14 avril 2023, CEZ Bergerie de Rambouillet

Rencontre européenne Erasmus +

Some insights of research in agroecology

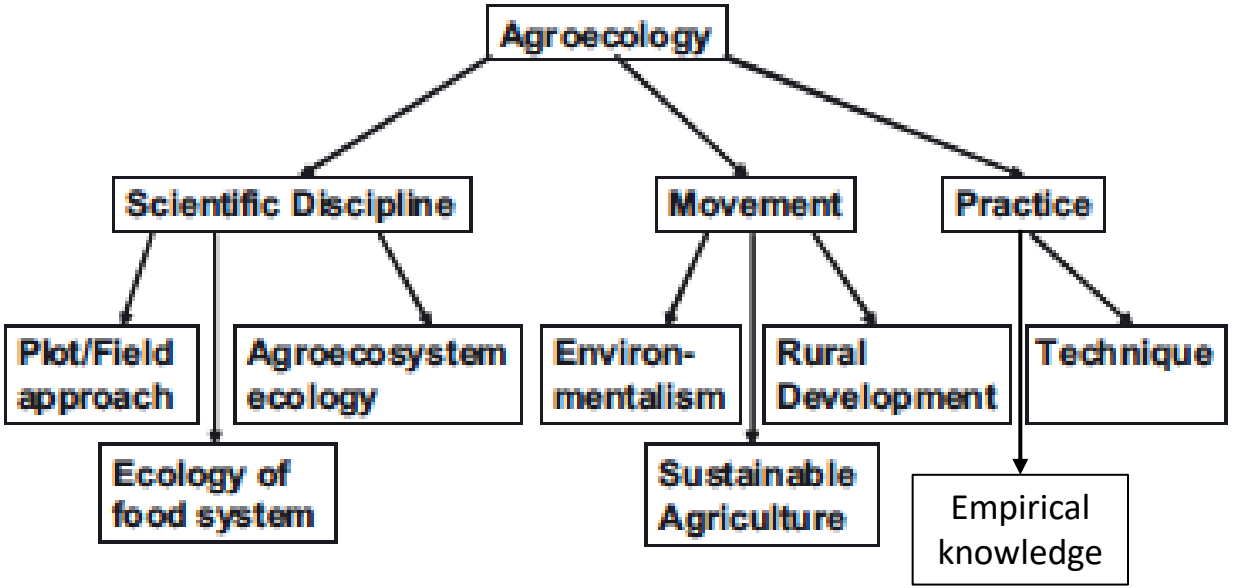
Marie-Odile Bancal & Safia Médiène

AgroParisTech

Outline of the presentation

- Brief introduction on agroecology
- Research issues in agroecology
  - Ecosys research unit : ecophysiology, bioclimatology, environmental sciences
  - Agronomy research unit : agronomy, ecology, social sciences
  - Example of an interdisciplinary research project at territory level
- Opening to teaching

The three dimensions of agroecology



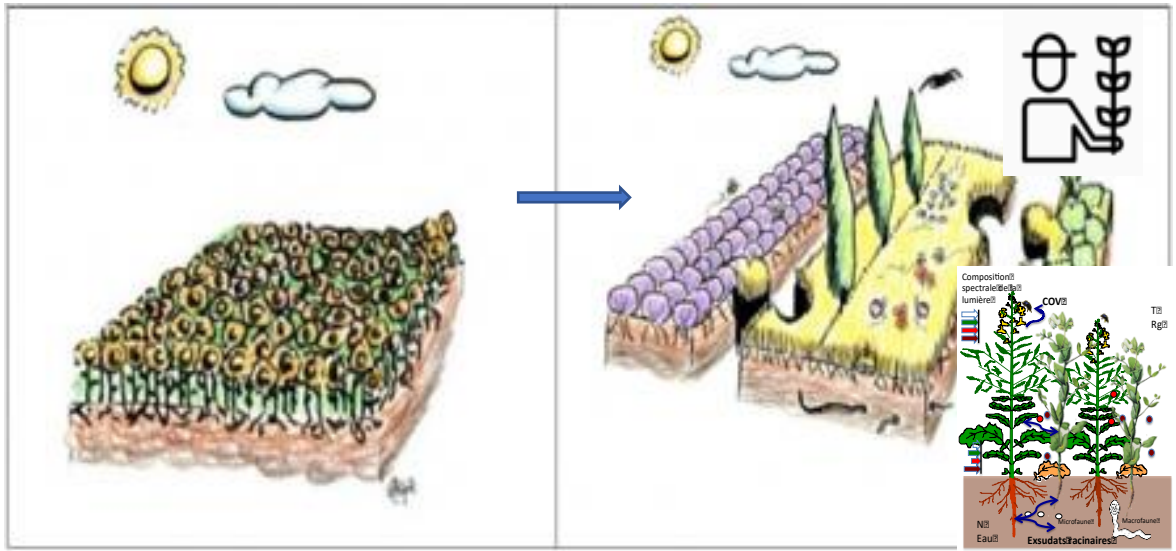
From Wezel et al., 2009

Key principles in agroecology

1. Recycling of biomass and balancing nutrient flow and availability.
2. Securing favorable soil conditions for plant growth, through enhanced organic matter and soil biotic activity.
3. Minimizing losses of solar radiation, air, water and nutrients by way of microclimate management, water harvesting and soil cover.
4. Enhancing species and genetic diversification of the agroecosystem in time and space.
5. Enhancing beneficial biological interactions and synergisms among agrobiodiversity components resulting in the promotion of key ecological processes and services.

