AgriResearch Conference

Innovating for the future of farming and rural communities

2-3 May, Brussels

Towards a chemical pesticide-free agriculture

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#AgriResearchEU

European Commission

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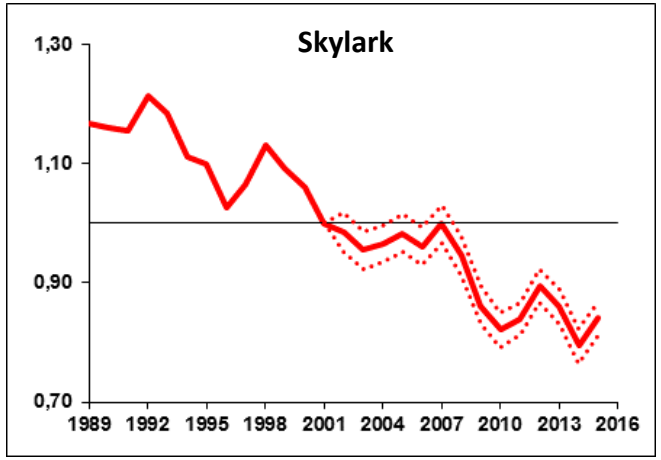
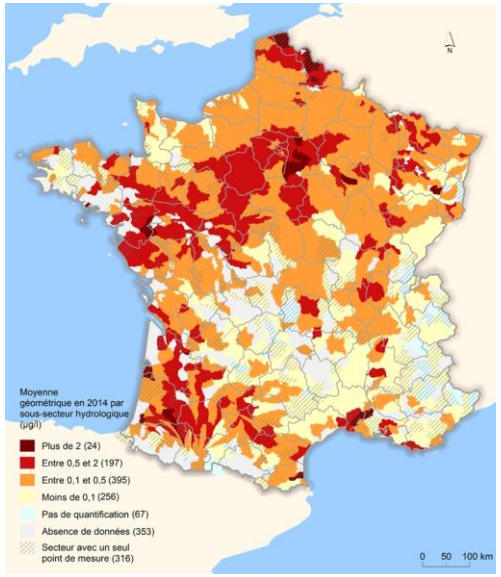
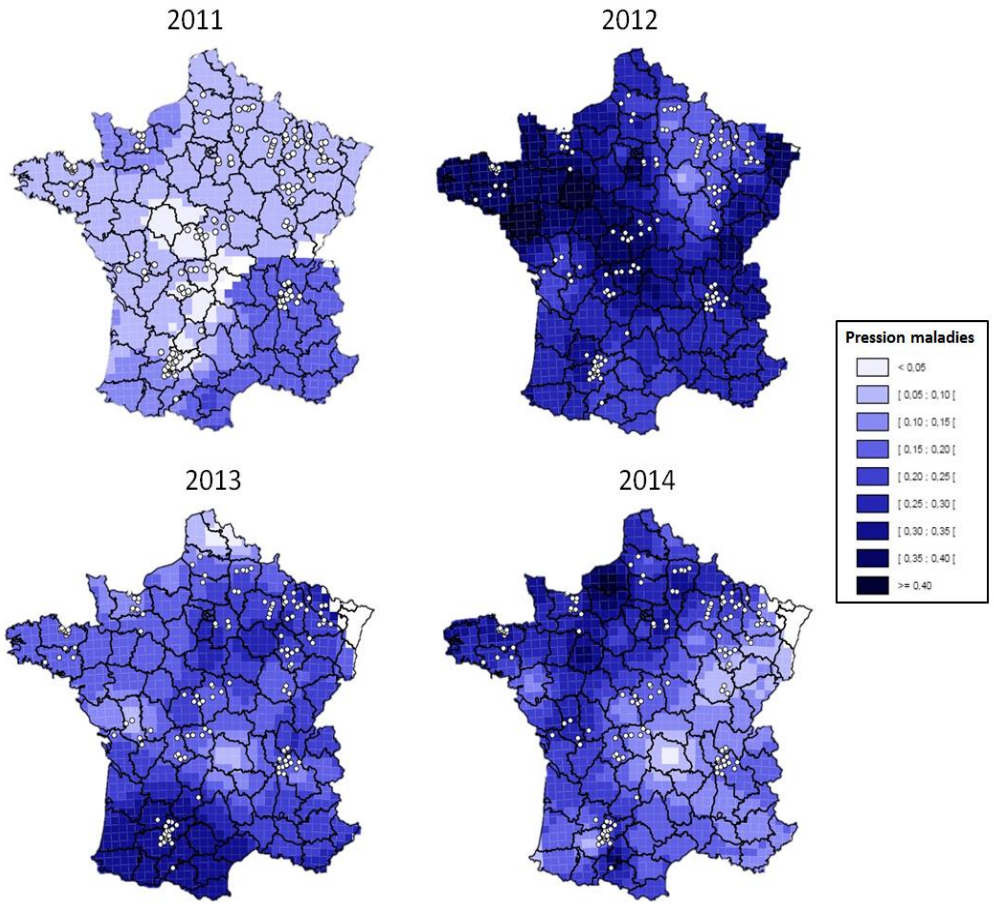
Pesticide issues in Europe and France: scientific evidence

