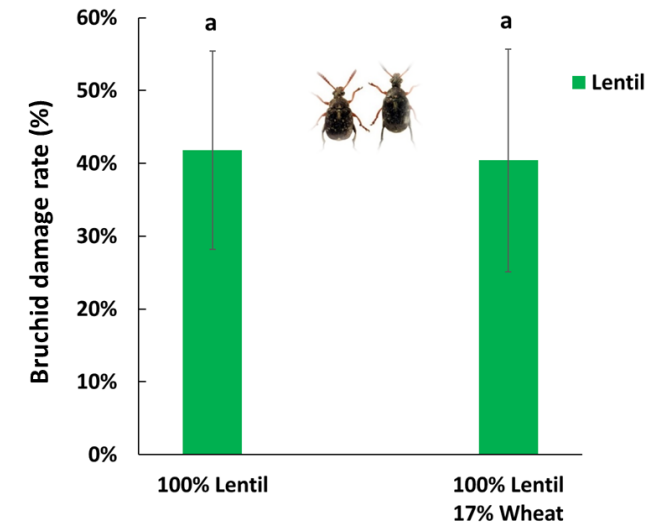
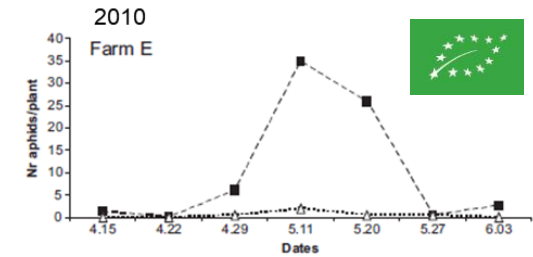
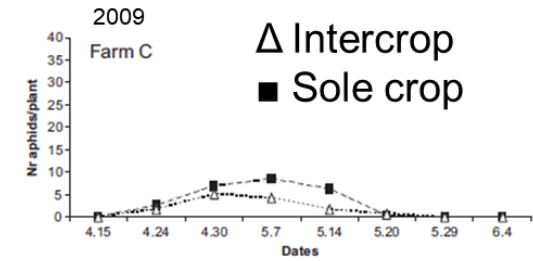
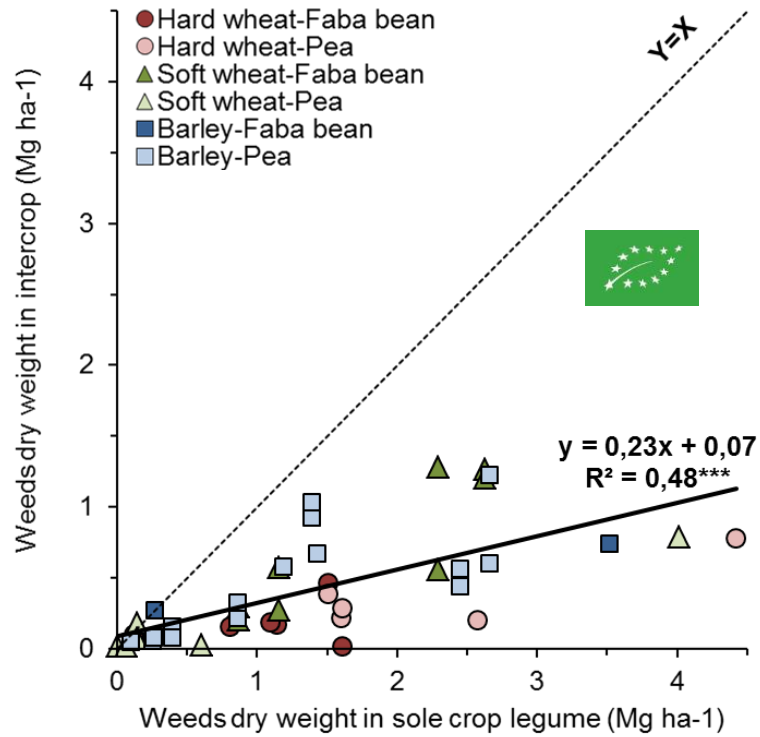
Bedoussac et al. Agr. Sus. Dev. 2015



- ▶ Intercropping more efficient with low N
- ▶ Due to competition and complementarity
- ▶ How to compare intercrop and sole crops ?