Altiéri, 2002

The role of research in supporting the agroecological transition

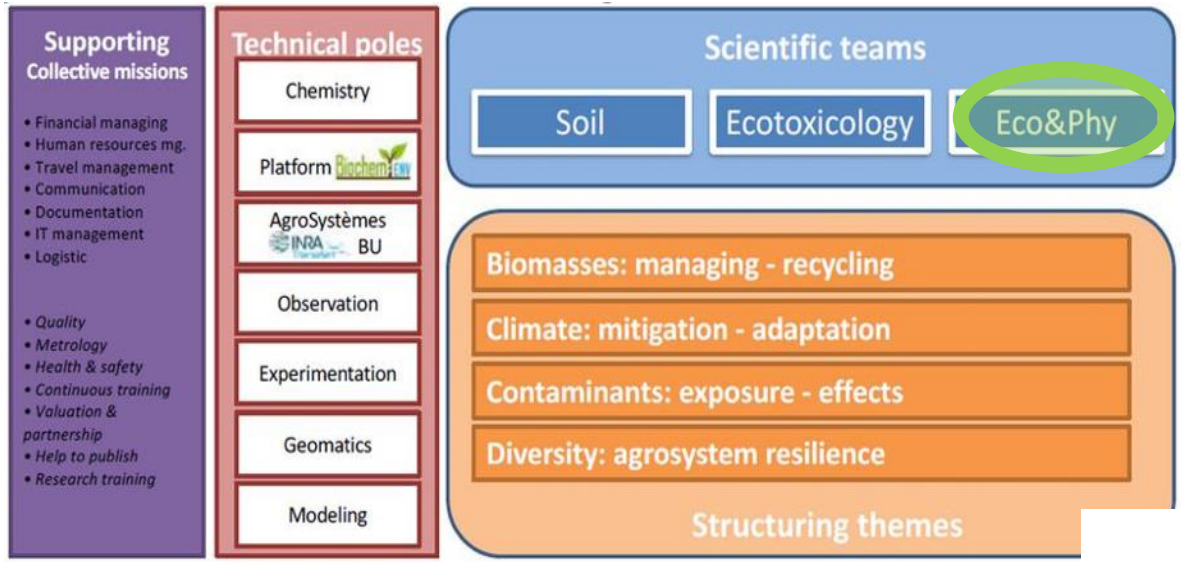


- Complexification of agroecosystem functioning and adaptation of management
- Research can help to imagine, design and manage new agroecosystems to meet current and future challenges (climat change, energy transition, social equity, food sovereignty) with and for farmers

Research issues in agroecology

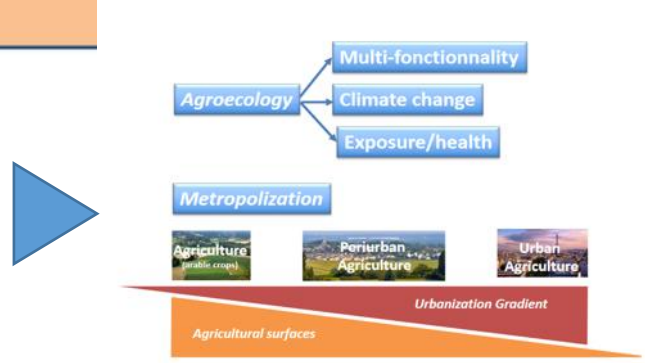
Ecosys Research Unit

ECOSYS: Functional Ecology and Ecotoxicology of AgroEcosystems



~100 perm. staff

Process-based biophysical approach
Combining experimental and modeling
To assess or simulate ecosystemic services
At different time and space scales



As an ex., Eco&Phy “Ecophysiology and physico-chemistry of the biosphere-atmosphere interactions”

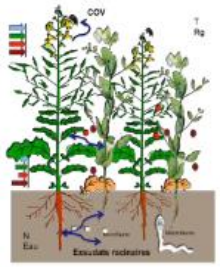
→ new questions to get better knowledge of complex systems

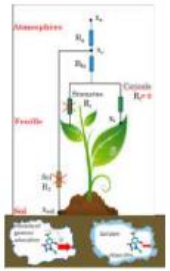
Functioning & services **biodiverse crops**

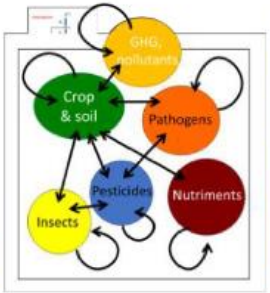
Multiple stress and **interactions**

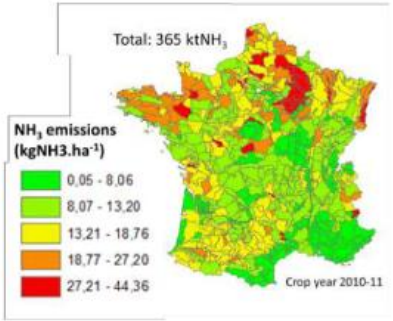
Exposure (pesticides, NH_3, COV)

