European Chemical Pesticide-Free Agriculture in 2050

Olivier Mora, Chantal Le Mouël, Claire Meunier, Jean-Louis Drouet

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with the contribution of Chantal Le Mouël (INRAE SMART), Claire Meunier (INRAE DEPE), Jean-Louis Drouet (INRAE ECOSYS/DEPE)

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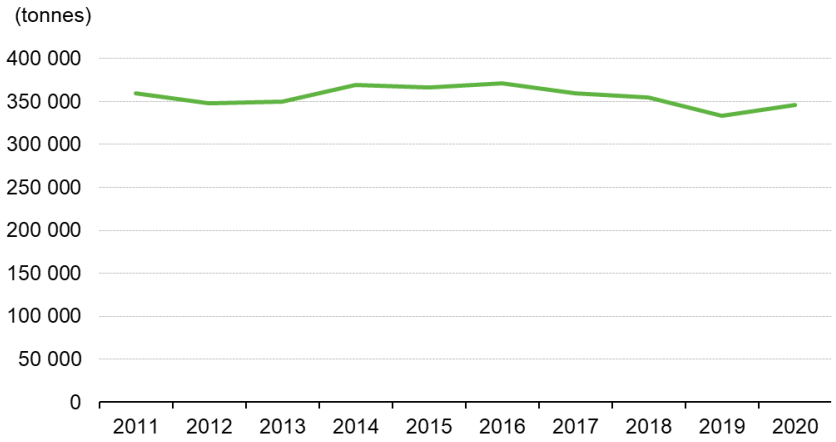
Crop protection futures in agriculture
Uppsala 24 May 2023

Why a foresight on European chemical pesticide-free agriculture in 2050?

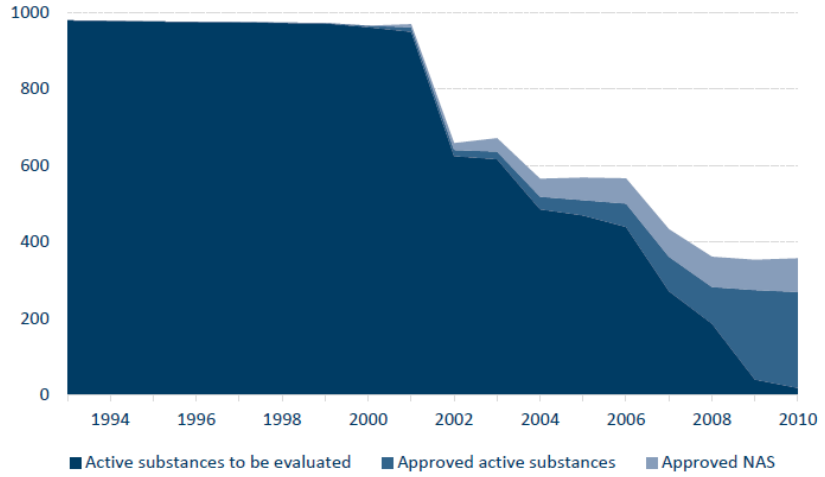
- Chemical pesticides are key elements of crop protection: improving and stabilising yields and the quality of agricultural products. Conventional cropping systems strongly depend on chemical pesticides.
- Increasing genetic **resistance** observed in species targeted by pesticides (herbicides, insecticides, fungicides, bactericides) (Aubertot et al., 2005; Ravigné et al., 2021) leading to an « **arms race** ».
- Negative impact of chemical pesticides on:
  - **environment** (water, soil, air; biodiversity) (Leenhart et al., 2022; Rigal et al., 2023; Pisa et al., 2021; Sanchez-Bayo et Wyckhuys, 2019; Hallmann et al., 2017)
  - and **human health** (EAA, 2023; HBM4EU, 2022; Teysseire et al., 2021; Inserm, 2021; Mostafalou and Abdollahi 2013)

Limited impacts of pesticide reduction policies in the EU (2011-2020)



Note: The EU data do not take into account confidential values. They represent < 1 % of the total sales over the entire time series. *Source:* Eurostat (online data code: aei_fm_salpest09)

Decrease in the number of available active substances in the EU (1993-2010)