- Protection of crops against **weeds, pests and diseases:** a real need to ensure competitiveness and secure plant products quality
- Availability of **pesticides**, **at low prices**
  - intensive farming systems and more homogenous farming landscapes
  - deleterious environmental impacts: biodiversity and water quality







Winter wheat yield gap due to fungi.
Urruty et al, 2016

- An increasing concern of their impact on human health: emergence of the exposome concept

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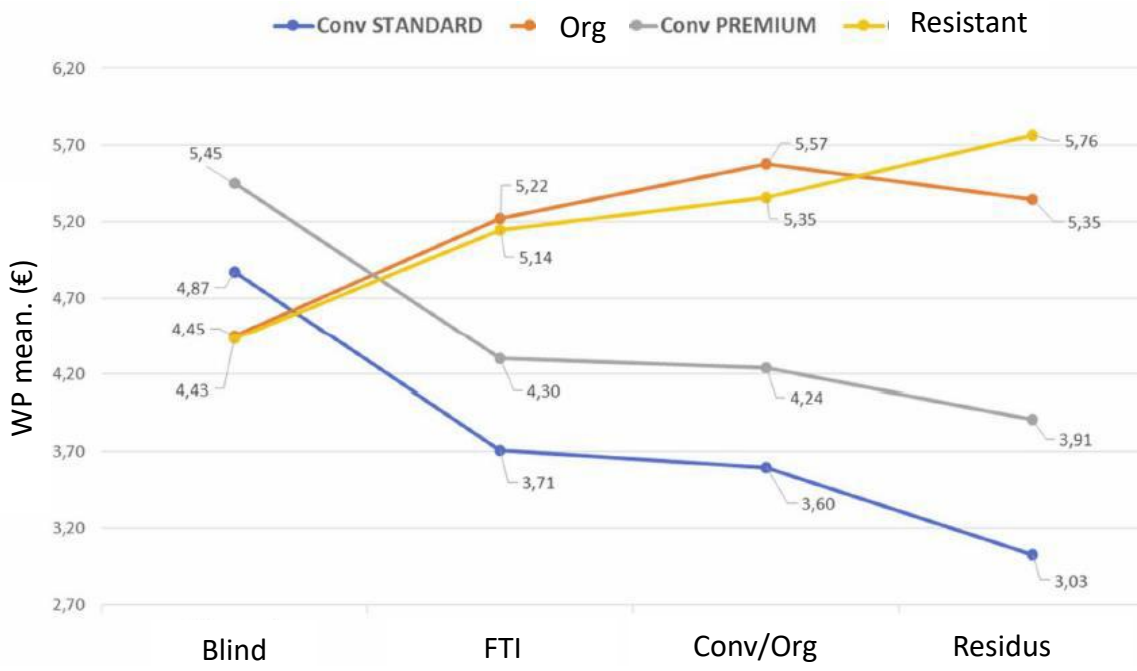
Pesticide issues in Europe and France: social evidence

Willingness to pay for various wines (Y. Raineau, PhD, 2018)



- A strong demand of society and consumers for new production systems with low pesticide uses and no pesticide residues

- Pesticide uses and agricultural models are at a high position in the society and policy agendas: cf the glyphosate issue

- To be combined with other environmental performances of agricultural (nitrates, carbon and climate change)

Demonstration in Brussels, November 2017

Pesticide-free is the key option

- A reduction by a few % units will not solve the health and environmental issues
- A path-dependency would hinder major changes in production systems
- This very challenging objective will require to mobilize all possibilities of the ESR scale (Hill and Mac Rae, 1995)
  - E for Efficiency
  - S for Substitution
  - **R for Redesign**
- Based upon the C-K theory (Hatchuel, Le Masson and Weil, 2009), what are the assumed invariants that could be unlocked?
  - Producing the same products in the same quantities ? *The wine example!*
  - Focussing on individual crops? *Why not thinking the whole crop rotations !*
  - Plant-animal productions interactions