Mitigation option Climate and air pollution









Above – below ground interactions (roots, crop residues)

Functional ecology and **ecology** at **landscape scale**

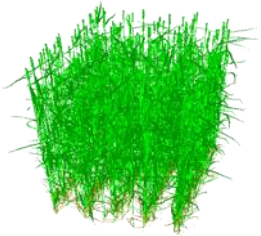
New practices (low inputs, mixed crops substitution N org, landscape management)

New objects (VOCs, aerosols, rhizosphere, microbiome)

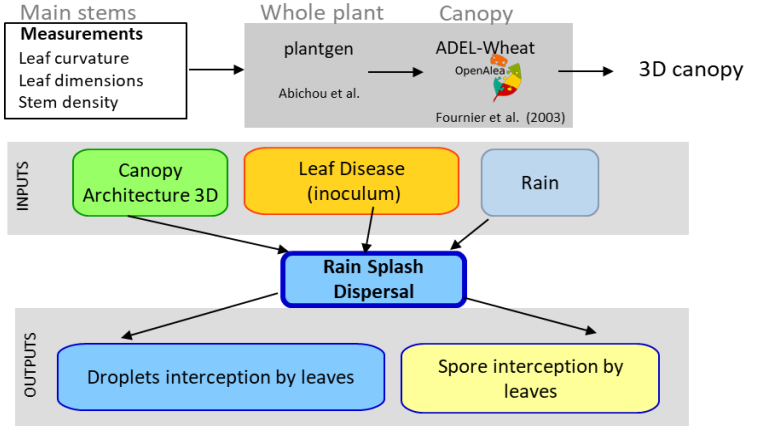
Knowledge transfer (nitrogen, pesticides, …)

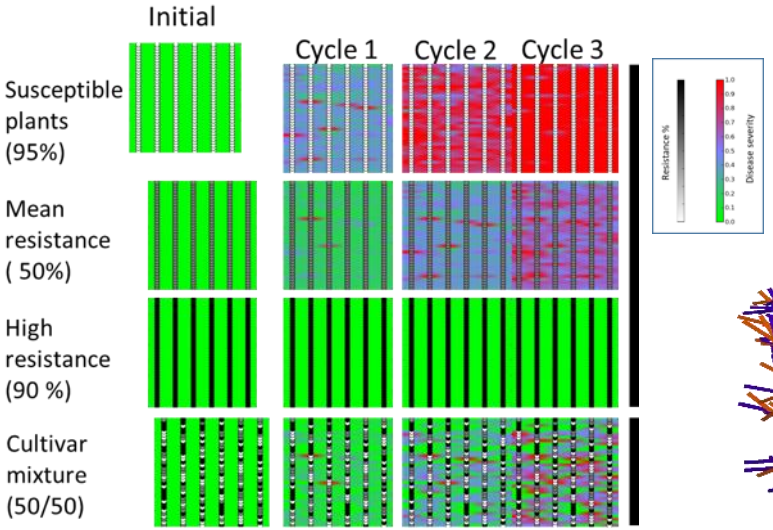
Process based models: Rain Splash Dispersal in heterogeneous canopies

- Mechanistic and stochastic model
- (Saint-Jean 2004)
- Successive infections (Gigot 2013)
- Heterogeneous canopies (Vidal 2017)

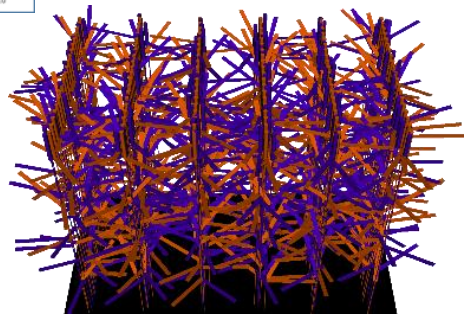


3D-simplified architecture of Wheat





➠ Fits well to experimental data (Gigot et al. 2014)



35% reduction in severity

Combining experiments and modeling to address complex questions

Current research directions

Experiments

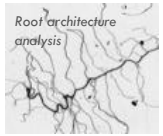
Modeling

Do mixtures improve rapeseed vigor ?

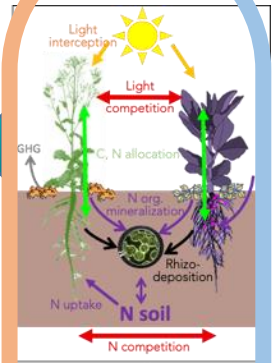
EXPE

Project VIGO (Casdar)

- Identify architectural and functional traits determining vigor during implantation
- Testing the genotypic vs. association levers



Rhizodepot collection



What benefits of mixtures on soil C storage ?