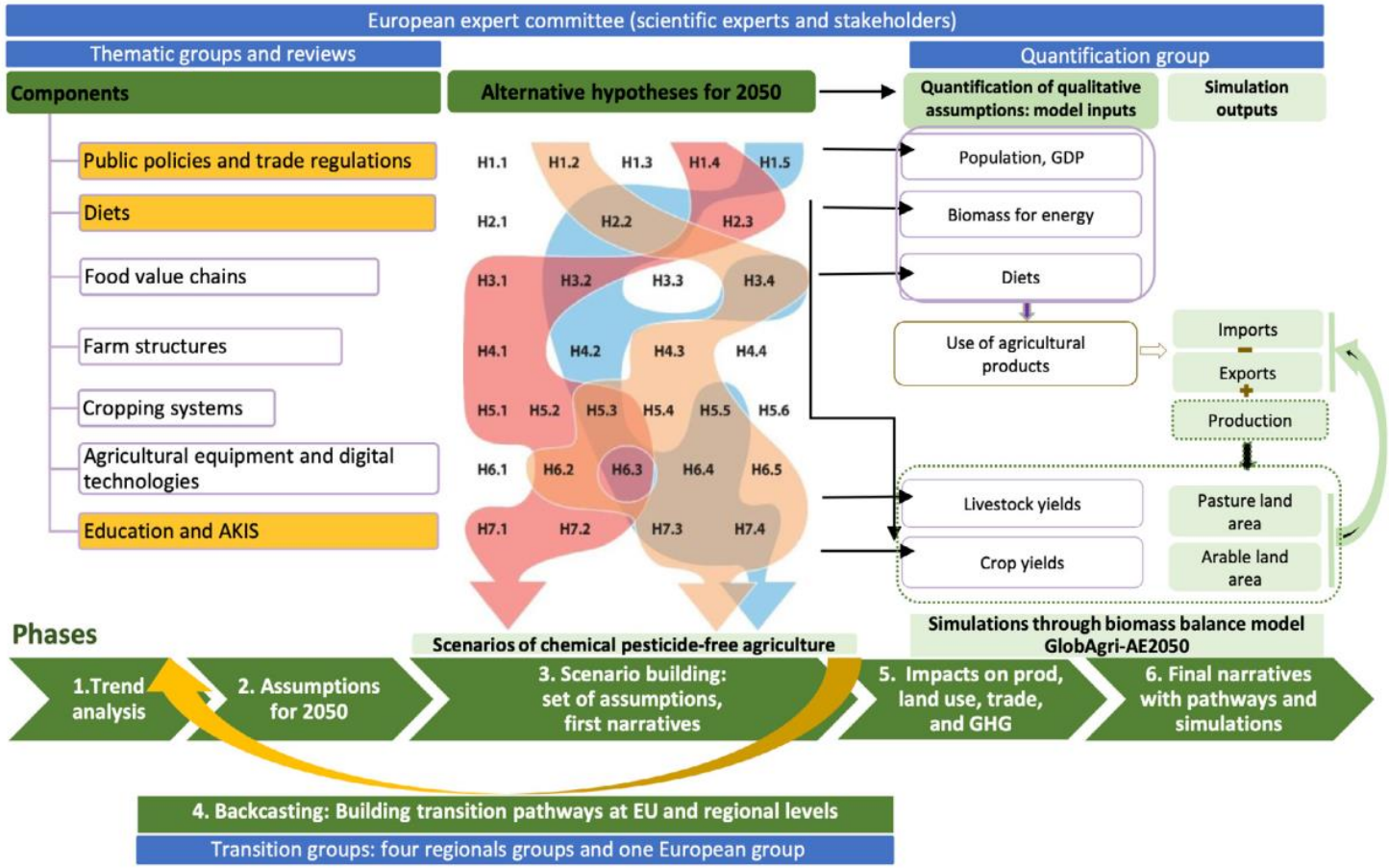
Source: European Commission

Why a foresight on European chemical pesticide-free agriculture in 2050?

- Targets of European public policies that are part of the Green Deal (F2F): **- 50% in the use and risk of chemical pesticides** and more hazardous pesticides by 2030
- Limited impacts of past policies in terms of pesticide use justify a change in the approach of innovation in cropping systems (Jacquet et al., 2021): A **paradigm shift** in research from an **incremental approach** aiming at reducing pesticide use to a **disruption approach** aiming at building cropping systems without chemical pesticides
- A foresight study to **explore the possibility of chemical pesticide-free agriculture in 2050 at EU level** and build transition pathways
- Supported by the French national priority research programme (PRP) 'Growing and Protecting crops Differently', and linked (through case studies) to the European Research Alliance 'Towards Chemical Pesticide-free Agriculture'. Presented during a one day conference the 21 March in Paris (https://www.inrae.fr/en/news/european-pesticide-free-agriculture-2050)

- *Chemical pesticides correspond to synthetic pesticides and mineral pesticides that have a negative impact on environment and human health.*

An original foresight method mixing scenario planning, modelling and backcasting



- 2 years project
- A dedicated project team
- 144 European experts mobilised in a European expert committee and thematic experts groups

Three results:

- **Three scenarios and their transition pathways**
- **A quantitative assessment of the impacts of the scenarios**
- **Four case studies in 4 EU regions (Finland, France, Italy, Romania)**

Building disruptive strategies of chemical pesticide-free crop protection in 2050

