



# TOWARDS CHEMICAL PESTICIDE-FREE AGRICULTURE





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## STATE OF PLAY

● Chemical pesticides, here used synonymously for 'synthetic pesticides', intensively used in Europe and throughout the world against pests and diseases on cultivated plants and weeds in agriculture, are strongly suspected to severely affect the environment, biodiversity and non-target organisms including human health. Recent studies suggest that bird populations have decreased by up to 33% in the last 15 years and potential negative effects have been identified in various European agroecosystems. Agriculture has been criticised for its negative impacts on the environment, biodiversity and human health before, but the dimension and the focus on chemical pesticides are unique. Moving towards environment-friendly and healthy production systems is thus a strong demand by European citizens and a strong political commitment. However, quantity, quality, and price of agricultural goods produced by European plant production systems are currently heavily dependent on chemical control of pests and weeds (including all types of organisms as per EU directive 2009/128/EC).

Transition to an agriculture free from chemical pesticides is key for entering the agriculture of the second half of this century. It is also a huge challenge that prompts to a complete reassessment of production practices, with the least possible pesticide use and no critical residues in plants and foodstuff. The EU directive 2009/128/EC has defined the first reduction goals by calling for the reduction of risks and dependency on pesticides. Chemical pesticides are being progressively withdrawn from the stock of solutions and national policies are encouraging an acceleration of the process while ensuring a sustainable transition for farmers.

THIS SCIENTIFIC PRIORITY CONTRIBUTES TO ACHIEVE THE FOLLOWING SUSTAINABLE DEVELOPMENT GOALS:



## BOTTLENECKS TO OVERCOME



In the next decades, a thorough change of agriculture has to be implemented to reach future pesticide-free plant production systems. An holistic approach is required to (i) mobilize all possibilities of the ESR scheme (E for Efficiency, S for Substitution, R for Redesign; Hill and Mac Rae, 1995); (ii) explore and profit from new paradigms (agroecology, microbiome, exposome); (iii) combine a range of levers (locally adapted resistant varieties in combination with biological control, but also machinery, precision farming, and systems modelling and projections of impacts); and to (iv) foster upscaling and outscaling of new approaches (e.g., open innovation platforms, Living Labs).

The bottlenecks to overcome are of various natures:

- Agronomic, to understand the underpinning biological mechanisms and to set new production systems which should be conceived in an integrative way. Crop production is a system where the benefits of cultivation techniques, crop rotation, intercropping and spatial field arrangements are efficient tools to increase resilience and reduce damage due to pests, diseases and weeds.
- Economic, to reach a sustainable production for farmers associated with the end-users' willingness to pay adjusted prices for agricultural goods.
- Sociological, to solve transition and work reorganization challenges and overcome risk aversion.
- And political, to elaborate and enforce new and adapted regulations.

The first prerequisite to overcome these bottlenecks is comprehensive knowledge of the biology of plants and their pests and diseases, especially host–pathogen interactions, induced resistance and plant defence mechanisms, epidemiology and population dynamics of pests and the understanding of these in an ecosystem context.

The second prerequisite is to develop data acquisition on disease and pest pressure and their integration into real time modelling.

The third prerequisite, to ensure a proper transition, is to engage all relevant stakeholders in finding solutions, revisit and adapt education, training and advisory systems, including through digital tools. To boost transfer and facilitate adoption, results of basic research should be tested and applied in real farm conditions, for instance in Living Labs or networks of farms, to ensure their readiness for on-farm use.

## IMPACT



The main impacts of this ambitious initiative will be to foster the protection of the environment and biodiversity, and reverse their degradation and loss, respectively, and to mitigate the risks associated with chemical pesticides, by reducing the volumes used. This will be a consequence of the extensive development of fully functional agroecological systems across European rural landscapes.

In order to achieve independence from chemical pesticides in the next decades, a reduction should immediately be prepared, benefiting from a production using both organic farming and high environmental value production systems. This progressive reduction should be based on major innovations and breakthroughs while maintaining the economic balance of farms and preventing dramatic economic losses. Reduction and replacement of chemical pesticides should first be initiated focussing on “candidates for substitution”, namely chemical pesticides with higher risks to human and environment. Faster authorization processes for biocontrol agents and substances of low concern such as microorganisms and plant extracts will be needed.

A fully ambitious objective of reduction in pesticide use must be immediately set in order to restore biodiversity and reduce risks for the environment and human health. After starting immediately with risk mitigation in chemical plant protection, a determined step-wise reduction of the use of chemical pesticides needs to follow.