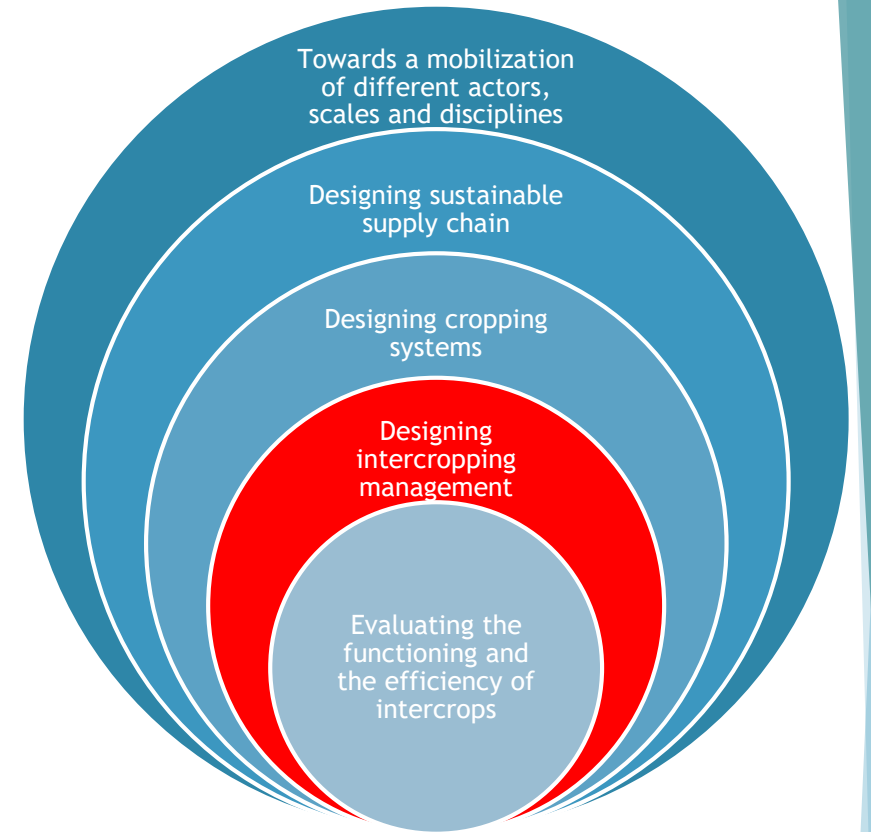
...also to reduce some pests

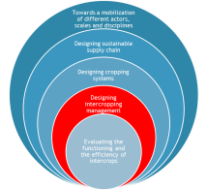


- ▶ Less weeds than the legume and similar to the cereal
- ▶ Less green aphids in intercrop
 - ▶ Modification of cover and plant characteristics
- ▶ No effect on bruchid while important consequences

Project-Axis 1: Tracking on-farm innovations and agricultural machinery

On-farm tracking





On-farm tracking to provide resources for others farmers

(Salembier et al. 2016)

- ▶ Diversity of intercrops and practices
- ▶ Ex. of (un)successful implementation
- ▶ Technical levers to achieve objectives
- ▶ Explanation of practical-objective link
- ▶ New knowledge on intercrops
- ▶ Reveal missing knowledge

Define the innovation to be analyzed

- Pluri-specific intercrops with legumes

Identify farmers cultivating intercrops

- 47 farmers surveyed cultivating intercrops

Describe their agronomic logic

- Practice, reason, criteria of satisfaction

Define the conditions for success

- Agronomic, economic and social conditions

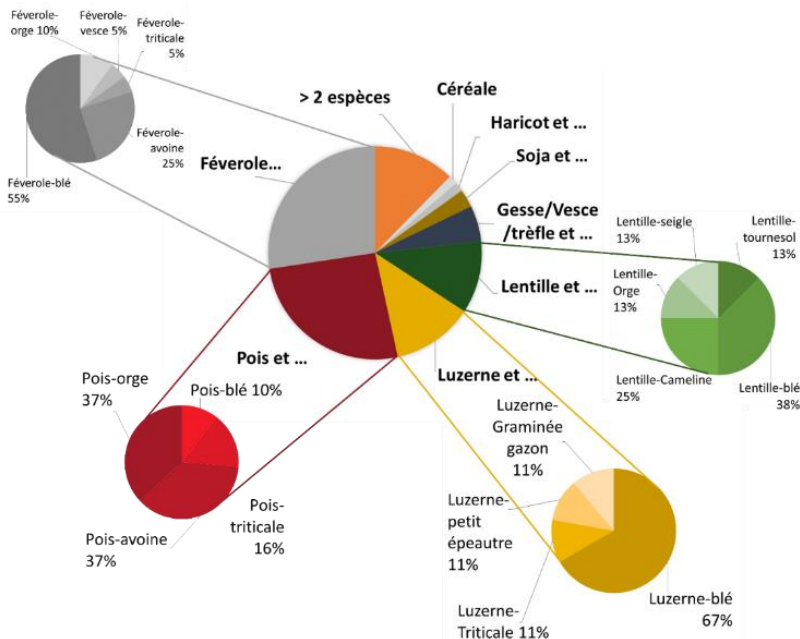
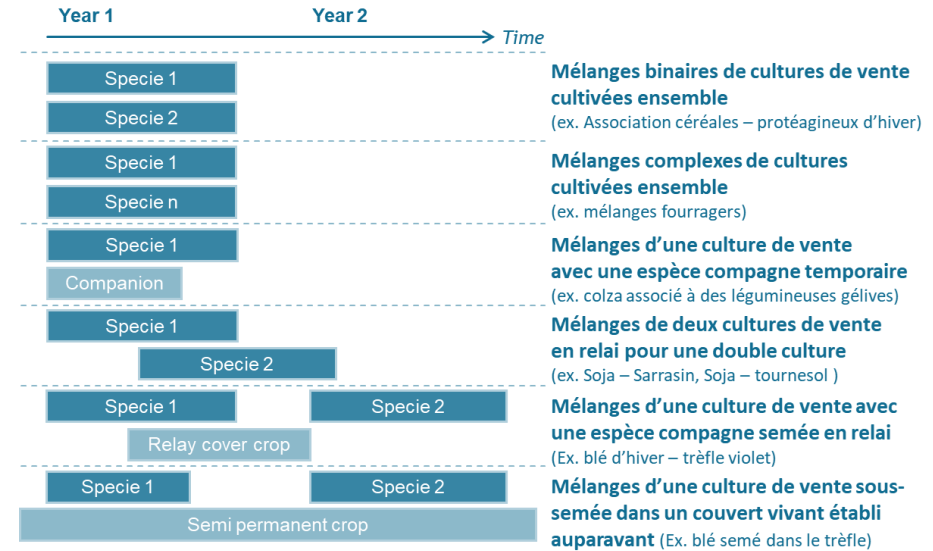
Producing resources for other farmers

- A variety of resource for a variety of intercrops



On-farm tracking reveals wide range of intercrops

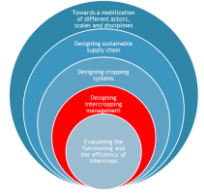
- ▶ Many levers and a potential to reach
 - ▶ Species and cultivars
 - ▶ Sowing (densities, date...)
 - ▶ Fertilization (amount, fractioning...)