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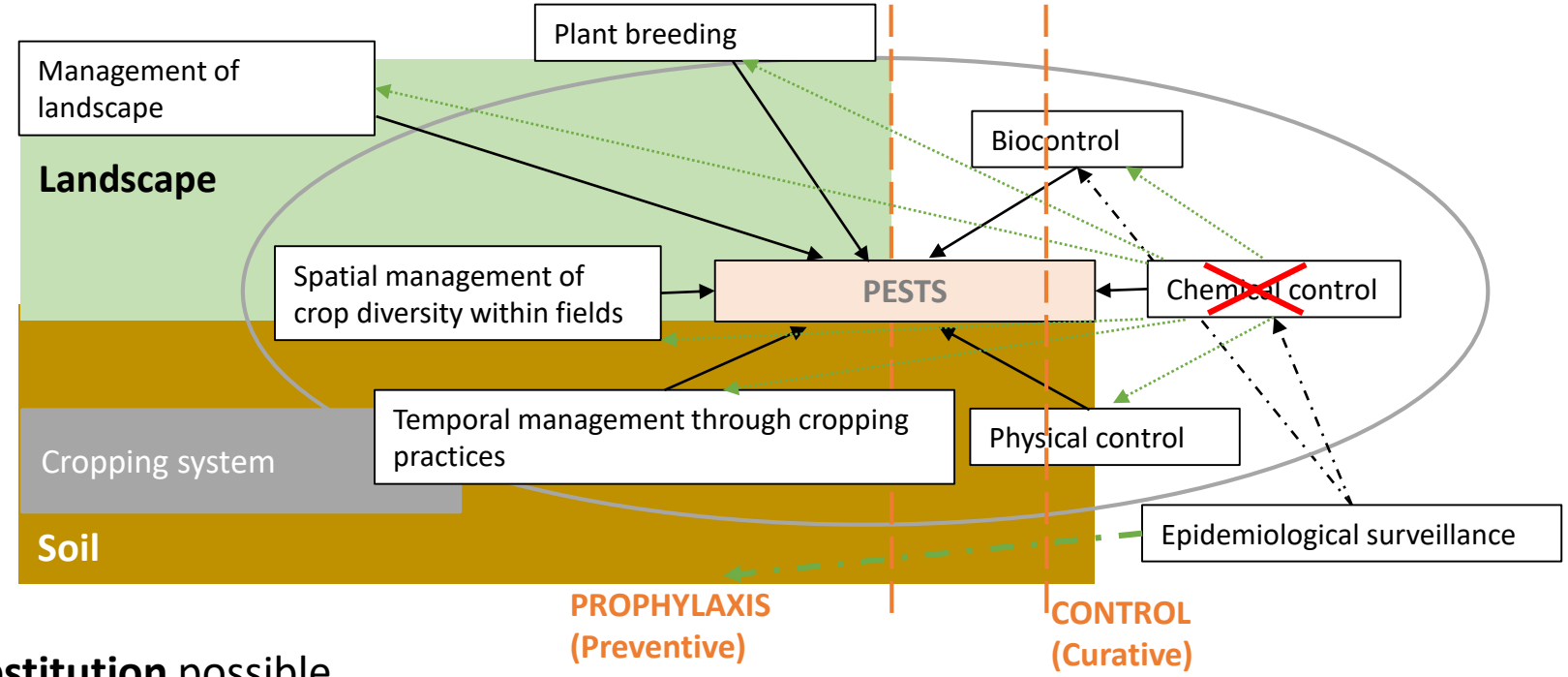
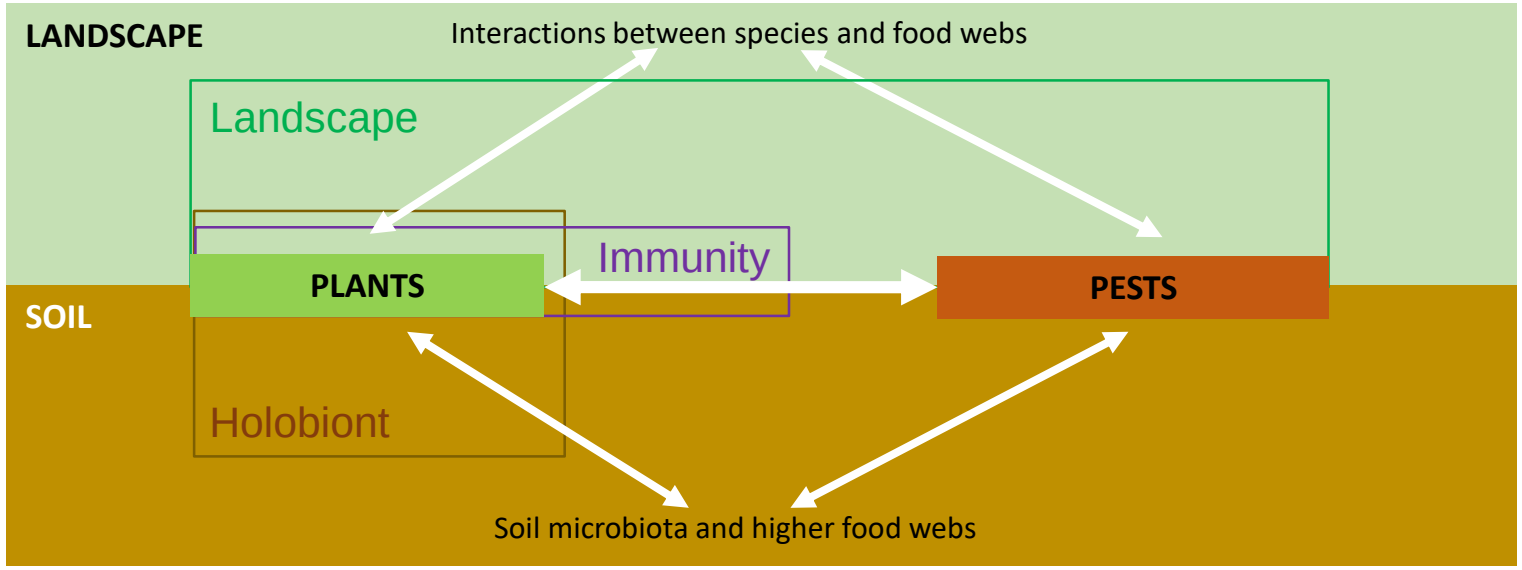
What strategies for chemical pesticide-free crop protection in 2050?



1. **No simple substitution** possible
2. A need for a **redesign** of cropping systems
3. A shift from a **curative** strategy against pests to a **preventive** strategy (anticipation of pests)
4. Developing tools for **monitoring pests** and the environment
5. Reinforcing **biological regulation** in **soil** and **landscape**
   - mobilising **agroecological** principles,
   - including temporal and spatial **diversification**

Three disruptive strategies of chemical pesticide-free crop protection in 2050



Cropping systems	Strengthening the **immunity** of cultivated plants	Managing the crop **holobiont** by strengthening **host microbiota interaction**	Designing **complex and diversified landscapes** adapted to local contexts and their evolution

By using plant defence stimulators, biostimulants, biocontrol (Zhang et al., 2020), plant breeding (resistant varieties), by reinforcing interactions with microbiota, other crops and plant services

By developing microbial biodiversity, in order to strengthen the adaptability of the holobiont and the functions of microbiota (Tosi et al., 2020; Simon *et al.*, 2019), by modulating the existing microbiome through agricultural practices, crop choice, inoculations of microorganisms (Berg et al, 2021) and plant breeding (Wallenstein, 2017)

By promoting biological regulations by increasing biodiversity and agrobiodiversity over space and time, building complex landscapes with 20% of the land with semi-natural habitats (Garibaldi et al., 2021; Tscharntke et al., 2021), a changeable mosaic of diversified crops (Alignier at al, 2020; Sirami et al, 2020), and crop diversification at plot level (Tibi et al., 2022; Thomine et al., 2022), and through plant breeding

Three scenarios of European chemical pesticide-free agriculture in 2050

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Scenario 1 (S1) : Global and European food chains based on digital technologies and plant immunity for a pesticide-free food market