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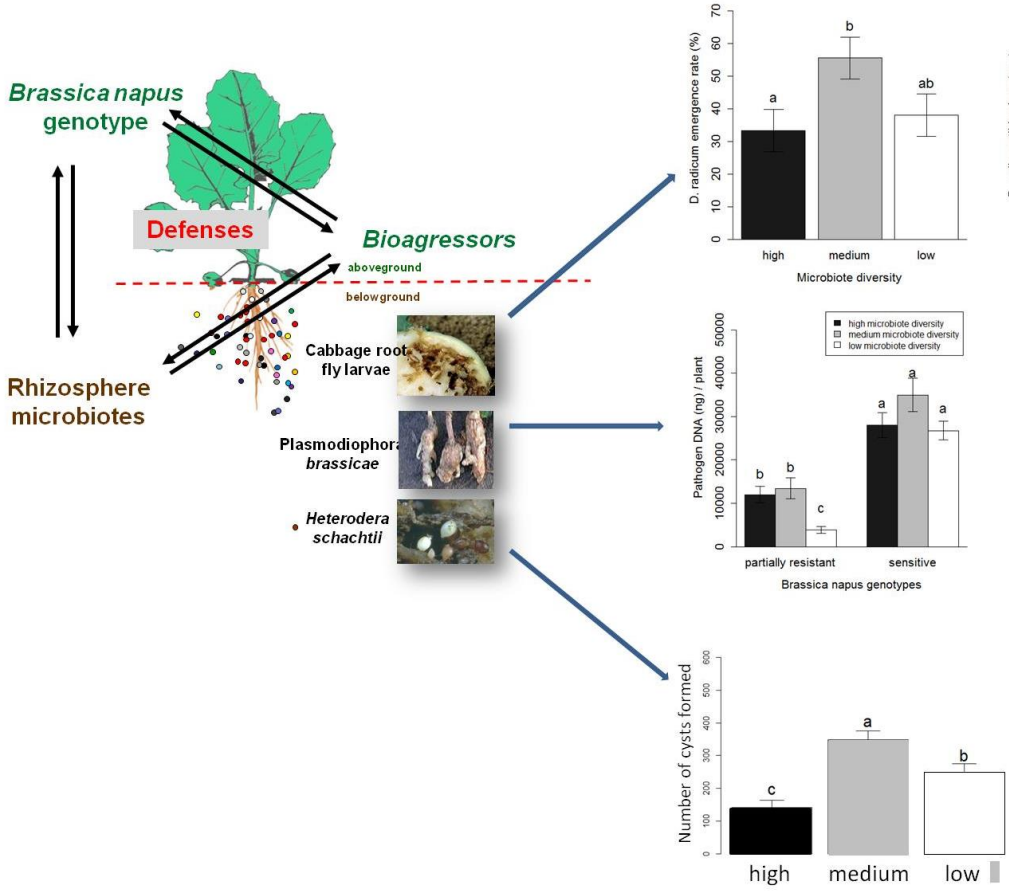
New paradigms emerged, offering new possibilities in crop protection, requiring more research

- Agroecology (Wezel et al, 2009):
  - Crops may be regarded as agroecosystems
  - Biological regulations within an agroecosystem may provide ecosystemic services, including the regulation of pest and diseases
  - Plant-Plant interaction, as a possibility to control weeds
  - Agroecosystems with more functional diversity
    ➡ More biological regulations
- Microbiomes
  - Plants are hosting complex microbial communities on their leaves and roots. A disease outbreak may be regarded as a disequilibrium of these communities
  - New molecular techniques give access to these communities and their functions



New paradigms emerged, offering new possibilities in crop protection, requiring more research

- Plant immunity
  - Genetic resistance to pest and disease → Sustainable management of genetic resistance
  - → Plant immunity
- Chemical ecology
  - Insect behaviour is strongly determined by the volatile chemical environments
    - Sexual confusion
    - Detection of their hosts
- Pest-scouting and prophylaxis are essential to use soft levers
- Digitalisation in agriculture
  - Sensors for detection of plant stress status
  - Algorithms, artificial intelligence and deep learning
  - Robotics
- New paradigms in socio-economy
  - Lock-in
  - Nudges

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Some success stories

- Inter-cropping winter rapeseed with annual frost susceptible legumes
  - No herbicide in autumn and winter
  - 40-60 kg of N provided by the legumes
  - No insecticide against cabbage stem flea beetle (*Psylliodes chrysocephalus*) in autumn (chemical ecology)

- Mixing winter rapeseed variety with a very early flowering variety (95/5)
  - No insecticide against *Meligethes aeneus,* a pollen beetle grazing flower buds and completing its single cycle on the early variety