▶ Causes of failure related to management

- ▶ Bad establishment of a crop
- ▶ Competition from one species to another
- ▶ Lodging
- ▶ Maturity gap
- ▶ Inefficient pest regulation





Explaining the practice-objective link is crucial

Objectives to produce:

- ▶ Equilibrate mixture
- ▶ Qualitative durum wheat

Hypothesis:

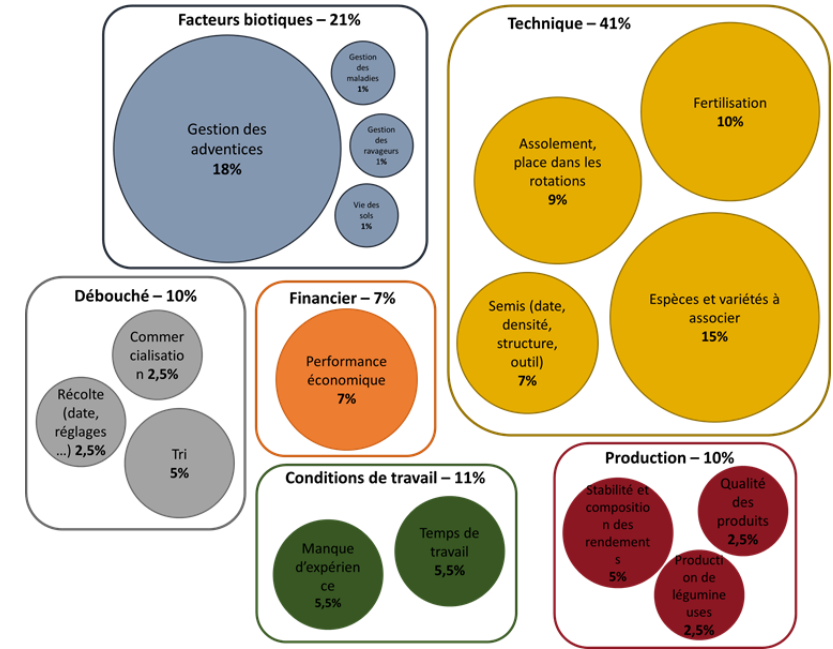
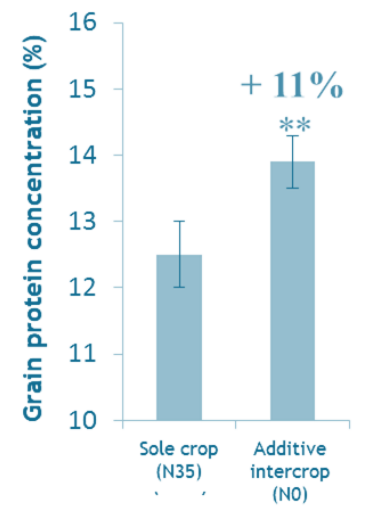
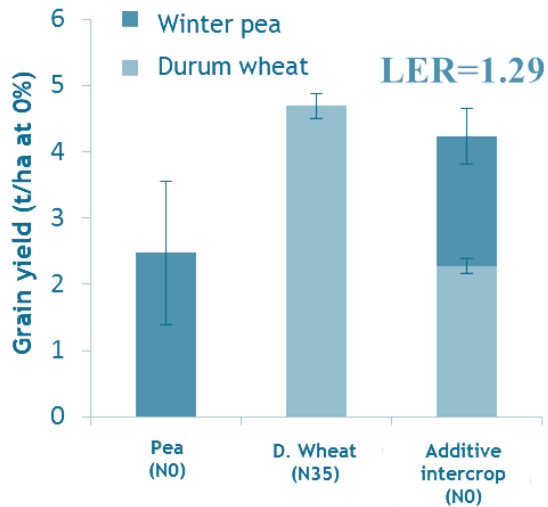
- ▶ Wheat more competitive
- ▶ Need to reduce wheat tillering

Technical choices:

- ▶ Increase pea density
- ▶ No nitrogen fertilization

Additive Intercrop

P W P W P W P W P W P W P W P W P W P W

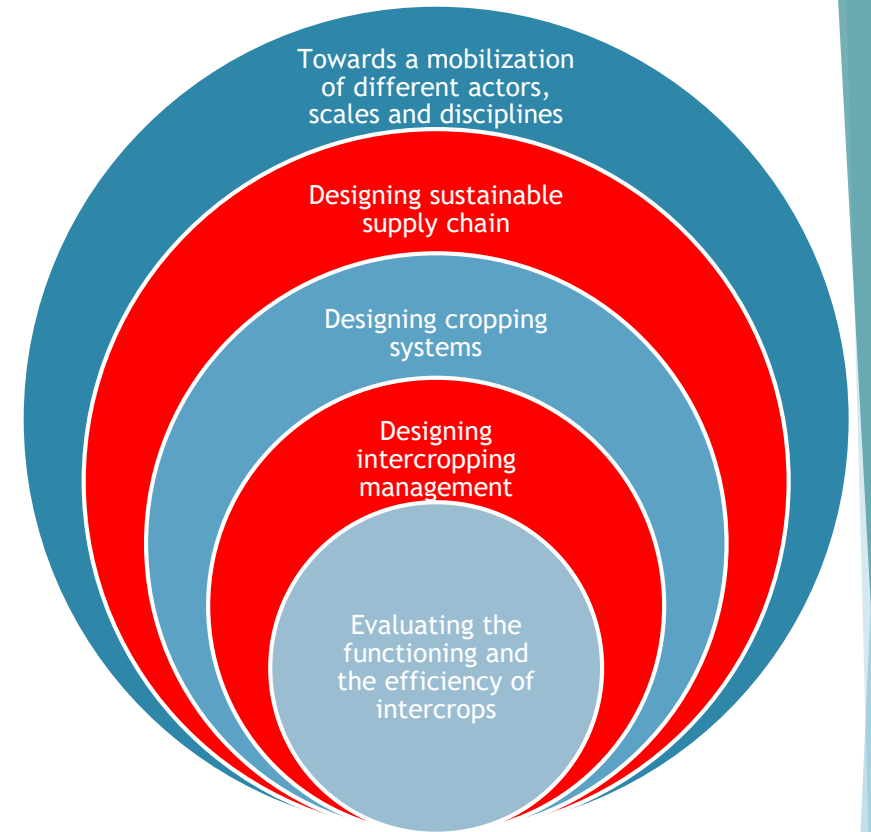


Others causes of failure

- ▶ Existing market
- ▶ Proportions at harvest
- ▶ Sorting problems
- ▶ Quality of product

Project-Axis 1: Tracking on-farm innovations and agricultural machinery

Economic efficiency depends on harvest and grain separation

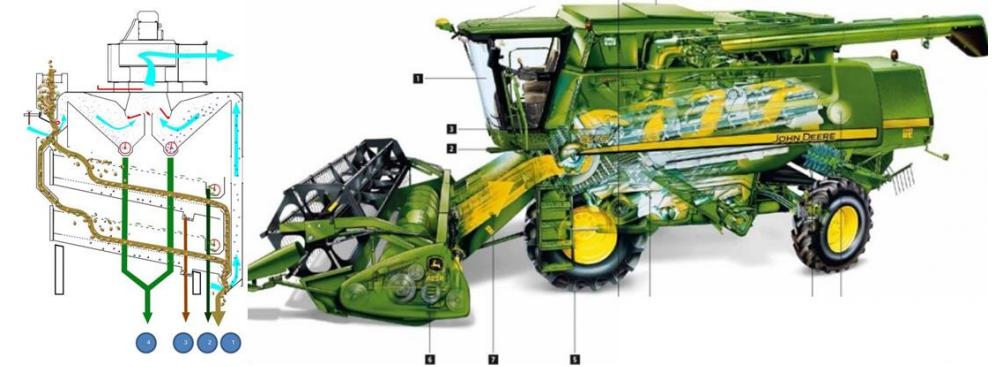
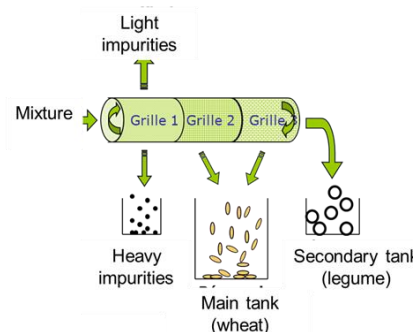




Economic efficiency depends on harvest and grain separation

- ▶ Sorting out grains is difficult and costly
 - ▶ For human consumption
 - ▶ More at the cooperative scale
- ▶ Which solutions?
 - ▶ More efficient machine?
 - ▶ Make the separation easier (combine harvester and cultivar)?
 - ▶ Diluting impurities with sole crops?
 - ▶ Developing new products without separating grains ?
- ▶ Method
 - ▶ PhD with ENSFEA co-director in machinery
 - ▶ Funding: CIFRE from machinery company or collector

	D. Wheat (%)	Pea (%)	Impurities (%)	Broken peas
Initial mixture	65.4	22.5	6.6	5.5
Clean Wheat	85	0	6.5	8.5
Clean pea	1.5	97	1.5	0





The concept of “commercial crop management”