Food value chain	Global value chains producing pesti-cide-free food as a food safety standard	Local, European and global value chains producing healthy foods for a healthy diet	Territorial and regional value chains for food preserving human and environmental health and contributing to diversified landscape
Farm structures	Specialisation and financialisation of farm structures with residual family farms	Regional diversity of farm structures	Territorialisation and diversification of farm structures
Cropping systems	Strenghtening the immunity of cultivated plants	Managing the crop holobiont by strengthening host microbiota interactions	Designing complex and diversified landscapes adapted to local contexts ond their evolution
Agricultural equipment and digital technologies	Autonomous robots to act on each plant	Pooling of equipment, sensors and data (landscape and organisation scale)	Modularity of equipment for adaptation to practices

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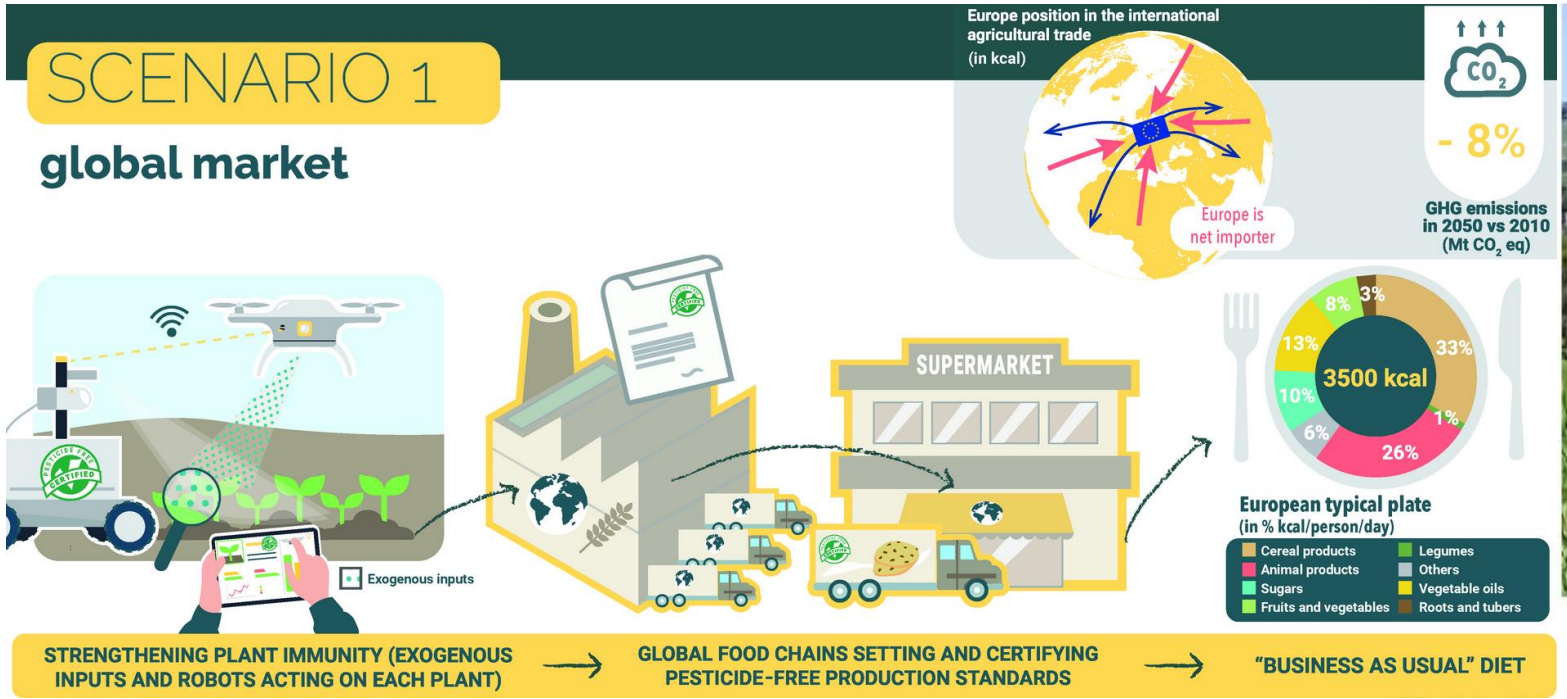

Durum wheat production in Toscany (Italy) in 2050

- Global food chains
- Private certifications and international standards for pesticide-free production
- Specialisation and financiarisation of farm structures
- Tools for monitoring pests and individual plant health in the plot
- Robots acting on each plant
- Reinforcing plant immunity through biocontrol and plant defence stimulators
- BAU Diets

Scenario 2 (S2) : European food chains based on plant holobiont, soil and food microbiomes for healthy foods and diets

