EU CAP NETWORK

EU CAP Network Workshop

Innovative arable crop protection - using pesticides sustainably

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1. Introduction

The EU CAP Network workshop entitled 'Innovative arable crop protection - using pesticides sustainably' was held in Amsterdam, the Netherlands, on 19-20 April 2023. It brought together 66 participants involved in arable crop protection, including farmers, advisors, researchers, students, entrepreneurs and other stakeholders representing innovative projects and solutions to enhance arable crop protection throughout the European Union.

Arable crops, such as cereals, legumes, potatoes and sugar beets, are a significant part of European agriculture and critical for food security as both human and livestock food sources. However, arable crop production is facing multiple challenges, such as native and invasive pests, diseases, weeds, mechanisms of pesticide resistance in addition to extreme weather conditions. Reducing pesticide use while ensuring sustainability and competitiveness poses a major challenge for arable crop production.

Farmers are currently heavily reliant on chemical pesticides to protect crops and achieve higher yields of desired quality. However, the use of and dependency on pesticides can pose a risk to human health and further contribute to the risk of biodiversity decline in agricultural areas impacting, for instance, non-target organisms such as bees and other pollinators. Additionally, pests, diseases and weeds can become resistant to these chemicals over time, particularly if they are overused.It is therefore crucial to develop and implement efficient and environmentally friendly methods to prevent and control harmful organisms in arable crops. Doing so will contribute to sustainable and economically viable agricultural production while also expanding the supply of sustainably produced food and feed.

The European Union (EU) and its Member States aim to decrease the dependence on chemical pesticides in agriculture by implementing more integrated and sustainable practices. Simultaneously, they aim to maintain the competitiveness of the EU's agriculture. Concrete objectives of the Farm to Fork Strategy include reducing pesticide usage by 50% by 2030 at the EU level, promoting the use of safe alternative methods for protecting crops and enhancing provisions on Integrated Pest Management (IPM). Achieving these objectives require considerable resources and attention to support the transition to sustainable crop protection measures, promote innovation and exchange best practices.

From the Farm to Fork strategy:

"By 2030 the use and risk of chemical pesticides and the use of more hazardous pesticides are reduced by 50% at the EU level".

https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides_en

Due to the large cultivation areas covered by arable crops, reducing dependence on chemical plant protection products on these crops has a significant positive impact on the environment. The reduction of chemical pesticides and the further implementation of Integrated Pest Management sets a new course of action for sustainable agriculture. To meet the challenges of the transition towards new practices and more complex production systems, farmers and advisors need to feel confident and to get comprehensive support through information and knowledge exchange and training.

The overall objective of the workshop was to exchange knowledge and share innovative, inspirational practices that support farmers, advisors, and other stakeholders to ensure greater uptake of non-chemical plant protection methods in arable crops by using economically and ecologically sustainable approaches. The overall aim of the workshop was to promote networking among Operational Groups (OGs) and other innovative projects and to showcase more sustainable initiatives and ways to reduce chemical pesticides in arable crops (cereals, oilseeds, legumes, potatoes, sugar beets).

The specific objectives of the workshop were:

- Exchanging knowledge and good practices, initiatives, opportunities and tools which are relevant regarding the reduction of the use of chemical pesticides in arable crops (but also approaches that did not work – be that technically or economically);
- Identifying challenges and exploring potential solutions;
- Identifying needs from practice (from both farmers' and advisors' perspectives) and possible knowledge gaps that may be filled by research;
- Promoting networking among EIP-AGRI Operational Groups and other innovative projects dealing with sustainable plant protection measures;
- Collecting new ideas for OGs dealing with the topic of the workshop.

The workshop focused on building and exchanging practical knowledge on innovative and alternative pest and disease management tools and strategies in arable crops (cereals, oilseeds, legumes, potatoes, sugar beets) including:

- Innovative approaches and good examples to scale up sustainable plant protection;
- Holistic, ecologically and economically-sound solutions for existing plant health problems and for those that are emerging or increasing as a result of societal demand, for instance reducing pesticide dependence, including: crop diversification, robust varieties, soil management, targeted plant protection methods and supportive tactics;
- Challenges and opportunities for sustainable plant protection measures;
- Interaction and networking with relevant stakeholders along the value chain ('from farm to fork');
- Research, advisory and training.

The interactive programme provided participants with many opportunities to exchange knowledge, meet challenges and find solutions and to also discuss innovative and new ideas.

Each session had a particular setting and methodology. The interactive sessions varied. Depending on the setting, participants either worked in pairs or in groups of different sizes. Prior to the workshop, field visits were organised in an area around Amsterdam to inspire participants and showcase inspirational cases of pesticide use reduction. More information about the field visits can be found in the separate field visit report[1].