EXPE

Project MixRoot-C (EEC)

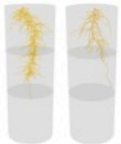
- Experimentally quantify rhizodeposition and root dynamics on rapeseed-legumes mixtures (^{13}C labelling)
- Prioritize processes modulating C storage and identify tradeoffs with performance (modelling)

Modeling rapeseed-legume mixtures

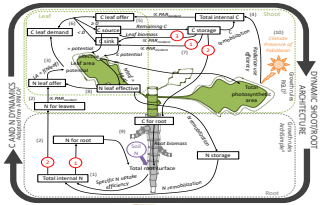
MODEL

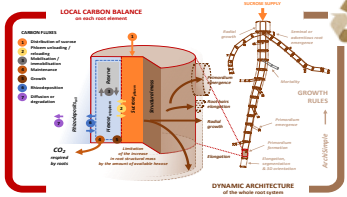
Project SILICOL (SeleoPro)

- Implement a FSPM of associated oilseed rape, interacting with faba bean and soil at the organ scale
- Generate a effective metamodel
- Define *in silico* morphotypes and critical periods for the success of the mixture and evaluate its effect on rapeseed vigor



OpenAlea





Rhizodep model

CANTIS model

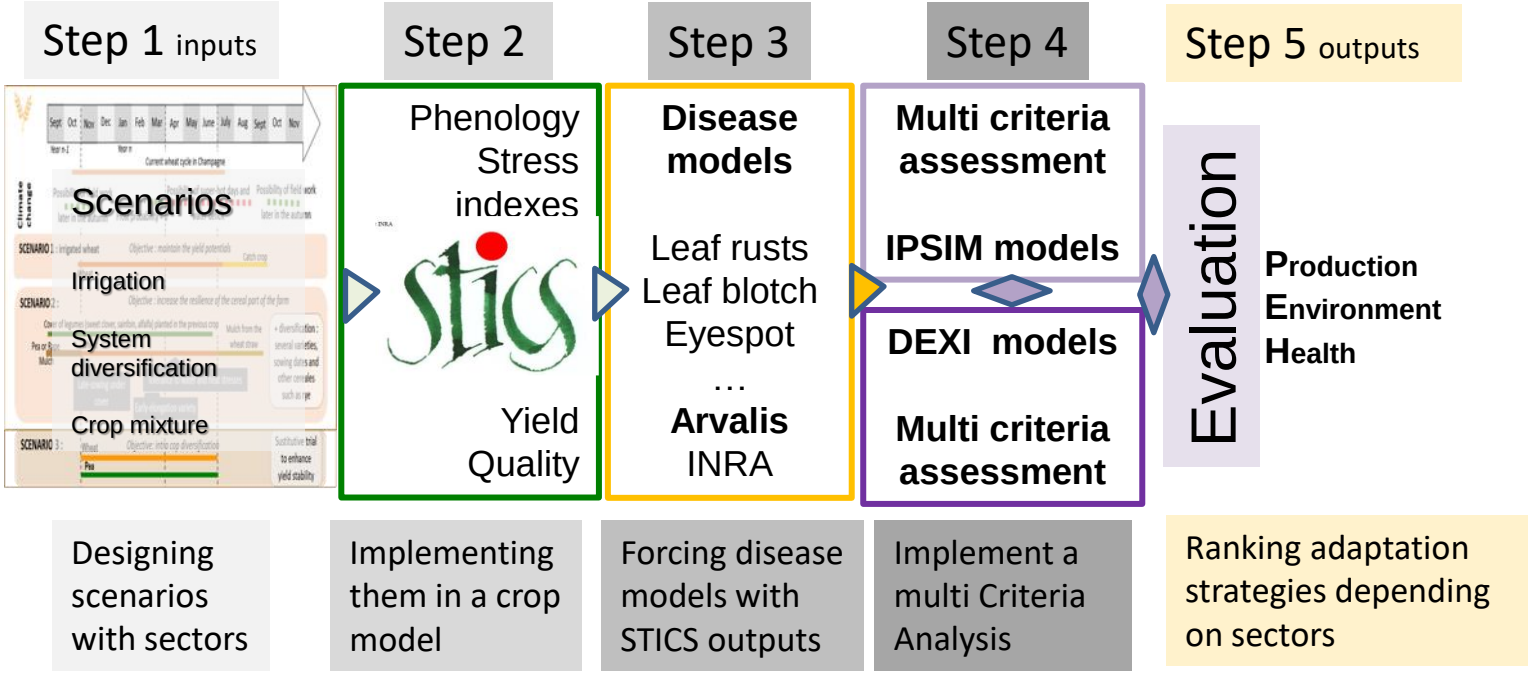
Alexandra Jullien, Laurène Perthame, Frédéric Rees, Céline Richard-Molard

UMR ECOSYS, Université Paris-Saclay - INRAE – AgroParisTech, Palaiseau, France

Combining modeling frames to address complex questions

OPERATE Project : crOP disEase Response to climATE change adaptation

- Identifying how sectors will cope with abiotic stresses allowed the building of eligible scenarios
- Mixing modeling approaches further allows to quantify future disease risks in adapted crops

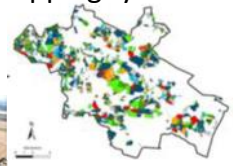


Simulations : RCP 4.5 & 8.5 x12 contrasted french sites
x 3 virtual soils with high medium and low water capacity