Food value chain	Global value chains producing pesti-cide-free food as a food safety standard	Local, European and global value chains producing healthy foods for a healthy diet	Territorial and regional value chains for food preserving human and environmental health and contributing to diversified landscape
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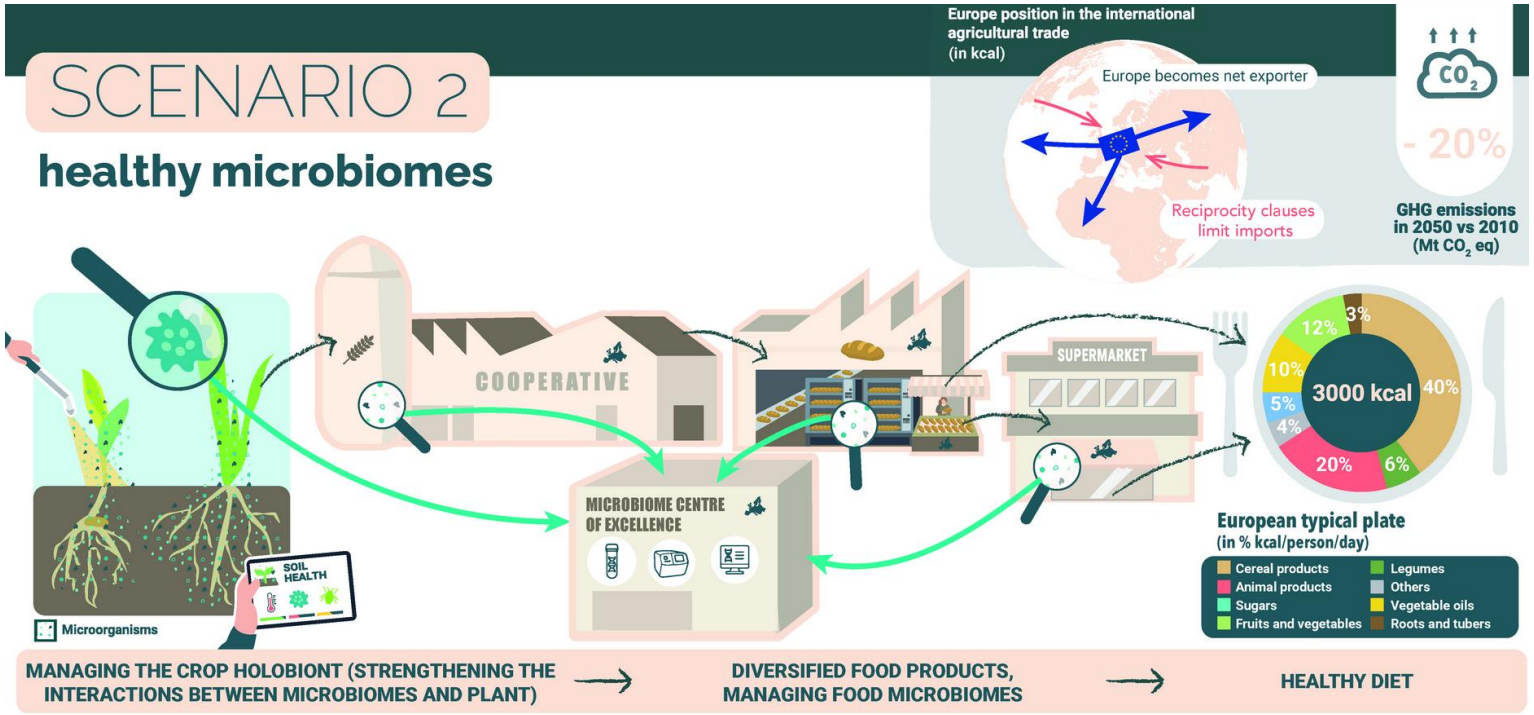

Vegetable production in South-East Romania in 2050

- Consumer demand for healthy foods
- European value chains without chemical pesticides
- Impact on the whole food system
- Monitoring of microbiomes: soil, plant, food storage and processing, and final food product
- Crop diversification to respond to the target of healthy diets
- Reinforcing interactions between host plants and microorganisms (management of the holobiont) for crop protection
- Transition to healthy diet, more diversified diets: less calories, less animal products and sugar, more fruits and vegetable, more pulses, diversified cereals

Scenario 3 (S3) : Complex and diversified landscapes and regional food chains for a One Health European food system

Food value chain	Global value chains producing pesti-cide-free food as a food safety standard	Local, European and global value chains producing healthy foods for a healthy diet	Territorial and regional value chains for food preserving human and environmental health and contributing to diversified landscape
Farm structures	Specialisation and financialisation of farm structures with residual family farms	Regional diversity of farm structures	Territorialisation and diversification of farm structures
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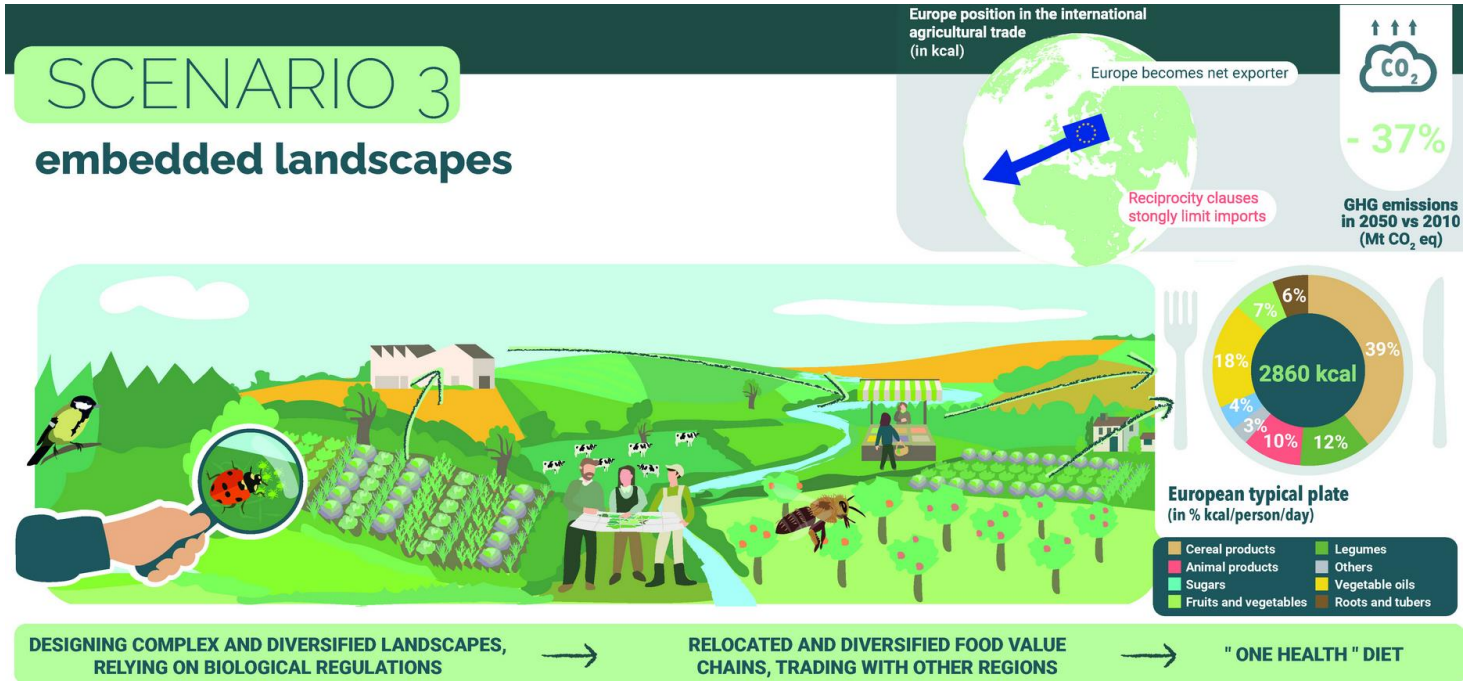
Scenario 3 (S3) : Complex and diversified landscapes and regional food chains for a One Health European food system

