1rst March 2022,
On line

Is a 2050 chemical pesticide-free world possible?

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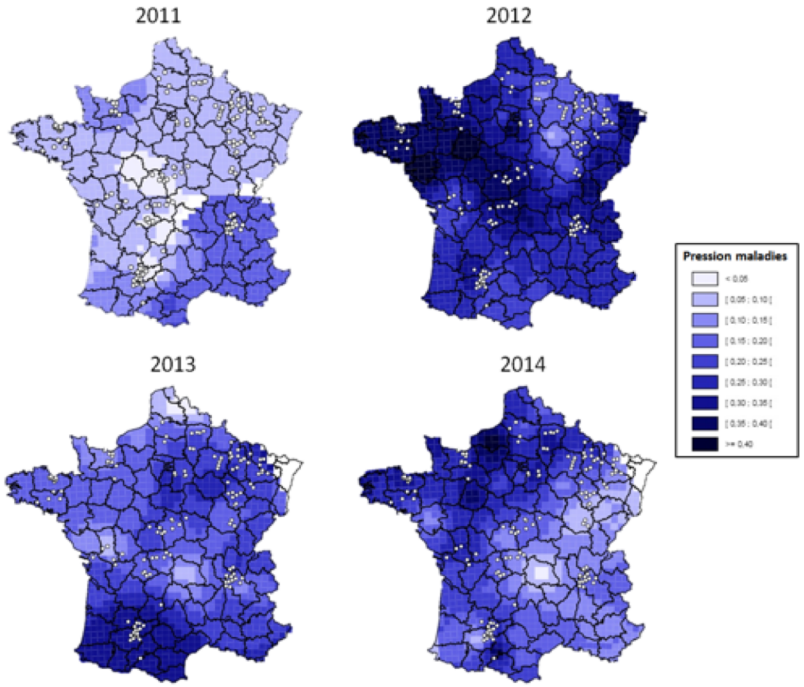
Crop protection is compulsory to ensure safe and affordable food to all



Yield losses due to foliar diseases in bread wheat in absence of any protection
Urruty et al, 2016

- In absence of protection, losses may be high, are variable among sites and years and not predictable
- Levers already exist (genetics, biocontrol) but are not sufficient for a 0-pesticide agriculture
- What are the possible knowledge and innovation breakthroughs, in the coming decades *(under the hypothesis of absence of limitations due to regulations and societal acceptance* ?

The knowledge and innovation breakthroughs in the coming decades

- Crop and practice diversification to maximize the ecosystem services

According to a synthesis of 98 meta-analyses, gathering 6160 original studies (Tamburini et al, 2020, Science Advances 6 : eaba1715): **Increasing diversity of practices and of crops massively increases environmental services while preserving production**