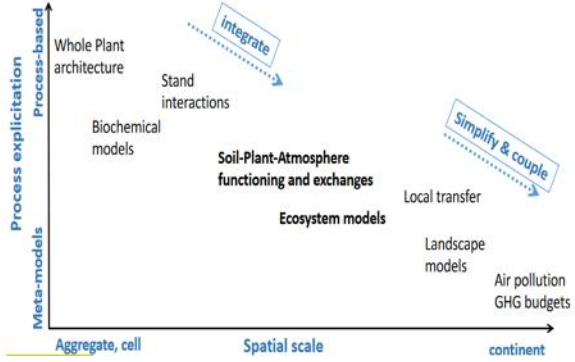
Launay, Huber , Bancal, 2021

Combining metrology and modeling frames to up scale outputs

Cropping systems



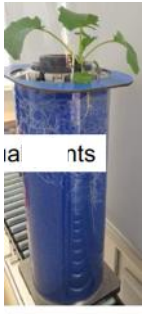
Experimental designs from organ to landscape



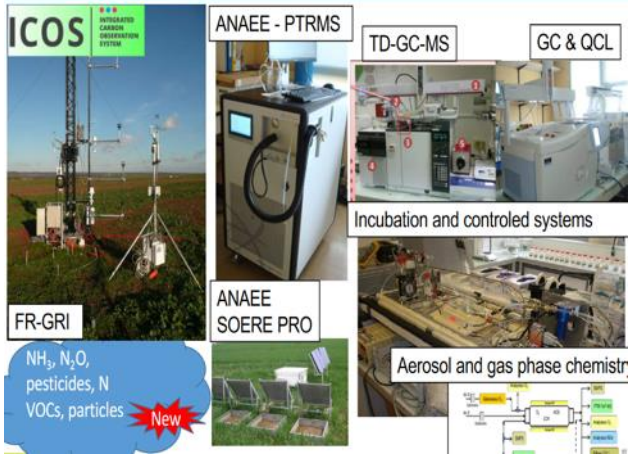
Thanks to both

Metrology from organ to landscape

Micro-mesocosmes



Gas exchange measurements



AgroParisTech

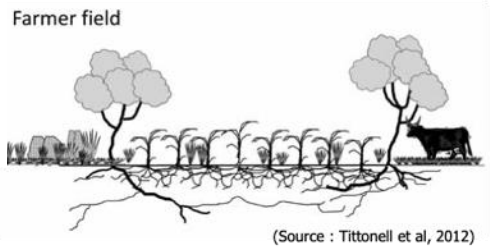
Research issues in agroecology

Agronomy Research Unit

UNITÉ MIXTE DE RECHERCHE
Agronomie
CONNAISSANCES ET CONCEPTION POUR ACCOMPAGNER

The objective of the unit is to produce and promote scientific and expert knowledge and methods, from local to global scale, in order to:

Characterize actual agricultural practices

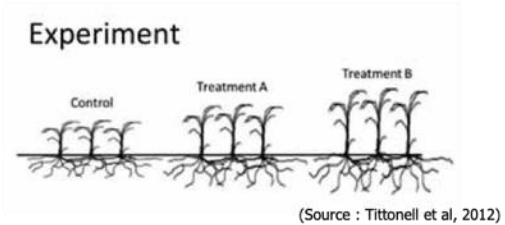


(Source : Tittonell et al, 2012)

Design cropping systems from local to landscape scale

Test inovative cropping systems

(Source : Meynard et al, 2012)



(Source : Tittonell et al, 2012)

D'après Meynard *et al.*, 1998

Special concern for biodiversity in agroecosystems

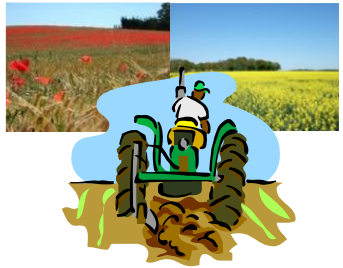
Earthworms / Insects / weeds

Intercrops: cereal/legumes

Mixture with service plants

Flower strips/ beneficial organisms

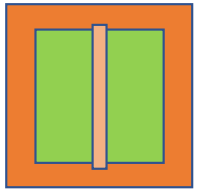
Crop rotation, diversification of farming practices at landscape and regional level



functional role of different forms of biodiversity at different scales

Sub-plots

Plots



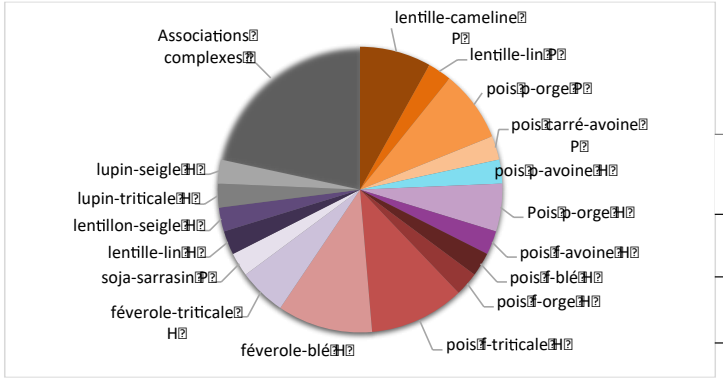
Plots + boarders

Landscape

Regional & country level

Next to the dominant system, some farmers grow grain legumes : they have invented practices (rare but satisfactory) ➔ understanding how they do may help disseminating new type of knowledge for further innovations