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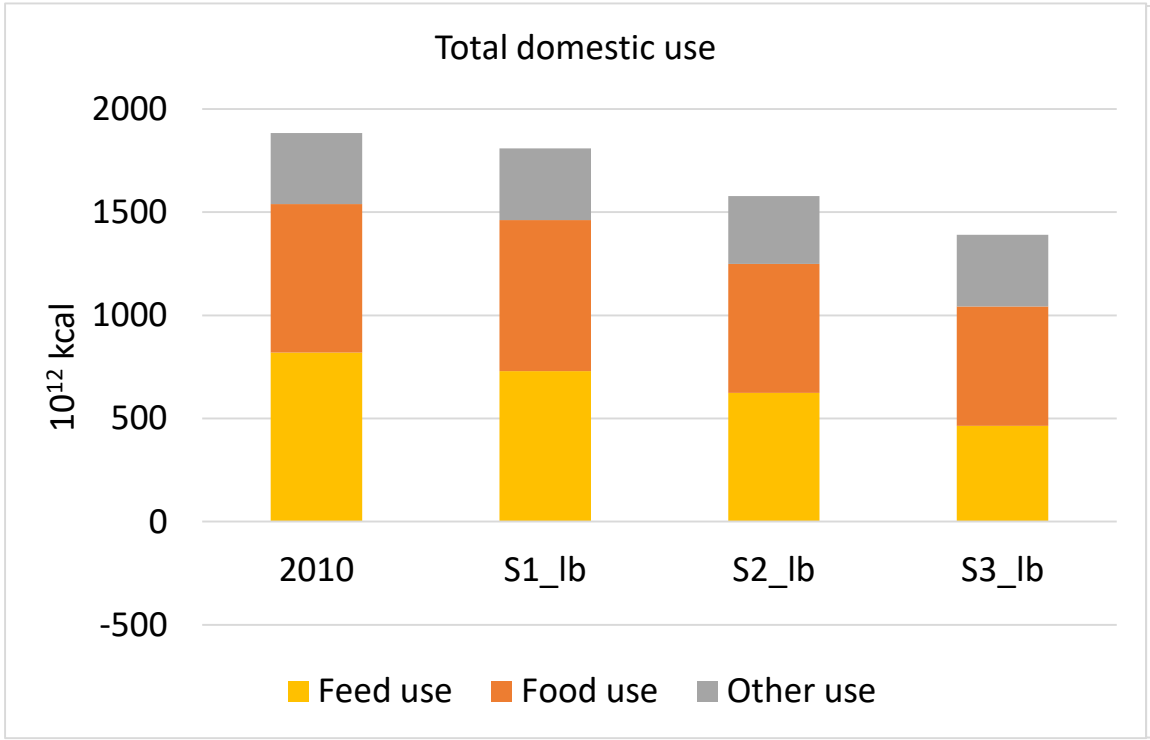
Cereals and oilseeds production in South Finland in 2050

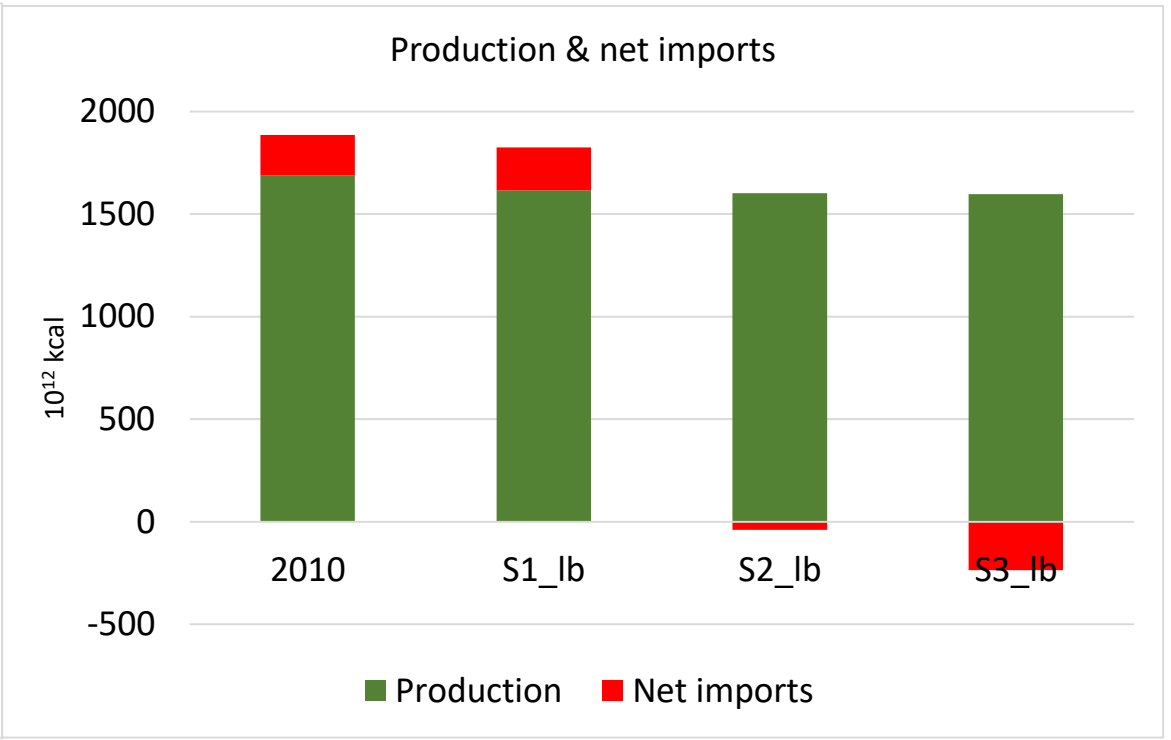

© IVBD

Wine production in Bergerac-Duras (France) in 2050

- Territorial and regional food value chains
- Food protecting human health and environment (One Health)
- UE transition towards One Health approach
- Territorial coordination to reinforce biological regulation (landscape) and relocate value chains
- Complex landscapes with 20% of land dedicated to semi-natural habitats
- Adaptation of the mosaic of crops to the issues of crop protection, temporal diversification of crops
- Monitoring of the environment and anticipation of pests
- Transition to healthy and sustainable diets: less calories, less animal food and more pulses, less sugar

How does the 3 scenarios impact domestic use, production and net imports in Europe?