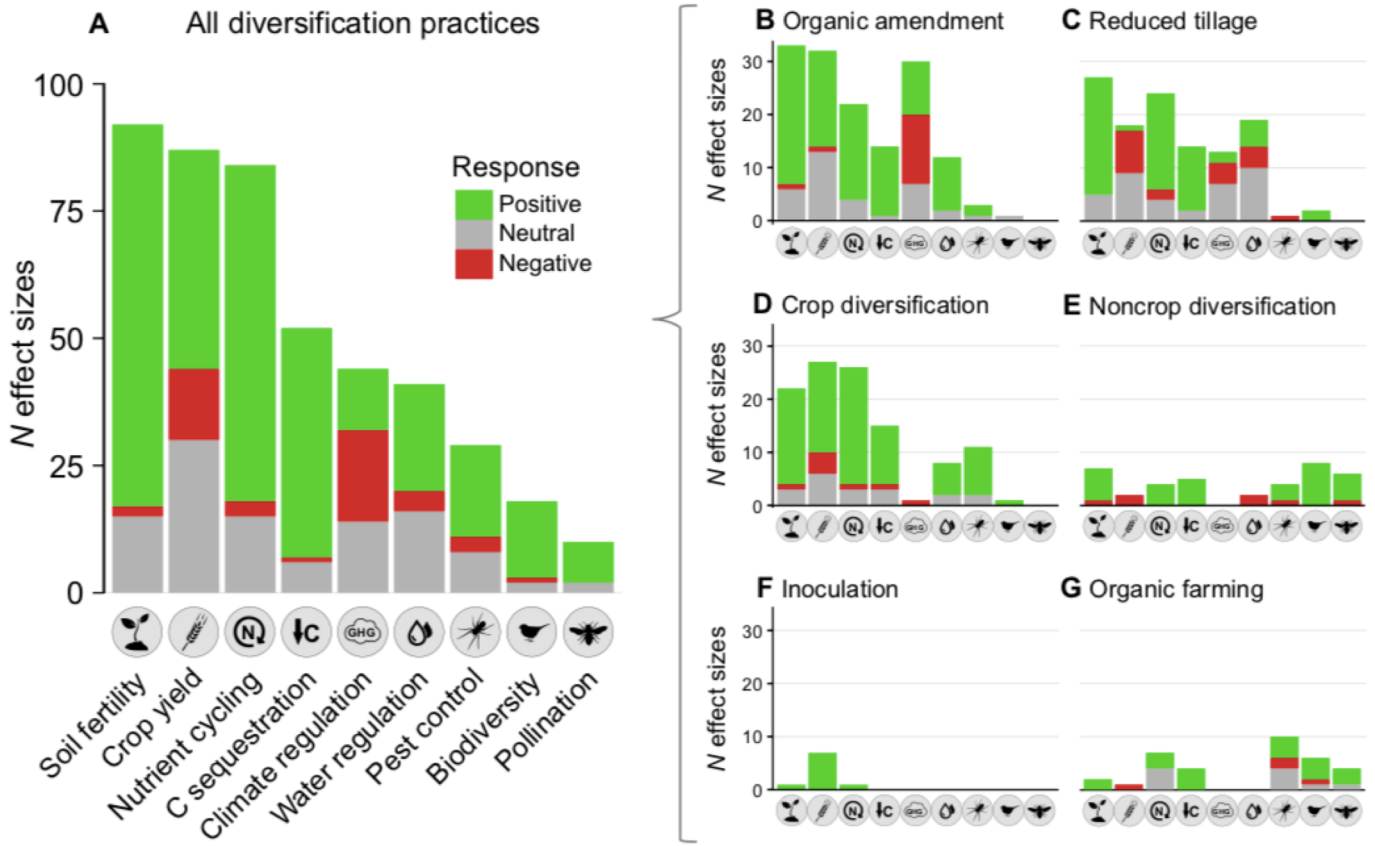


Fig. 1. Vote count reveals that agricultural diversification practices generally have a positive impact on biodiversity and ecosystem services. Number of reported effect sizes with a significant positive (green), negative (red), or neutral (gray) response to agricultural diversification, overall (**A**) and to each category of diversification practice separately (**B** to **G**). The systematic review comprises 456 effect sizes from 98 meta-analyses based on 6167 original studies (fig. S1). Diversification practice and ecosystem service categories were based on classifications following (*8*, *9*) and (*13*, *14*, *27*), respectively (tables S1 and S2).

In practice

New species and new swards to produce ecosytem services

- New species
  - Crops for new food and non food demands: meeting dietary transitions
  - Crops adapted to climate change
  - Cover crops and intercrops to preserve environment (e.g. soil conservation) and/or to produce renewable biomass (methane) : Towards multi-services intercrops
  - Living mulchs

- New cropping systems
  - Growing mixtures of species, with different functional traits

  - Relay-cropping (crop n+1 sown long before the harvest of crop n (LER >>1). *Here soybean sown in winter wheat*

The knowledge and innovation breakthroughs in the coming decades

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics

- Drilling multi-species swards

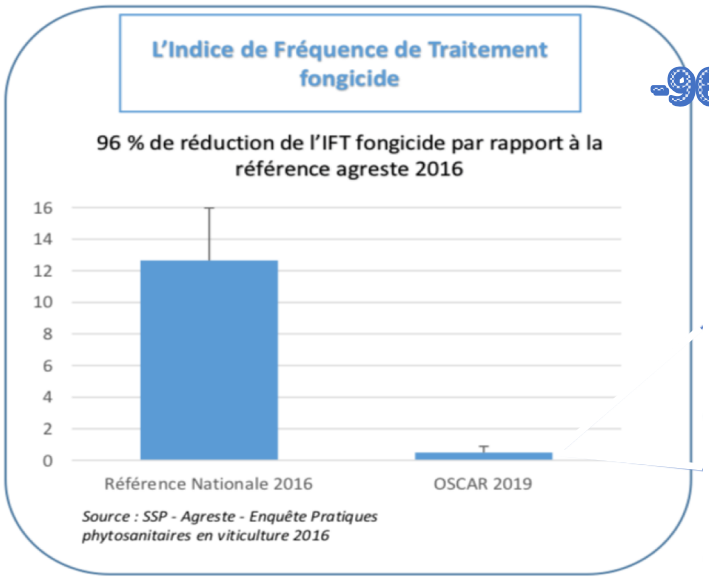
- Leading to reconception of agronomic practices

- Efficient alternative for weed control

The knowledge and innovation breakthroughs in the coming decades

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties

Oustanding successes already exist such as in grape, with resistance to downy and powdery mildews



-96% FTI in farm conditions !