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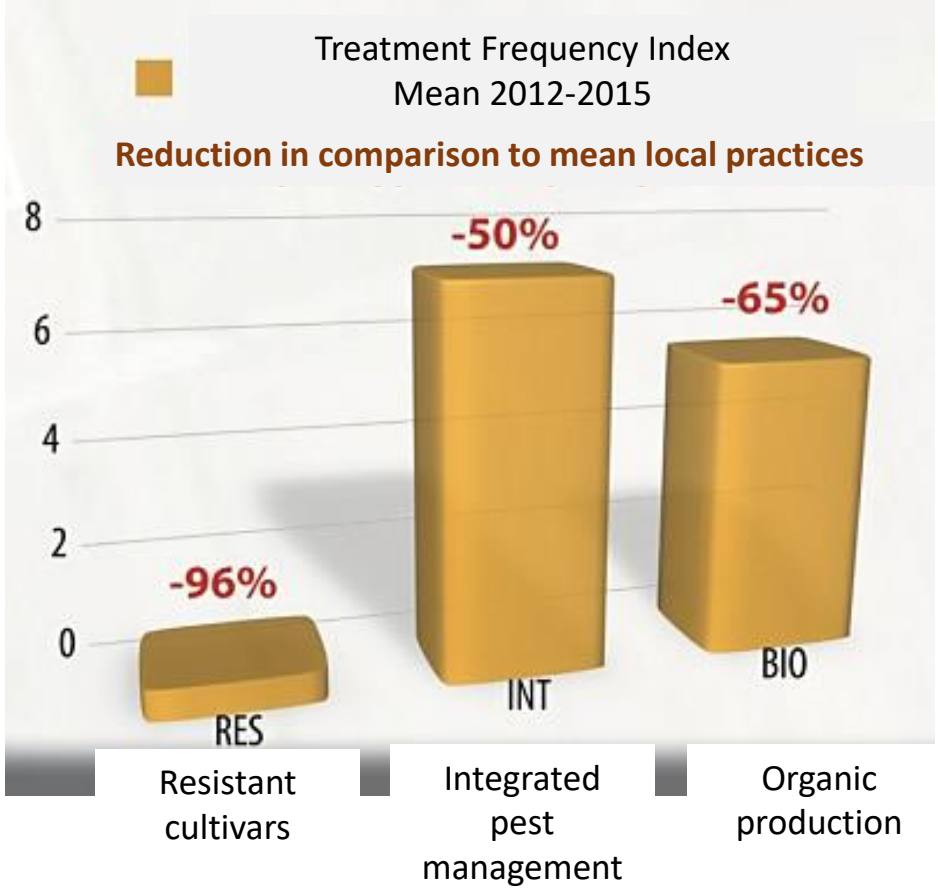
Some success stories

- Breeding vine varieties for resistance against downy and powdery mildew through gene pyramiding
  - From an average of 13 fungicides down to 2
- Sexual confusion against Eudemis and Cochylis in vineyards using pheromons
  - No insecticide
  - Improved efficiency when implemented at a large scale



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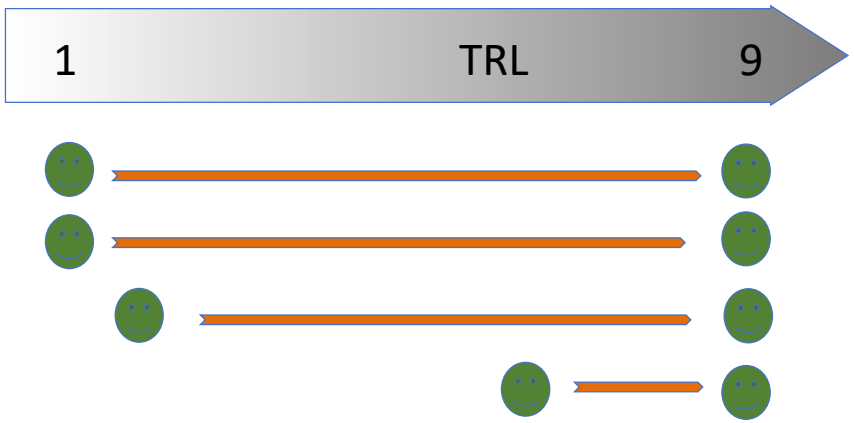
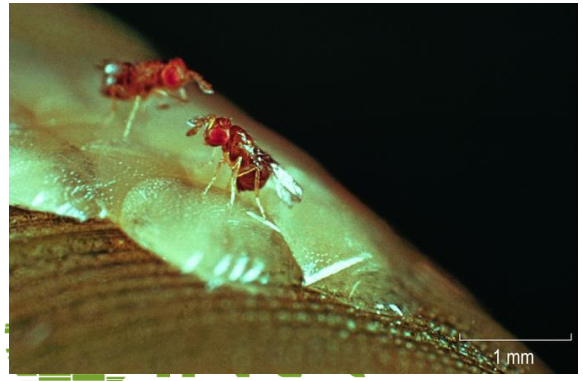
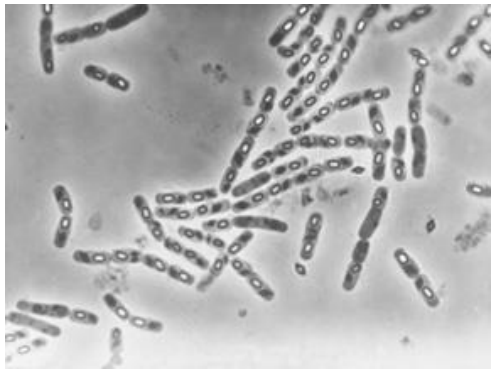
Research and applied research priorities