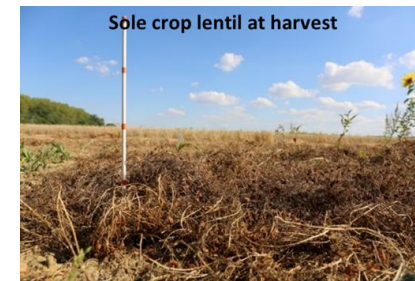
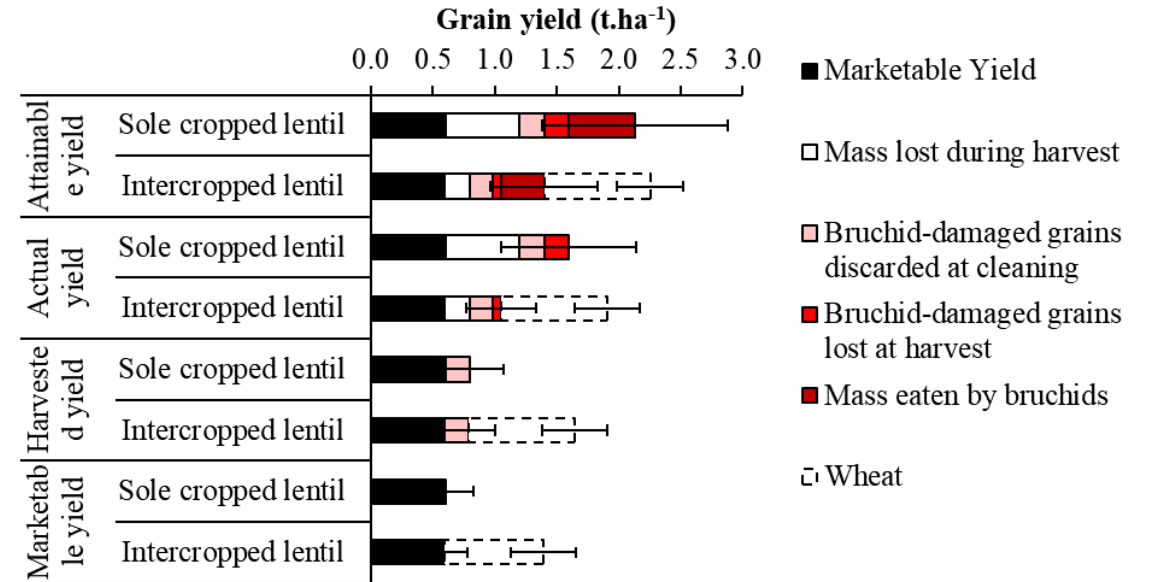
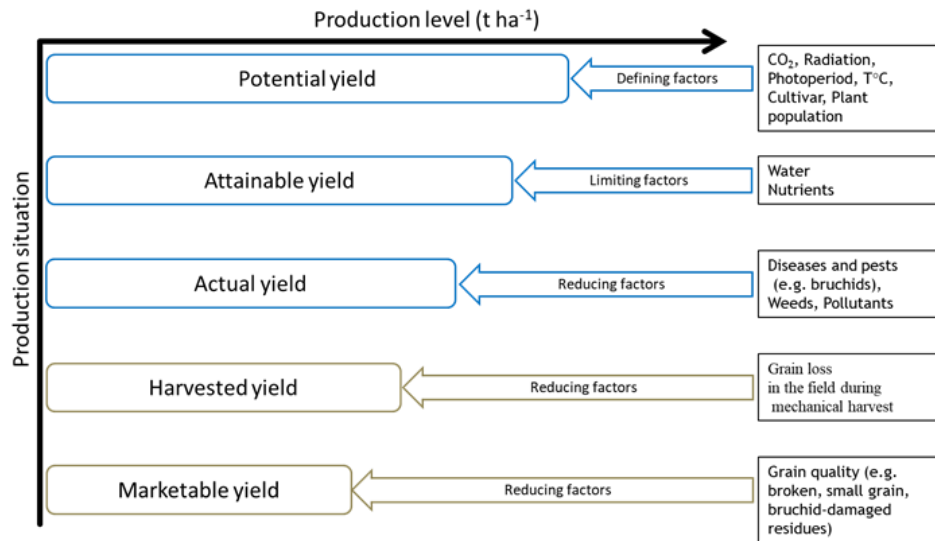
Agronomy for Sustainable Development (2018) 38:39
<https://doi.org/10.1007/s13593-018-0515-5>

RESEARCH ARTICLE



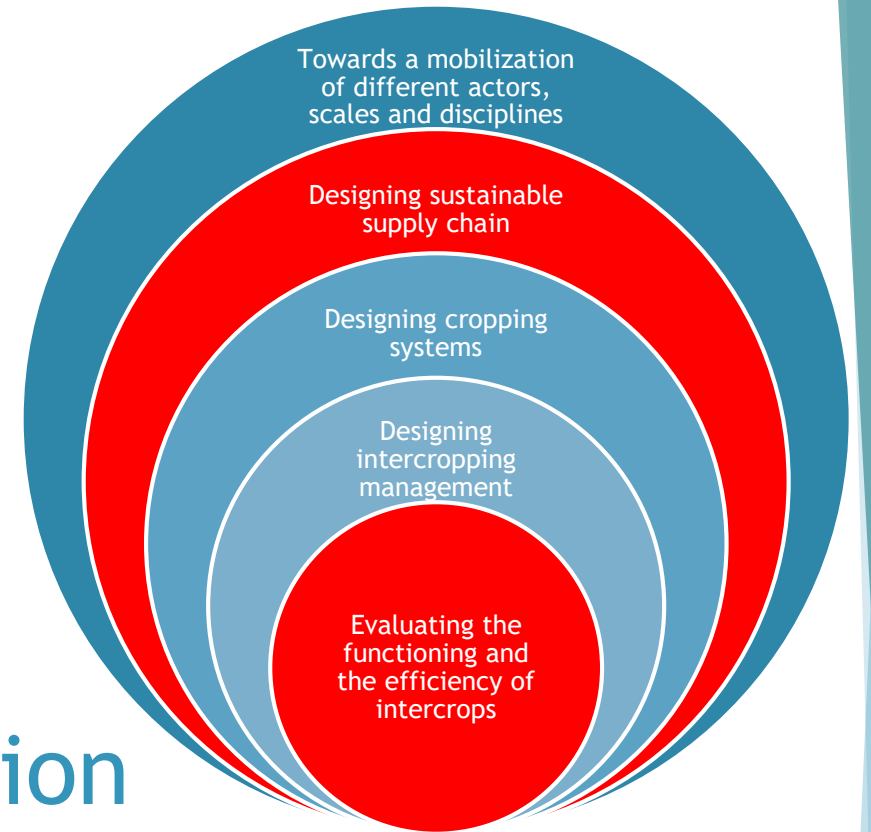
Yield gap analysis extended to marketable grain reveals the profitability of organic lentil-spring wheat intercrops