## EUROPEAN RESEARCH AMBITIONS

- Strong European professional and political dynamics exist on this issue. Major plans have been set up for fundamental and applied research across Europe which are clearly leading the concept of re-inventing European plant production systems to reach pesticide-free agriculture.

Large European projects have been conducted on plant protection and reduction of pesticide uses, such as FP6 Endure © (Diversifying Crop Protection) network. EraNet C-IPM was a very active network to produce and disseminate knowledge on integrated pest management over a wide range of agricultural productions.

In France, long-term experimental designs and farm surveys have been set up by Ecophyto national plans, leading to unique resources for research. Strong research networks have also been established on biological control, including a public-private partnership. A national interdisciplinary program has been implemented within INRA on crop health management and reduction of pesticides is included in all calls for proposals dedicated to applied research. In the research activities in support to public policies, many expertise reports have been produced to document the steps towards reduction of pesticide use and impacts.

In Germany, strong research networks have also been initiated on integrated pest management and on the reduction of pesticides. On the other hand, integrated pest management and reduction of chemical pesticides are not yet the main objectives of the national research funding in agriculture.

Both Germany and France wish to work together with other European partners to build an ambitious and large program towards an agriculture without chemical pesticides.

## ACTIONS TO BE UNDERTAKEN

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- Changes in the production systems must be implemented going beyond integrated pest management systems. Apart from agronomy and plant breeding, this must especially include changes in crop rotations (crop diversification leading to more functional diversity, and possibly higher resilience), the use of cover crops (intermediate crops, companion species, living mulches) and mixed crops.
- It is necessary to enable a secure use of biocontrol through:
  - Dedicated research on biocontrol options (micro- and macro-organisms, chemical ecology and insect sexual confusion, sterile insect technology...)
  - A combination of varieties with resistance against pests and diseases with biocontrol options, possibly provided through seed coating and biotisation of rootstock
  - Fundamental research on the plant microbiome and on plant immunity (see below).
- New farm equipment and development of precision farming will be necessary to introduce the new cropping systems (crop mixtures and living mulches), for weeding (e.g., weeding robots), and for coping with local heterogeneity.
- Coordinated long-term surveys are necessary as most databases are fragmented and poorly connected. This should include:
  - Farm surveys where all components are documented (practices, production, pest pressure, damage, local biodiversity, etc.)
  - (Eco)epidemiology of indicator species
  - Biodiversity with a special focus on insects and birds
  - Occurrence of pesticide residues in key environmental compartments.
- More fundamental research must be implemented to document:
  - The supporting pillars for future chemical pesticide-free production systems. This should include:
    - . Phytobiome (the microbiome surrounding the plant communities). It must be further described in order to understand how it is selected and organized, and its impacts on plant health and ecological functions supporting ecosystem services

. Plant immunity. Beyond resistance or tolerance against pests and diseases, there is increasing evidence of plant immunity mechanisms that must be described and understood with the objective of using them for the benefit of crops

. Soil weed seed bank (i.e., the natural storage of seeds in the soil of a given ecosystem), its structure, dynamics and fate.

. Population dynamics to suppress weeds through spatial and temporal plant and crop arrangements.

- The relationship between pesticides and human health. The concept of exposome (the whole exposure of humans to exogenous compounds, including pesticides, and the incidence of diet quality) is to be further deepened in connection with longitudinal surveys of individuals (cohort surveys of farmers and consumers).

- The impact (including direct and indirect effects) of current practices and proposed alternatives on biodiversity at various scales, from fields to landscape and rural areas.