15 farmers interviewed



➔ 38 grown intercrops

Type	Outlet of the harvested product	**Performance criteria favoured by farmers**	Most frequent species	Periods of sowing	Nb. Of weeding operations	Sorting species before use	Work load
1	Sale outside the farm	**No technical operation between sowing and harvest**	(2) Lentil, camelina, buckwheat	May	0	Yes	Low
2	Feed for the animals on farm	**No technical operation between sowing and harves**	(2 à 7) forrage pea, vetch, rye, triticale, wheat	September - october	0 to 1	No	Low
3	Feed for the animals on farm	**Decrease weeds in winter-crop rotation ➔ spring sowing**	(2) pea, wheat, barley	February to April	1 to 2	No	Medium
4	Sale outside the farm	**Produce high-protein wheat for sale**	(2) Winter Wheat + pea, fababean, lupin	October to Décember	2 to 3	Yes	High

Practices (species, density, N fertilization, weeding, sorting) are highly consistent with the satisfaction criteria of the farmers ➔ 4 agronomic logics

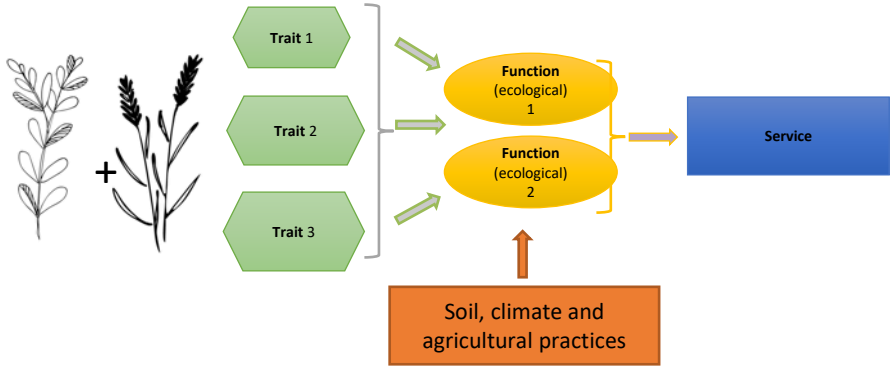
Jeuffroy et al.

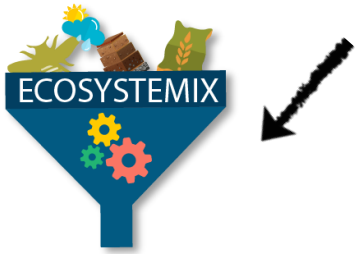
Need to produce knowledge and tools to help design crop mixtures

Empirical Knowledge

Scientific Knowledge

Functional model



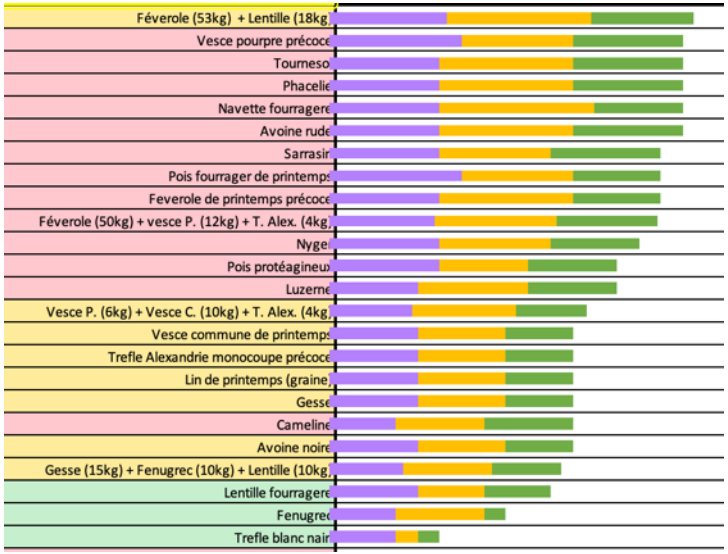


Classification of species mixtures according to their capacity to deliver services in the local context

Médiène et al.