Viguiier Loïc^{1,2} · Bedoussac Laurent³ · Joumet Etienne-Pascal^{1,4} · Justes Eric^{1,5}



- ▶ Based on technical adjustments related to:
 - ▶ Machinery (harvesting and sorting equipment)
 - ▶ Organizational parameters between farmers and collectors

Project-Axis 2: Increase and stabilize the production and the nutritional quality



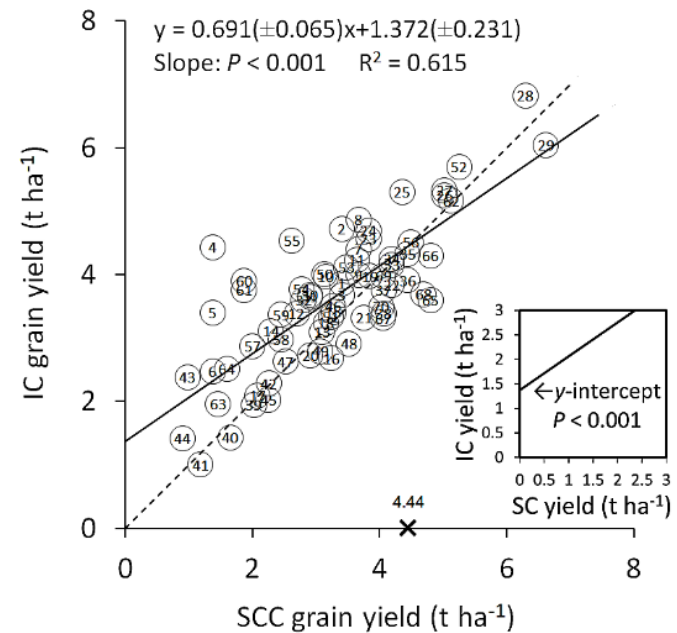
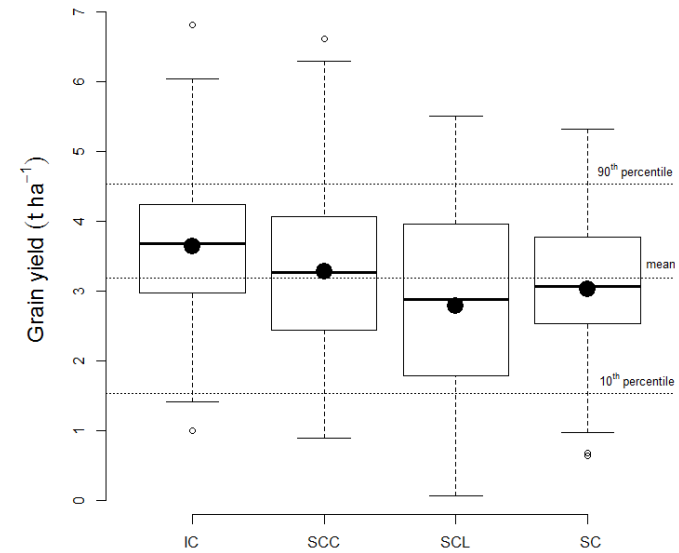
Modelling for Integrated Crop Management in low input farming, Assessment and Cropping system Design





Intercrops stabilize the production against hazards

- ▶ Hypothesis:
 - ▶ Intensively pure crops have comparable yield stability
 - ▶ Intercropped specie yield reduced but more stable
- ▶ Which indicator?
 - ▶ Coefficient of variation (Raseduzzaman and Jensen 2017), standard error, 10th percentile
- ▶ Compared to what?
 - ▶ Sole crop cereal, legume, mean?
- ▶ Methods:
 - ▶ Re-analyse all data collected since 2006
 - ▶ Post-doc with CAU to get a broad data set





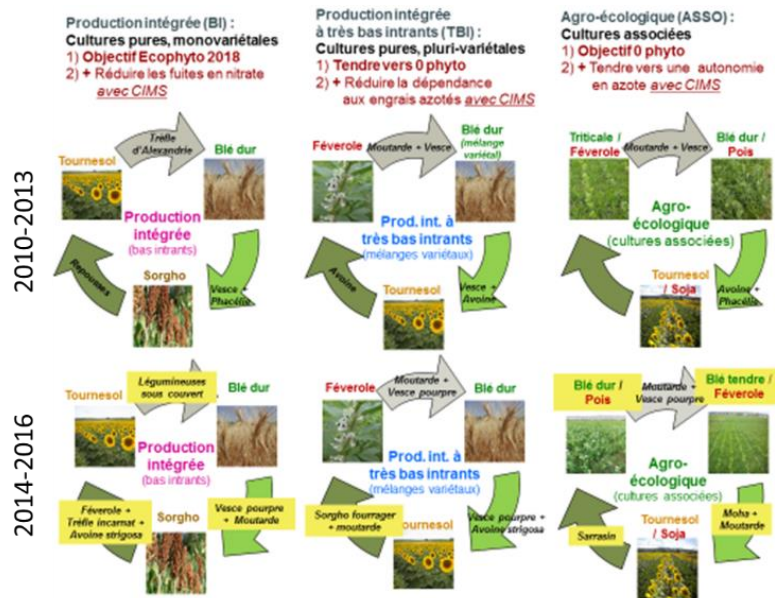
Intercrops stabilize the production by reducing pests damages

- ▶ Expected stability of associations in low-input systems is explained by the reduction of pests damages.