How to make this true **for all species**?

- Genetic resources
- High throughput phenotyping infrastructures
- Breeding technologies
  - *Genomic selection (that requires full length sequences)*
  - *New Breeding technologies and genome editing*

The knowledge and innovation breakthroughs in the coming decades

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology

- Insect behavior is highly driven by odors in the environment: presence of volatile organic compounds
  - Sexual confusion (pheromons)
  - Detection of host plants
    - Tagetes and protection against flies (in gardens)
    - Mixtures of rapeseed and annual forage legumes to control cabbage-stem flea beetle *Psylliodes chrysocephalus*
  - Attracting predators against aphids/pests (Verheggen et al, 2020)

- Emergence of the concept of odorscape
  - For screening substances or plant species
  - For setting new survey systems (trapping odors of pests)

The knowledge and innovation breakthroughs in the coming decades

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- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology
- Microbiota, including endophytes: a key role for plant protection and plant nutrition

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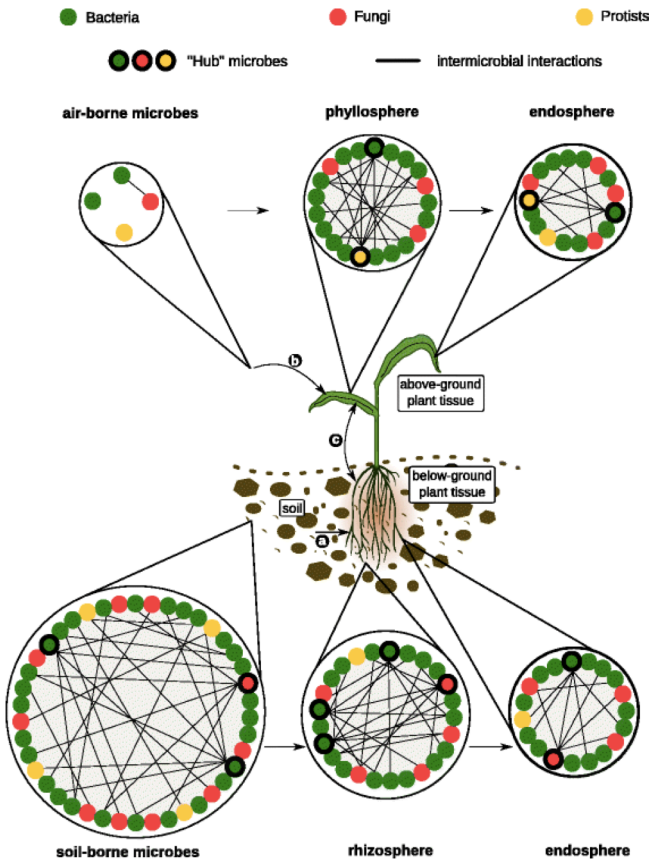
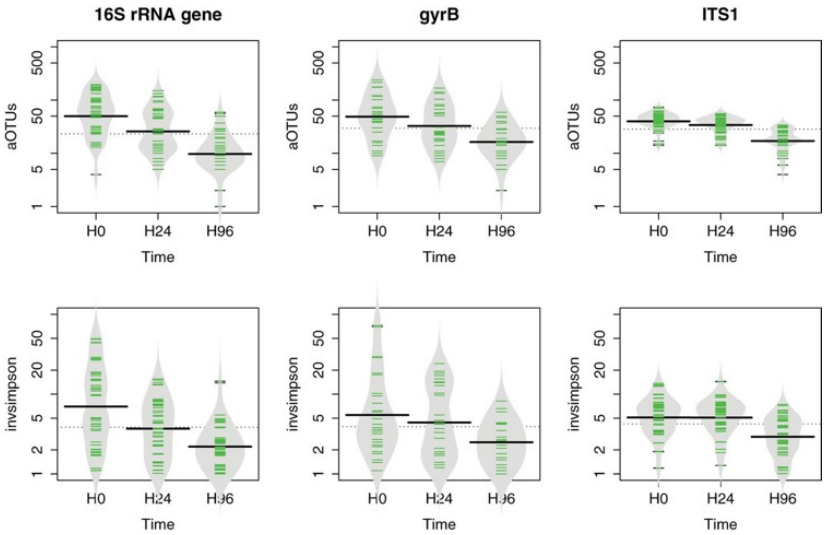


Hassani et al, 2018, Microbiome 6, Art 58

Complexity of microbial networks in the various plant compartments.