Resource-use balance in "2010" and in 2050 in S1, S2 and S3 (10^{12} kcal)

→ Two scenarios have a positive impact on the European agricultural trade balance in calories

Knowledge and technologies needs to support the disruptive strategies in crop protection by 2050

Strengthening the immunity of cultivated plants (S1)

- Existing knowledge on molecular mechanisms of action and on partial resistance to pests (plant defence stimulators, service plants, or flash UV-C)
- Knowledge needs to cover the **interactions between the various levers to stimulate plant immunity**, identify **plant immunity markers**, and **map resistance genes** to the main pests

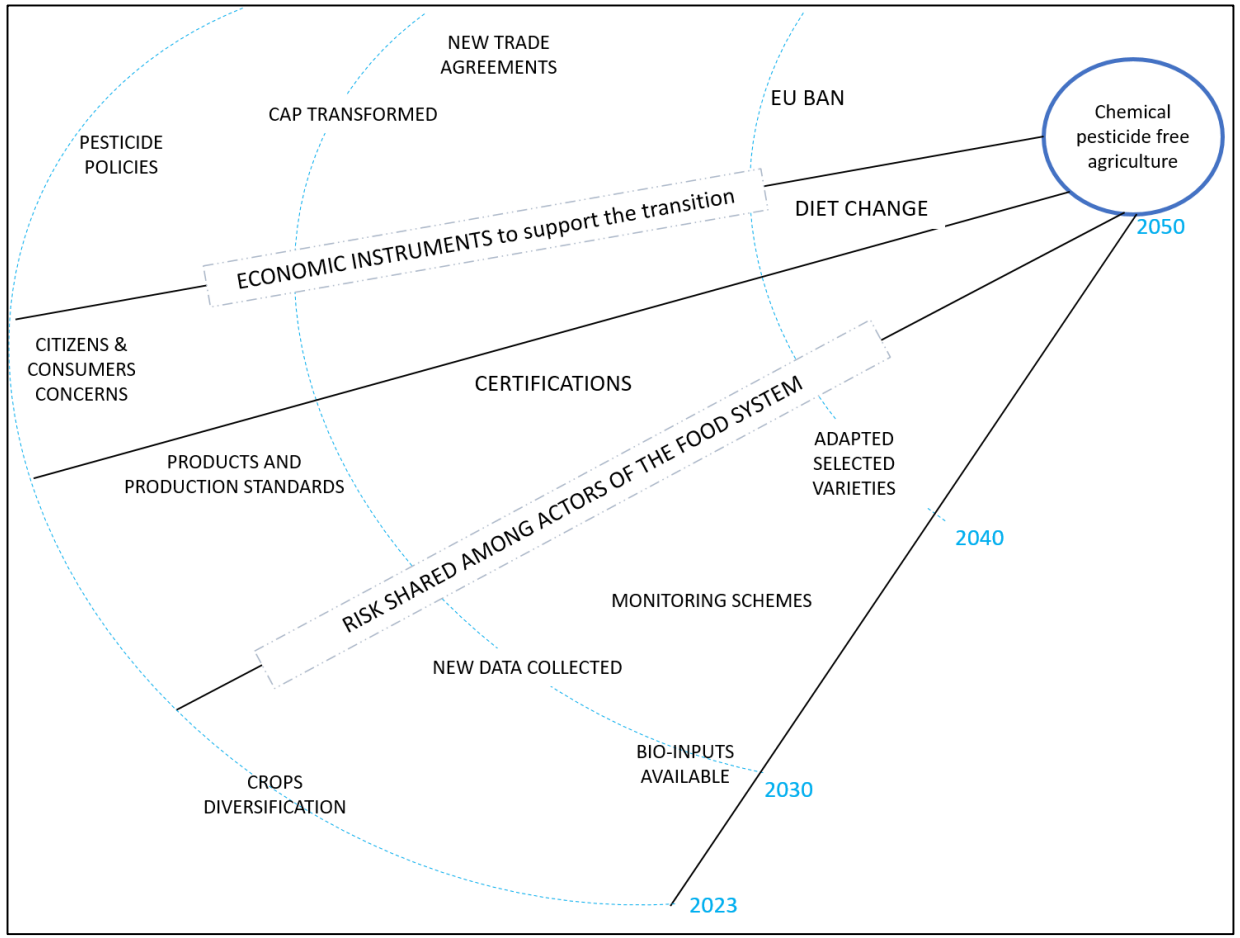
Managing the crop holobiont by strengthening host microbiota interaction (S2)

- Existing knowledge on mycorrhization, and tools for assessment of the genetic diversity and the detection of microorganism
- Knowledge needs to understand better the **link between a specific microbial community structure and its functional traits**, identify the **microbial communities** that are important for the different crops and their dynamics, and determine the ways to **modulate the soil microorganisms**

Designing complex and diversified landscapes adapted to local contexts and their evolution (S3)

- Existing knowledge on the principles and mechanisms linked to crop diversification and landscape design
- Knowledge needs on **modelling tools** for anticipating the **quantitative impacts of crop diversification** and **semi-natural habitats** on biological regulations and the quantitative **impacts of pests on crops** as well as **working out solutions for perennial crops**

Is there a highway to support the transition towards European chemical pesticide-free agriculture by 2050?