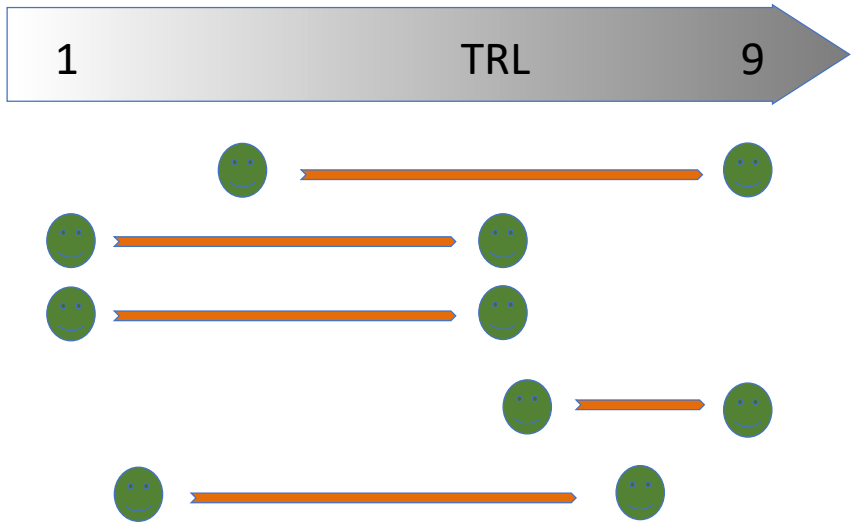
- Biological control. Four domains with contrasting perspectives
  - Macro-organisms (parasitoids, SIT)
  - Micro-organisms
  - Pheromons
  - Natural substances







Research and applied research priorities



- Genetics and plant breeding
  - Introducing new species for new services
  - Genomic selection (speeding up breeding)
  - Genome editing
  - Preserving genetic resources
  - Participatory breeding
- Change in the breeding paradigm of variety structure
  - From pure lines or hybrids to populations
  - Breeding for mixtures
- Seeds will carry an ecosystem: plant genotype + adapted microbiom

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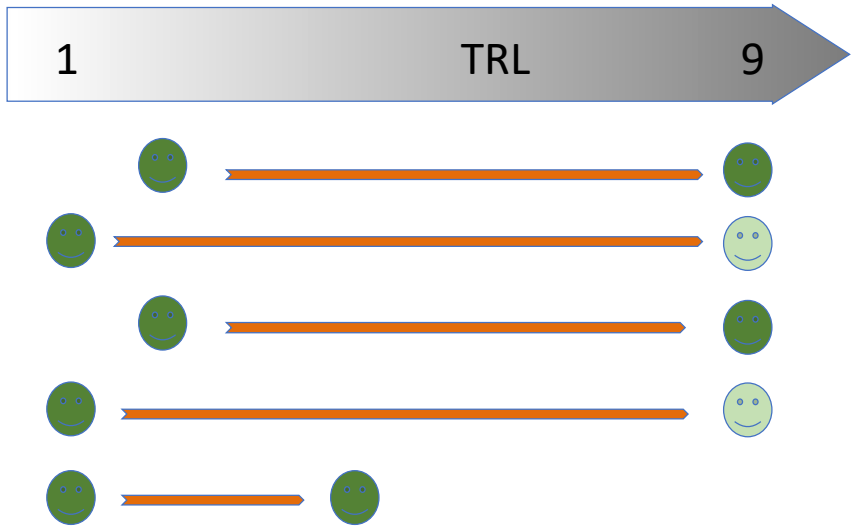
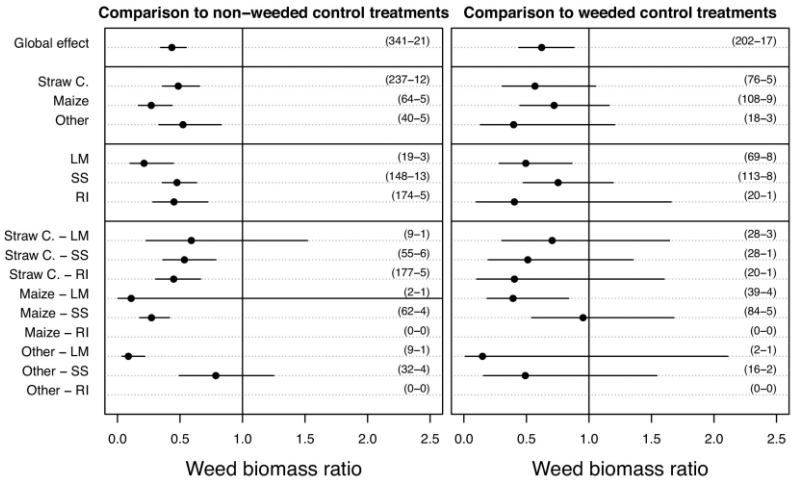
Research and applied research priorities