2. Part I. Starting our journey together

2.1 Opening remarks by Magdalena Mach and Gisela Quaglia

The workshop was opened by **Magdalena Mach**, Policy Officer at the European Commission - DG Agriculture and Rural Development, who introduced the concept of European Innovation Partnership for Agricultural productivity and sustainability (EIP-AGRI), emphasising the importance of stimulating and improving the exchange of knowledge as well as closing the innovation gap between research and agricultural practice through EIP-AGRI Operational Groups. Magdalena Mach highlighted the achievements of EIP-AGRI since it was launched in 2012, including 2,788 Operational Group projects, of which 475 projects are devoted to pest and disease control. She also summarised previous EIP-AGRI activities related to sustainable use of pesticides, such as focus groups, workshops and publications. Lastly, Magdalena Mach presented the new EU CAP Network launched in October 2022 highlighting one of its objectives that focuses on **'Fostering innovation in agriculture and rural development and supporting peer-to-peer learning and the inclusion of, and the interaction between, all stakeholders in the knowledge-exchange and knowledge building process.'**

'Optimising the flow of information about agriculture and rural policy within the EU is what the EU's Common Agricultural Policy (CAP) Network is all about.'

https://eu-cap-network.ec.europa.eu/

[1] Information about and presentations held during the workshop can also be found here: EU CAP Network workshop 'Innovative arable crop protection - using pesticides sustainably' | European CAP Network (europa.eu).

Gisela Quaglia, Research Programme Officer at the European Commission, presented the two key pesticide reduction targets in the Farm to Fork Strategy and the adopted proposal for a new Regulation on the Sustainable Use of Plant Protection Products (SUR) to ensure that all farmers and other professional pesticide users practise IPM. Gisela Quaglia highlighted the plant health and IPM projects in Horizon 2020, amongst which IPMWORKS (www.ipmworks.net) and IPMDecisions (www.ipmdecisions.net) that aim to stepping up IPM. For the future she emphasised that EU-funded support for healthy cropping systems will continue through Horizon Europe, including new instruments like the co-funded partnerships on Agroecology (Partnership on agroecology (europa.eu)) and Agriculture of data (ec_rtd_he-partnership-agriculture-data.pdf (europa.eu)) and the EU Mission entitled 'A Soil Deal for Europe'. Gisela Quaglia ended her presentation by providing examples of thematic networks that compile knowledge for practice fostering knowledge exchange:

- OPER8 (www.oper-8.eu) - European Thematic Network for unlocking the full potential of Operational Groups on alternative weed control;
- INNOSETA (www.innoseta.eu) - EU-wide Thematic Network dedicated to the world of spraying technology innovations, training and advisory;
- SMARTPROTECT (www.smartprotect-h2020.eu) - Thematic network focusing on knowledge sharing of SMART IPM solutions for vegetable crops for farmers and advisors.

The Cordis result pack was also presented, which showcases some of the cutting-edge projects is at the forefront of research and innovation activities addressing plant health : Plant health: Protecting plants to safeguard our future | Results Pack | CORDIS | European Commission (europa.eu), and Plant health: Keeping plants healthy while protecting the environment | Results Pack | CORDIS | European Commission (europa.eu).

2.2 Integrated Crop Management (ICM): a framework to support the design and adoption of IPM strategies at farm level

Marleen Riemens, coordinating expert of the workshop, presented a framework to support the design and adoption of IPM strategies at farm level. In past decades, developments towards the more sustainable use of pesticides have strongly focused on increasing the efficiency of pesticides or substituting pesticides with other single tactics. She emphasised that the reduction of pesticide use by 50% in 2030 demands a fundamental change in the management of pests, diseases and weeds at the farm level and a redesign of cropping systems to manage biotic stressors, and that this all comes with increased complexity for farmers and advisors.

A framework to manage the increased complexity was developed for weed management (https://doi.org/10.1016/j.eja.2021.126443) within the EU project IWMPRAISE (www.iwmpraise.eu) and recently extended to pest, disease and nematode management (https://doi.org/10.1079/9781789247541.0001).

The combined framework is called **Integrated Crop Management** (ICM) and consists of five pillars:

1. Crop diversity in time and space

2. Cultivar choice

3. Soil management

4. Targeted control, supported by precision agriculture

5. Monitoring and evaluation

All tactics and tools that a farmer can use to impact the life cycle of pests, diseases, nematodes or weeds can be attributed to one of the pillars. When combining tactics and tools from multiple pillars, a sustainable management strategy is obtained that affects target organisms at several points in their life cycle. Tools and tactics include preventive and curative measures, non-chemical control methods, functional agrobiodiversity and supportive precision agriculture tactics.