Matthieu Barret et al. Appl. Environ. Microbiol. 2015

Horizontal transmission through seeds and screening during seedling emergence

Challenges

- Screening plant microbiota and understanding the functions
- Defining complex and stable microbiota communities
- Applying them to seeds and fields
- *Adapting the regulations*

The knowledge and innovation breakthroughs in the coming decades

- Crop and practice diversification to maximize the ecosystem services
- Digital, machinery and robotics
- Varieties
- Odorscape and chemical ecology
- Microbiota, including endophytes: a key role for plant protection and plant nutrition
- In social sciences, unlocking the sociotechnic systems

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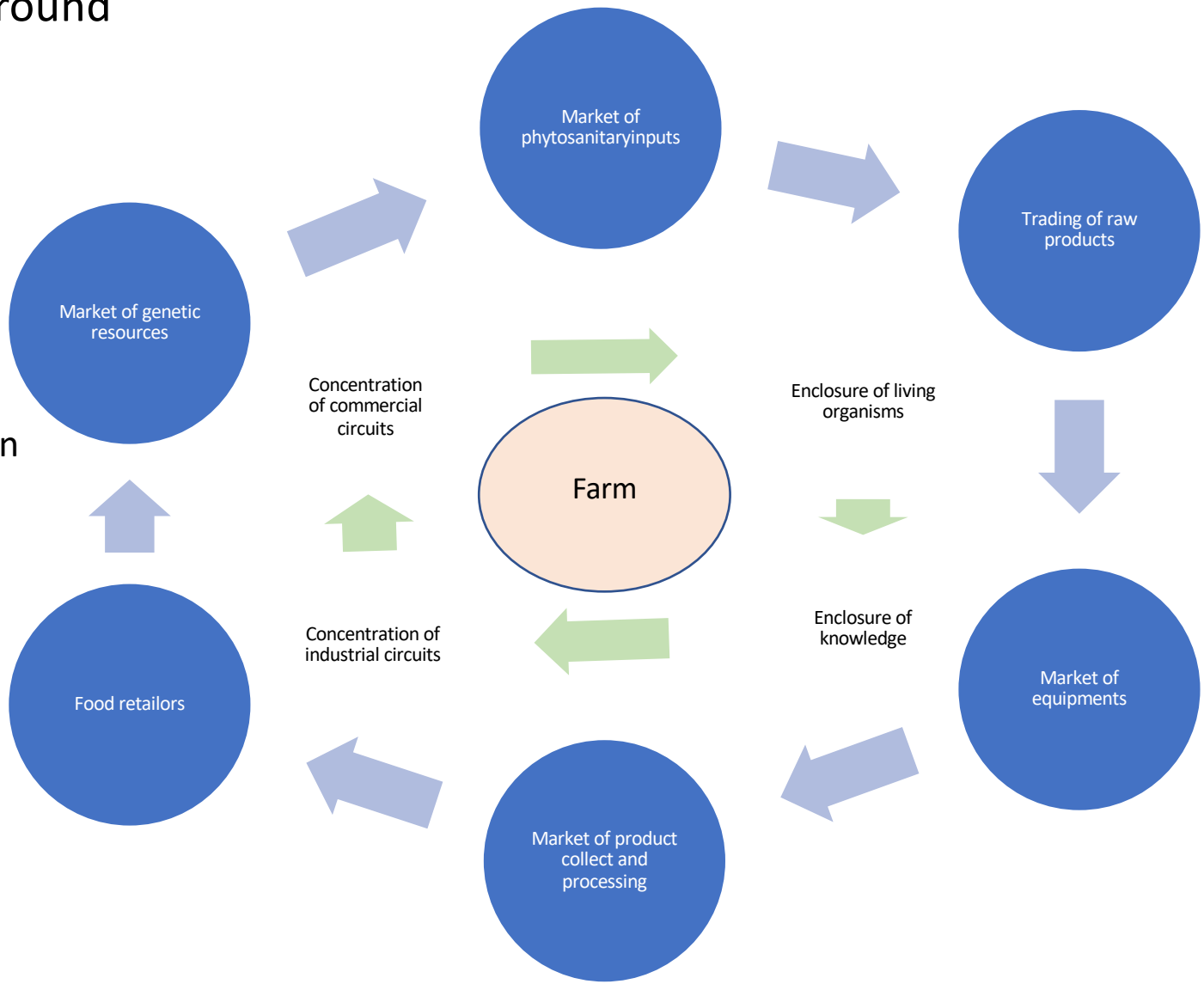
Strong socio-technic lock-in around farms (Geels, 2002)

Adapted from Valiorgue B (2020)

Two major issues to foster transition

- The enclosure patterns
- The weight of specific investments




Thank you for your attention …