CAPS

Oilseed rape mixed with service plants



Services

Nitrogen supply

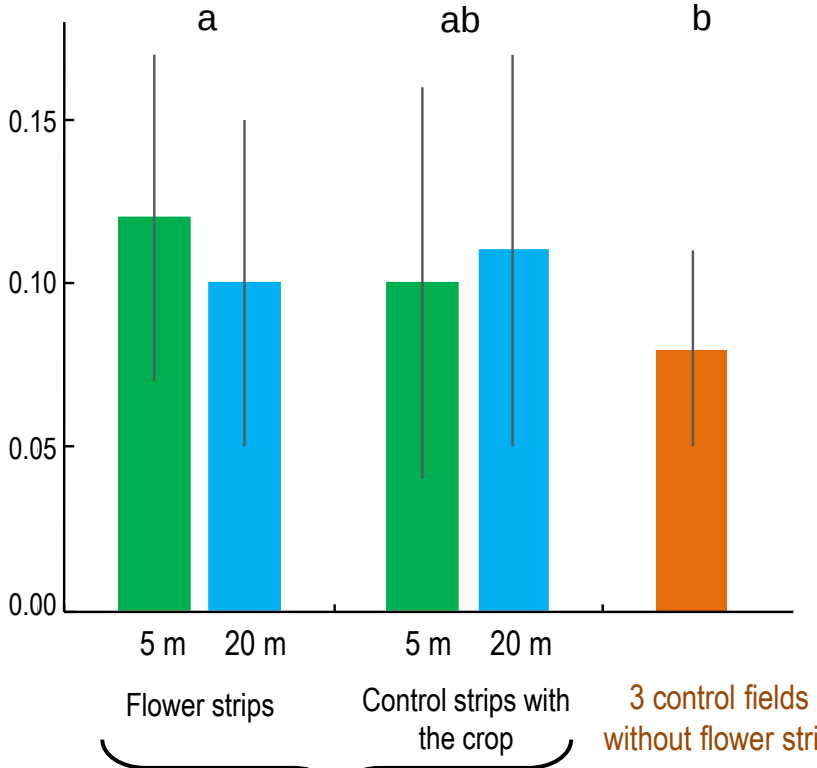
Pest regulation in autumn

Weed regulation in autumn

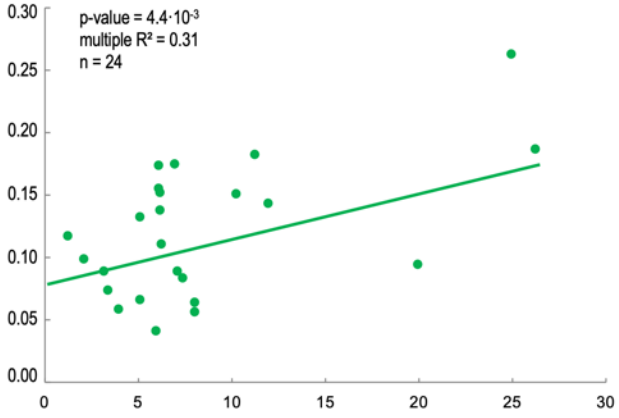
Brassicogethes aeneus: increased parasitism in the field with flower strips

Parasitism rate of larvae of *Brassicogethes aeneus* (mean ± SD)

Egg of *Tersilochus heterocerus* in *Brassicogethes aeneus*



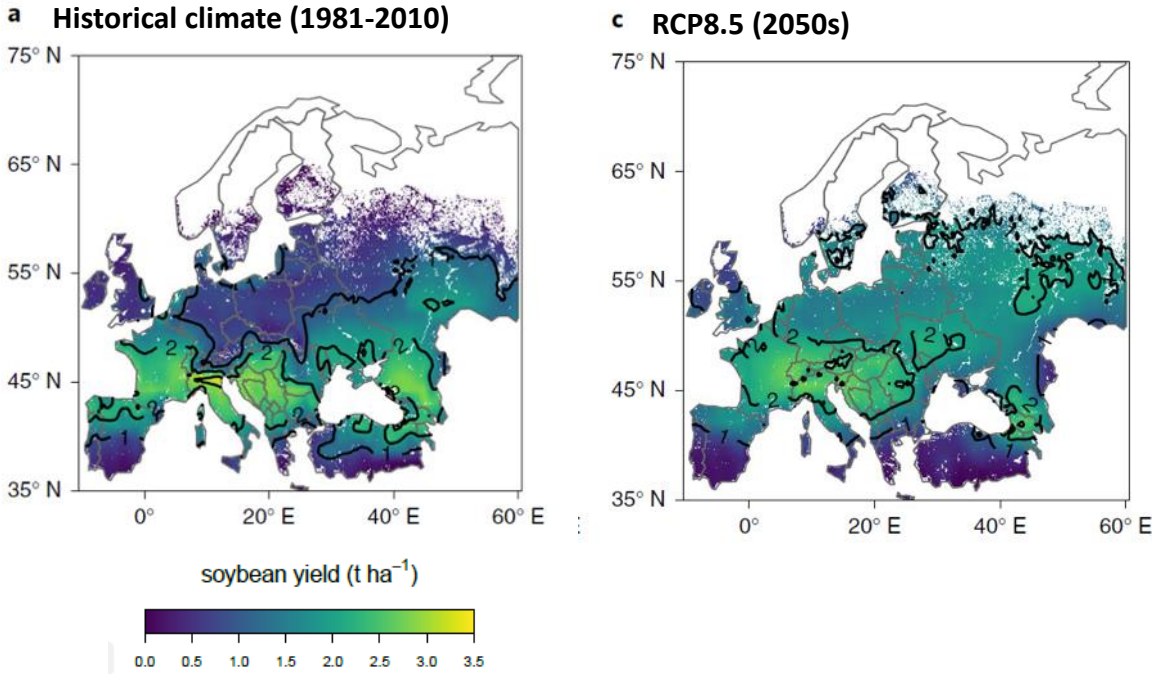
Parasitism rate of larvae of *Brassicogethes aeneus* at 5 m from the strips



Percentage cover of flowering plants in April providing accessible nectar for parasitoids

Gardarin et al.

Impact of climate change on soybean production potential in Europe



- We combined global maps of soybean yields with historical climate data to develop data-driven soybean yield projections based on machine-learning techniques (R^2>0.9)

Guilpart, N., Iizumi, T., & Makowski, D. (2022). Data-driven projections suggest large opportunities to improve Europe's soybean self-sufficiency under climate change. *Nature Food*, *3*(4), 255-265.