- Changes in crops and farming systems
  - Inter-cropping, co-cropping and living mulchs
  - Mixtures (with legumes) in annual crops
  - Mixtures (with legumes) in grasslands
  - Agroforestry
  - Landscape design



Verret et al, 2017, Field Crops Research



First achievements in setting new landscape structures in orchards

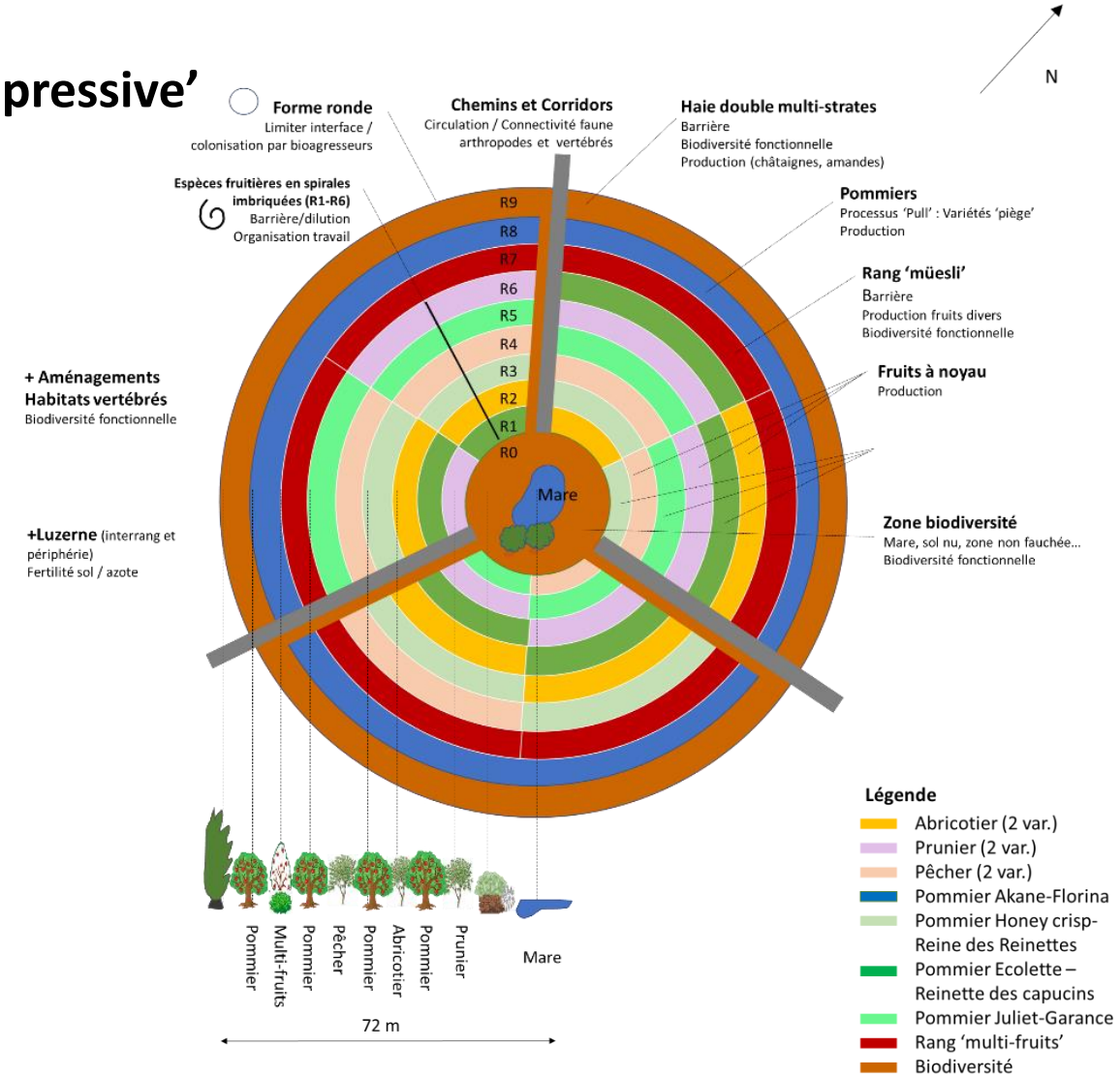
Design module 1 'pest suppressive'

Gotheron Experimental Unit

Module 1
(1.6 ha)

Experimental zone
«Z project» ~ 10 ha

Module 1—Planting February 2018



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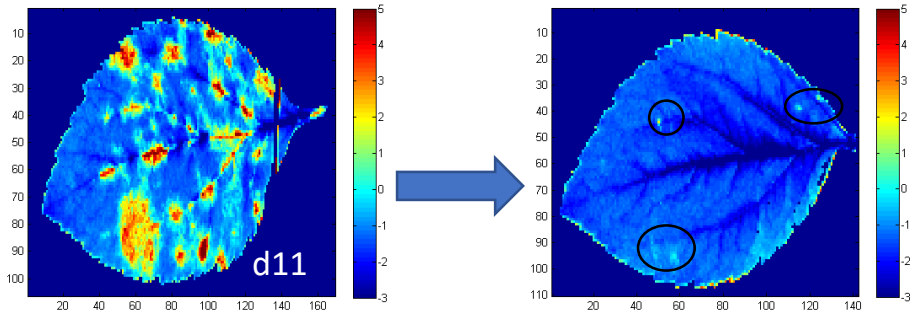
Research and applied research priorities