- Research must be dedicated to sociological and economic issues to facilitate transition towards these systems through adapted public policies (PES), new policy tools such as expert tools and revisited advisory systems and new advisory approaches. Special attention should be paid to the competitiveness and health value of goods produced from a chemical pesticide-free agriculture. Indeed, from an economic point of view, imported goods produced under conventional conditions are likely to be more attractive for industry and consumers and it can be expected that goods produced by a chemical pesticide-free agriculture will be in strong competition with conventionally produced goods.
- Assessment procedures to understand and demonstrate the beneficial environmental and economic values of pesticide-free produced goods including the interactions between all relevant ecosystem services. Understanding of the integration of a pesticide-free agriculture within global trade flows determining imports and exports of agricultural goods.
- New research infrastructures have to be established to document all issues, including participatory research in new dedicated places such as Living Labs.
- Dissemination of innovations, through adapted changes in education, demonstration farms, training and advisory systems, relying massively on digital tools such as open-innovation platforms. This should include long-term experiments and farm surveys to assess the risks and to demonstrate the benefits to farmers.
- Public policies and regulations have to be tuned, including through:
  - Accelerating the authorization process for biocontrol tools and for substances of low concern.
  - Accelerating the replacement of the so-called “candidates for substitution”.
  - Defining and implementing a strategy on how to deal with imported goods that were produced under conventional conditions.
  - Adopting a clear, legally binding, and well-communicated decision on whether new breeding technologies such as genome editing can be integrated into national and EU-wide breeding programmes. More generally, this should be applied to all new technologies, for instance sterile insects, that would significantly contribute to a pesticide-free agriculture.
  - Assessment and valorisation of ecosystem services delivered by agriculture, e.g., by amending payment schemes in the CAP.
  - Development of procedures to develop, test and implement effective pest and weed control mechanisms for plant production systems in agricultural practice (e.g., suitable crop rotation or use of biocontrol options) to ensure the dissemination and success of a chemical pesticide-free agriculture.



## RELEVANT HORIZON 2020 PROJECTS



Agricultural Knowledge: Linking farmers, advisors and researchers  
to boost innovation



ERA-NET Cofund on Sustainable Crop Production



Diversification through Rotation, Intercropping, Multiple cropping,  
Promoted with Actors and value-Chains Towards Sustainability



emphasisproject

Effective Management of Pests  
and Harmful Alien Species - Integrated Solutions

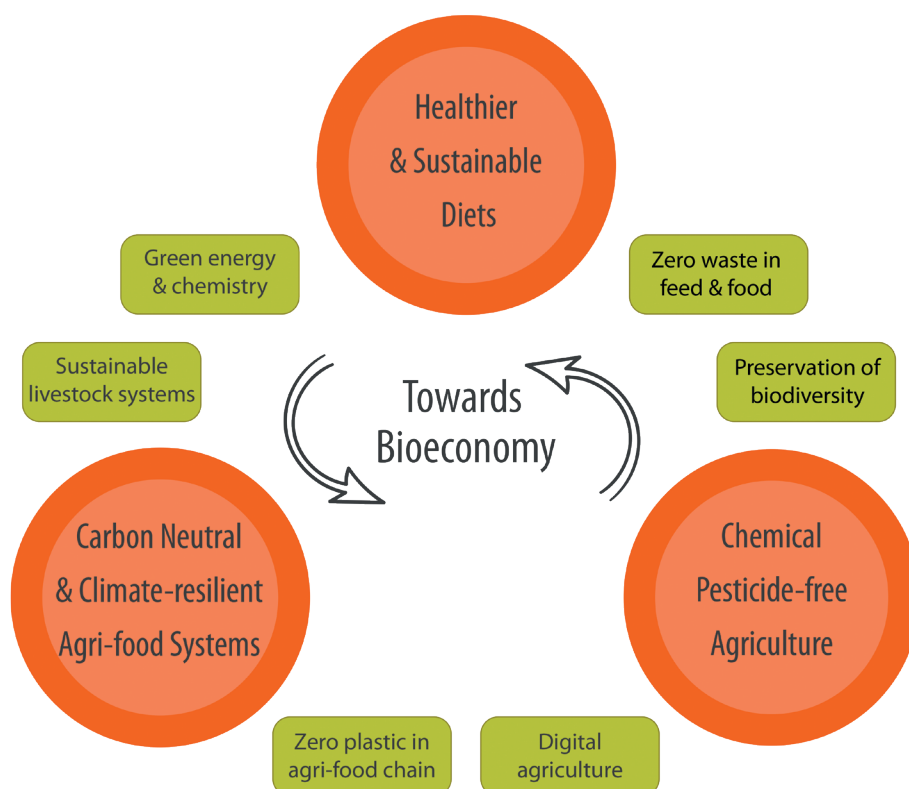


Pest Organisms Threatening Europe



Breeding Invertebrates  
for Next Generation BioControl (BINGO)

# TRANSFORMING AGRI-FOOD SYSTEMS: RESEARCH AND INNOVATION PRIORITIES CONTRIBUTING TO THE EUROPEAN BIOECONOMY



Legend :

-  Priorities for Horizon Europe
-  Examples of complementary research contributing to the European bioeconomy



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