Robust elements of a transition pathway towards pesticide-free agriculture

In all the scenarios, **strong and coordinated measures** are required for a successful transition:

- Key role of **consumers**, citizens and inhabitants in the transition. Concerns about impacts of chemical pesticides. Shift of their **dietary patterns** (S2 and S3).
- **Mix of public policies**: **regulatory policies** for reducing and ultimately banning chemical pesticides, **sectoral policies for supporting farmers transition** (a redesign of the **Common Agricultural Policy**), **environment policies**, **food and nutrition policies** to support transition to healthy diets (S2 and S3).
- New **trade agreements** with non-European partners in order to develop a pesticide-free European market.
- New production **standards**, enabling the **certification** of productions, and their valorisation through food **labels.**
- Mechanisms for **sharing the risks** among the different actors involved in the value chain through market contracts, or in the territory.
- Agricultural, knowledge and innovation systems for knowledge **creation and co-conception** with farmers, of pesticide-free cropping systems (inc. Living labs).

Key messages from the foresight study

- The entire food system, **committing all its actors**, must be considered to build a European chemical pesticide-free agriculture in 2050.
- In addition to the shift towards chemical pesticide-free agriculture: **Three scenarios** would contribute to **improving the greenhouse gas balance**, biodiversity and overall ecosystems health in Europe.
  Two scenarios would contribute to **improving food sovereignty** in Europe, human **nutrition and health**.
- Key role of **dietary changes** in the transition.
- The **diversification** of crops in time and space, the development of **biocontrol** products, bio-inputs, adapted **selected** varieties, agricultural **equipment** and digital tools, and **monitoring** schemes of pests dynamic and environment are key elements to be combined for **an efficient chemical pesticide-free crop protection**.
  Biological regulations at the soil, crop and landscape levels should be favoured, as **prophylactic** actions.
- Several chemical pesticide-free cropping systems are possible depending on whether they rely on a **high level of external inputs**, or on **a high level of diversification** and **ecosystem services**.
- The **resilience** of each scenario to climate change can be assessed through its robustness (linked to internal factors, e.g. diversification and ecosystem services) and adaptability (linked to external factors, e.g. external inputs).

Key messages from the foresight study

- For building efficient crop protection strategies without chemical pesticides, **knowledge** on biological processes, data and simulation tools are needed for conceiving **anticipatory tools** for pest management, for designing **landscapes**, and for understanding the soil **microbiome**, plant **holobiont** and plant **immunity** mechanisms.
- The transition towards chemical pesticide-free agriculture requires **a mix of coherent public policies** related to **pesticides use**, articulated with other policies such **as food policies**; it involves a transformation of the **Common Agricultural Policy** (CAP) and economic instruments to support the transition ; finally, **trade agreements** at the European Union's borders must be set up to ensure the development of chemical pesticide-free markets.
- The transition must also involve **risk sharing** among actors, **co-conception** of technologies and cropping systems, and transformations in the **upstream and downstream sectors** of agriculture.

The foresight study feeds an ongoing debate on the issue of pesticides

- A one-day conference with +1300 participants
- All deliverables available on INRAE website : https://www.inrae.fr/en/news/european-chemical-pesticide-free-agriculture-2050-results-groundbreaking-foresight-study

- Important media coverage and public debate

- Interest from scientists and stakeholders:
  - Research
  - Public policies
  - Stakeholders

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Le Monde, 22 March 2023

Agriculture
Des scénarios pour une Europe sans pesticides à l'horizon 2050

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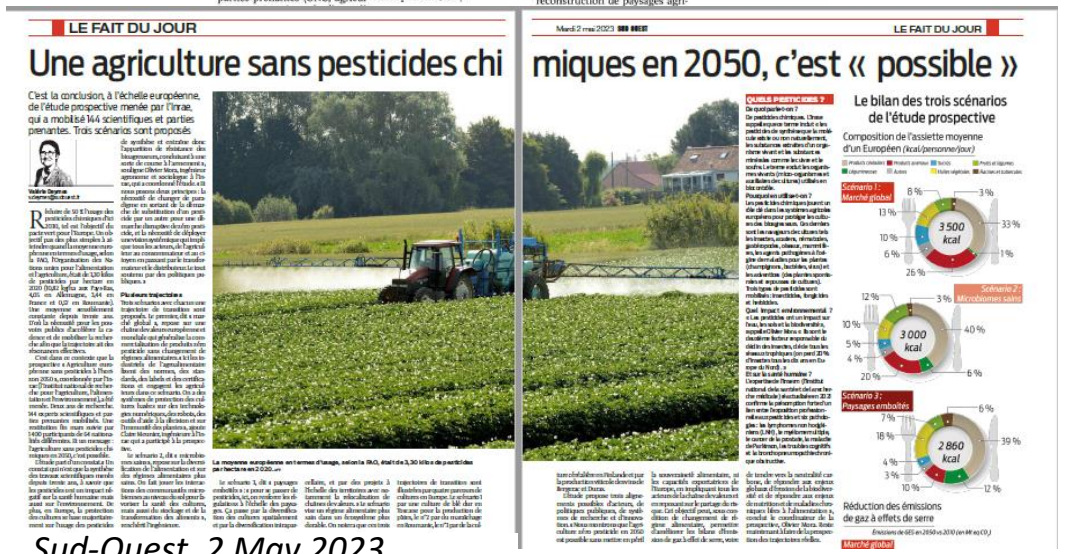
L'agriculture sans pesticides imaginée par l'Inrae

Les auteurs de l'étude estiment qu'il est possible de ne plus utiliser d'intrants chimiques d'ici à 2050



LE FAIT DU JOUR

Une agriculture sans pesticides chi

miques en 2050, c'est « possible »

Sud-Ouest, 2 May 2023

Thank for your attention

More information on the foresight (summaries, videos, report):

https://www.inrae.fr/en/news/european-pesticide-free-agriculture-2050

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