- **Machinery and Digitalisation:**
  - Capturing heterogeneities
  - Detecting plant stress status and emergence of pests
- **In Machinery,** a system in transition
  - From a logics of power and size increase to a logics of increasing functionalities
  - Increasing decision automations: robots and autonomous modules (self-guidance)
  - Strong connections between machinery and digital
- **Digitalisation:** an exogenous innovation
  - More sensors
  - Computation and artificial intelligence
  - High throughput networks
  - Emergence of new players



First visible apple scab symptoms at d11

First signs of apple scab detected by sensors at d2

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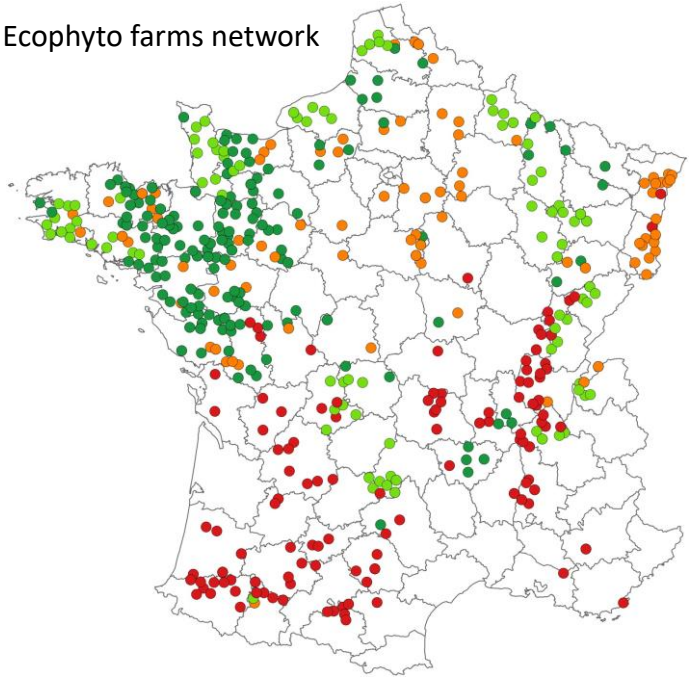
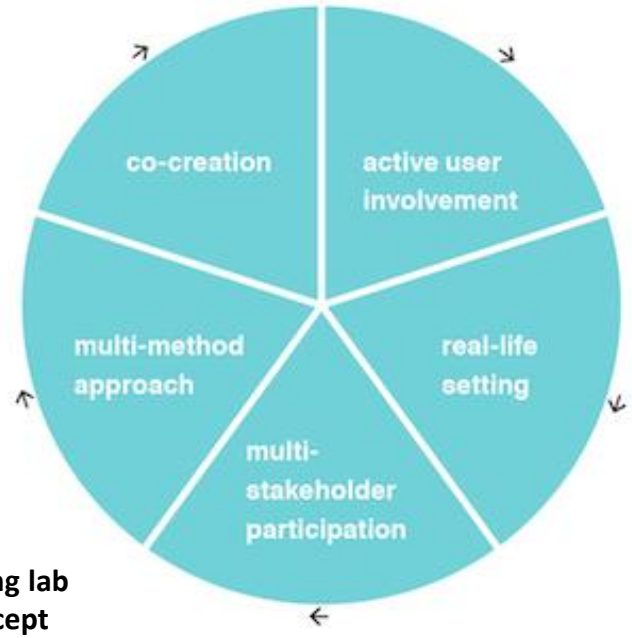
Setting new designs for experiments
Adoption and transition

- Farmers groups and farm networks
  - Farms from the French Ecophyto design (3000 farms)
  - Sharing among countries, including through Operational Groups of EIP-Agri
  - How to learn from these designs?
    - Identifying what is generic and what is specific to local conditions
    - Limitations to achieve 0-pesticides
  - Transition at the farm level
- Living labs (TIGA in France)
  - Gathering fundamental and applied research, economic stakeholders and indirect beneficiaries
  - One on viticulture (Bordeaux region) and one on agroecological agrifood systems (Burgundy region)
  - Demonstrators at a large spatial scale.
  - Towards open innovation ….