- ▶ Modeling the effects of intercrops on biotic stress
- ▶ Using IPSIM frame (Aubertot and Robin 2013)
- ▶ Post-doc with J-N Aubertot and Marie-Hélène Robin

Average weights

Attribute	Local	Global
Injury level		
- Final severity of fusarium head blight, FHB (% of fusarium-damaged spikelets/ear)	100	100
- Effects of cropping practices	54	54
- Primary inoculum management (residues management)	28	15
- Preceding crop	45	7
- Preceding crop residues management	55	8
- Escape: effects of the sowing date	4	2
- Genetic resistance and mitigation through crop status	30	16
- Cultivar choice	82	13
- Level of N fertilisation	18	3
- Sowing rate	0	0
- Chemical control efficacy	38	20
- Effect of weather	46	46
- Weather at flowering	100	46



- ▶ Evaluate intercropping efficiency to reduce lentil bruchids

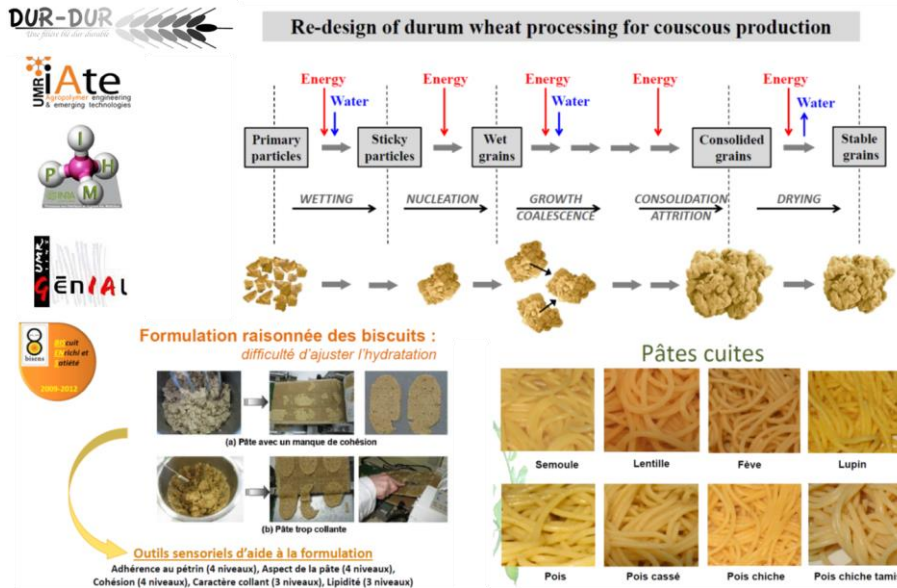
- ▶ Cultivars more tolerant (Pascal Marget)
- ▶ Kairomones (UMR 1392)
- ▶ Need for a systemic approach (lodging, weeds, diseases)
 - ▶ Which species to intercrop with lentil?
 - ▶ Effect of earlier sowing and cultivars mixture?
- ▶ PhD with ENSFEA co-director in ecology-entomology
- ▶ Funding: CIFRE from Qualisol






Intercrops modify the nutritional quality of grains

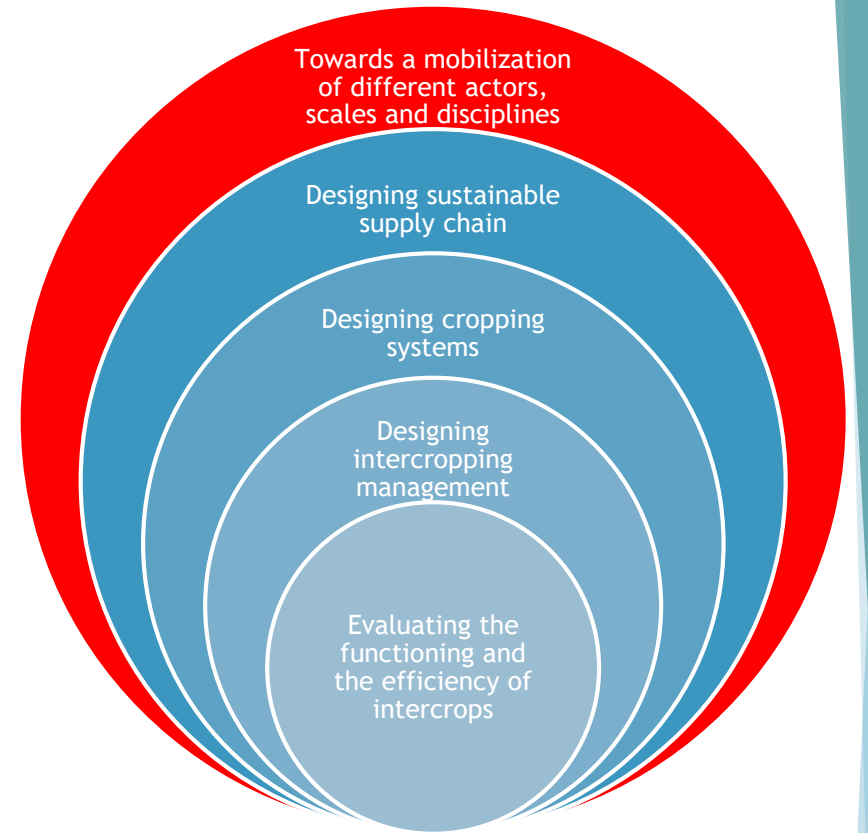
- ▶ Intercropping modify :
 - ▶ Composition in oligo-, macro-elements and heavy metals
 - ▶ Nutritional and sanitary quality
- ▶ Due to:
 - ▶ Intensity of inter- and intraspecific competitions
 - ▶ Dilution / concentration of resources or facilitation
 - ▶ Effect on structural and functional diversity of microbes