Guilpart et al.

Interdisciplinary research project at territory scale

PPR Be Creative (Priority Research Program)

Be Creative challenge & objective

➔ Pesticide-free agriculture : an innovative **design challenge** = a process organized to set ambitious goals and create solutions **at the territorial scale** and **with the local actors** (Le Masson et al. 2013, Verganti 2011, Yannou 2015, Meynard et al. 2017 a,b)

OUR OBJECTIVE

Design « pesticide-free territories » with and for the actors by using and producing biological, ecological, agronomic and socioeconomic knowledge

10 case study territories with different context & challenges

Diversification, a key ?

Crop-livestock integration, a lever ?

Pesticide-free

Role of processing actors to push ?

the role of territorial policies (urban areas, food, biodiversity, water quality) ?

Role of processing actors to push ?

Crop-livestock integration, a lever ?

CHAOURCE

Livestock farming with added value but complex forage autonomy

Chaource: Livestock + Grains crops

Development of crop-livestock integration on the scale of a territory as a lever

Diversification, a key ?

DEVROUZE

"Insects" resistance as a priority issue, a gateway to pesticide free agriculture

Work on landscape infrastructures, crop mosaics, crop diversity

Role of processing actors to push ?

Role of territorial policies ?

PILAT / PLAINE OUEST MONTPELLIER

Very varied sectors + land pressure + biodiversity issues

Delineate fields of innovation and then organize a territorial "pesticide-free dynamics"

Saffré-Nantes: livestock + grains

Diversification, a key ?

SAFFRE

Livestock farming but water pollution challenges

Development of crop-livestock integration on the scale of a territory as a lever for diversification for cereals farmers

Devrouze: Grain crops

Pilat: Vineyards + orchards + grain crops + Livestock

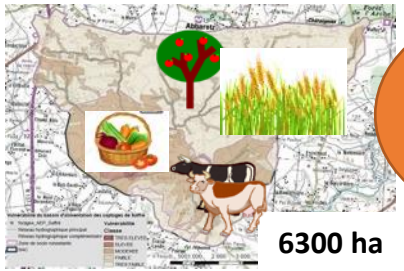
POM: Vineyards + Livestock + vegetables + orchards

An example for Saffré territory (West France, near Nantes)

Saffré-Nantes: livestock + grains crops
Academic leader : Rémy Ballot

groupe transition alimentaire (Nantes)
Atlantic'eau, Agri Eau Saffré,
CIVAM (Nantes)

WP 1
Understand socio-technical lock-in



6300 ha

WP 2 Create pesticide-free productive territories

Challenges : how to maintain livestock in SAFFRE and cultivate without pesticides, because of a water pollution issue ?

WP 3 : Assess performance, impacts and services

Opening to teaching

M2 « From Agronomy to Agroecology »

AgroParisTech, Paris-Saclay University

Master 2 course From Agronomy to Agroecology

Semester 1 (S3)

Global context and challenges for agroecology

- 3ECTS — Global Agronomy
- 3ECTS — Dynamics of technical and social changes
- 4ECTS — Seminars Agroecological trajectories

Function and design of agroecosystems from field to territory

- 1ECTS — Introduction to the design process
- 4ECTS — Designing agroecological systems at the territorial scale
- 7ECTS — Crops functioning and biological regulations within agroecosystems

Multidisciplinary In Depth project — 4ECTS

Tools and Methods

- English — 1ECTS
- Statistics — 3ECTS
- Professional and Personal Project

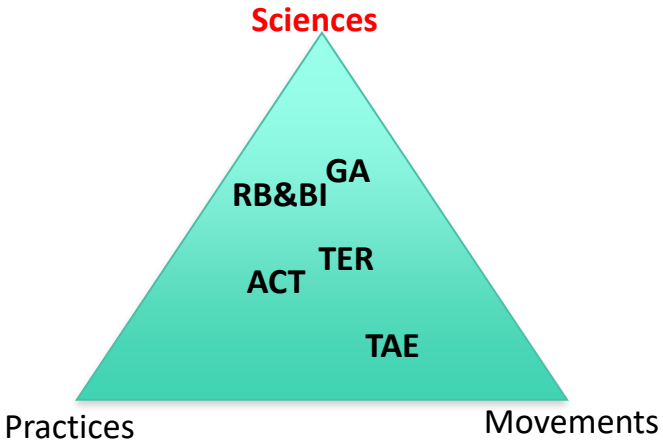
With external contributions from: INRAE, CIRAD, Arvalis, Earth and Humanism, CA, farmers

Semester 2 (S4)

Internship

- **Preparation to internship** — 5ECTS
- **Internship (6 months)** Research institutes or agricultural development institutes, associations, international institutes, cooperatives, chambers of agriculture — 25ECTS

AAE Classes	
RB&BI	Biological Regulation and Integrative Biology
TER	Territory
ACT	Actors
TAE	Agroecological Trajectories
GA	Global Agronomy



How does agroecology lead us to revisit our scientific approaches as agronomists?

Thank you for your attention

AgroParisTech

Contact
safia.mediene@agroparistech.fr
Marie-Odile.Bancal@inrae.fr