Ecophyto farms network





Living lab concept

common elements

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Adapting public policies and organisations

- Relationships to markets
  - Merchant and non-merchant payments
  - New contractual organisations
  - Future CAP: Payment for Environmental/Ecosystem Services (human health, biodiversity, water quality)
- All breakthroughs will be beneficial to organic farming
- Separation between market and advisory activity
- New policies to target 0-pesticides
  - Variety registration and more focus on pest resistance
  - Biopesticide homologation
  - French system of Pesticide Economy certificates to evidence the favourable levers

- More prospective analyses are needed to document
  - Long term effect on biomass production, separating the influences of plant protection and of fertilizers
  - Monetary value of environmental services
  - Monetary value of long-term public health benefits

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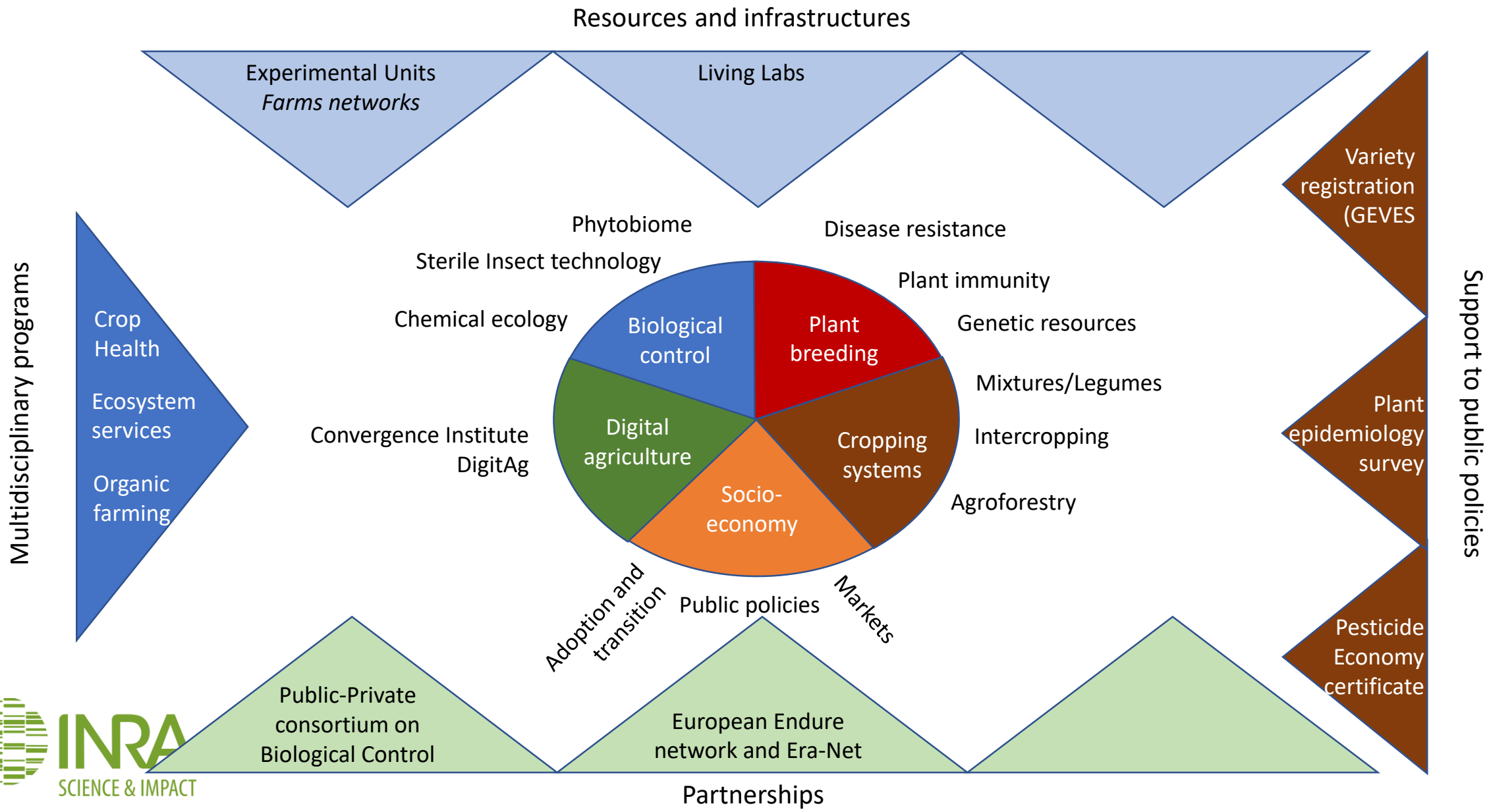
Global Inra strategy



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Conclusion

- A very long-term and challenging objective, meeting expectations of society
- It requires to thoroughly explore reconception
- Innovations are required in technology, organisation and policy
- New paradigms recently emerged offering totally new perspectives
- Much more research is needed
  - Covering a broad scope of the TRL scale
  - With more public-private partnership
  - With possibilities of open innovations
  - With holistic approaches, from production to food and human health

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Thank you!

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