- ▶ Depending on:
 - ▶ Chemical elements, species, cultivars, pedoclimatic contexts
- ▶ Methods:
 1. Analysis of samples collected since 2005 with SLU and CAU 
 2. If significant effect then propose a project including to analyse the potential effect of microbiote



Conclusion

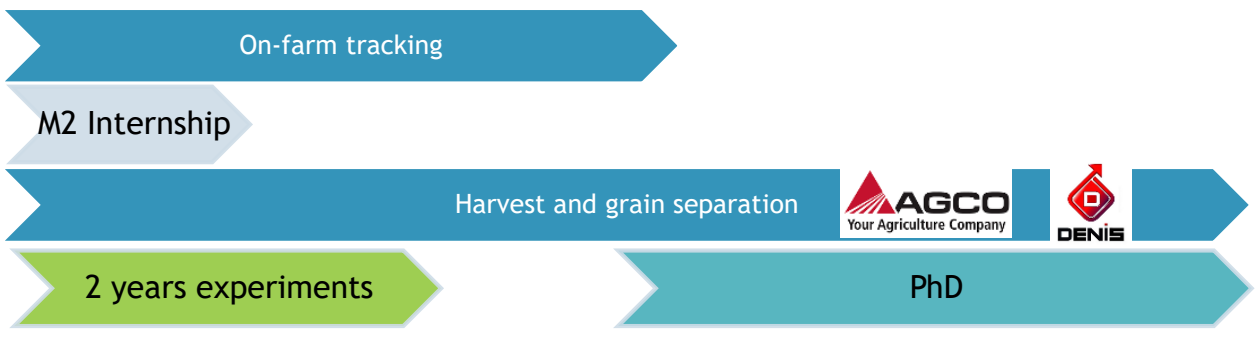




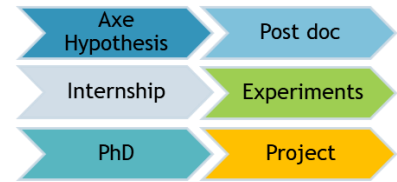
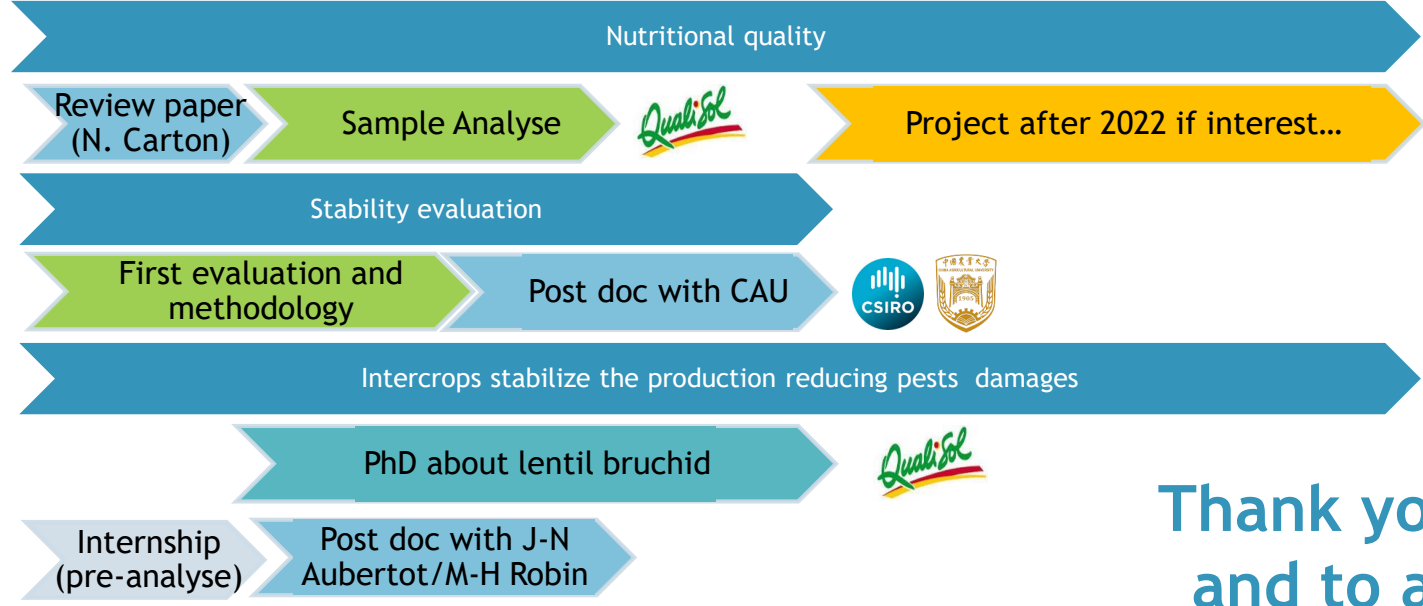
Scenario for my research project

2018 2019 2020 2021 2022 2023 2024

Axe 1: Tracking on-farm innovations, co-conception and agricultural machinery to support design



Axe 2 : Increase and stabilize the production and the nutritional quality



Thank you for your attention and to all people thanks to whom this work was possible