The framework can be used for both conventional as well as organic farmers. It is used to redesign cropping systems with less dependency on pesticides in several research and extension projects such as, for example Farm of the future (Homepage - Farm of the future), Green Crop Protection (https://www.groenegewasbescherming-bestuivers.nl/nl/ggb/groene-gewasbescherming/akkerbouw.htm) and Integrated approach for disease, pest and weed management (Integrale aanpak gewasbescherming voor de akkerbouw op zand - WUR). These projects are co-operations with governmental partners, farmers' organisations, advisors and private partners from the arable production chain.

Preliminary results indicate that it is possible to design an economically viable farming system independent of the Candidates for Substitution (CfS) and using on average 50% less pesticides compared to conventional reference systems. The research platforms are used within EU project IPMWORKS (www.ipmworks.net) farm networks (GROEN) as inspiration for farmers to experiment with alternative pest management.

3. Part II. Inspiration: Innovative examples across Europe

3.1 Inspiring cases

The introductory session was followed by presentations of four inspiring cases. The speakers introduced examples of Operational Groups, other innovative EU projects and inspiring ideas to increase sustainable crop protection.

Nicolas Munier-Jolain (France), coordinator of the H2020 IPMWORKS project, presented a European network of demo farms demonstrating cost-efficient IPM-based strategies with reduced reliance on pesticides. It consists of 31 partners from 16 countries, with 246 demo farmers, 22 hub coaches active in 264 demo events. Farmers exchange practical knowledge and are supported by the advisor-facilitators (hub coaches). The project helps farmers from the network to re-design their farming system to adopt a holistic approach to crop and pest management and use all components of IPM suitable to the farm specific context through peer-to-peer knowledge exchange. Through the organisation of farm-level DEMO events based on IPM success stories in the network, a larger number of farmers have been inspired. Furthermore, data is collected in IPMWORKS farms to prove that "IPM works". Nicolas Munier-Jolain presented a case study from France where the farmer implemented methods from three out of the five ICM pillars and was able to reduce pesticide use: through an increased crop diversity (extending the crop rotation), choosing resistant cultivars and mixtures, in combination with delayed sowing and moderate application of fertilisers and occasional soil management to support weed control. (More information can be found on the website: www.IPMWORKS.net). Nicolas ended his presentation with what he finds to be the most important steps towards becoming independent from the use of pesticides:

- demonstrate to the farming community that reducing pesticide use through holistic IPM is (i) possible, (ii) cost-effective and that maximising yield targets is not always the best option for sustainability. To do so, more demonstration farms are needed;
- support scenarios of general adoption of re-designed IPM-based farming systems with the use of Farm DEMO networks;
- inform consumers about pesticide use of the products they purchase. Make premium output product prices a possibility for farmers that reduce pesticides, perhaps with the help of a mandatory 'pesticide' label.

Sari Peltonen (Finland), responsible for developing advisory tools for crop production including sustainability aspects and environmental issues at ProAgria, presented the EcoStack project. The EcoStack project aims to develop and support ecologically, economically and socially sustainable crop production via stacking and protection of functional biodiversity. The project provides knowledge and tools to maximise ecosystem services for the production of crops while minimising the environmental impacts of agriculture and ensuring the profitability of farming. Methods include mixed cropping, flower strips and promotion of natural enemies. In oilseed crops, the options for chemical control products against pests like flea beetle and pollen beetle are very limited. Thus, there is a pressing need for alternative control methods. Some of the possible solutions are physical control, mixed cropping, amongst others. However, it should be noted that these methods may not provide the same level of control and crop yield as the "conventional" methods, and this fact should be acknowledged. Additionally, alternative pest control methods are often more expensive and require a higher frequency of treatment than chemical methods.

To achieve sustainable pesticide use, preventive measures like crop rotation, use of resistant cultivars and trap crops, whether used alone or in combination, can be helpful. This project aligns with the 'Crop diversity' five-pillar framework, particularly the use of trap crops, which is effective against flea beetle but less so against pollen beetle. Other strategies therefore need to be developed for this pest. (More info on the EcoStack Website: https://www.ecostack-h2020.eu/.) Sari ended her presentation with her perspective on the most important steps towards becoming independent from the use of pesticides:

- the primary objective remains, that is to ensure high crop yields and produce top-quality food and feed;
- focus on promoting the sustainable use of pesticides, which includes preventive measures such as crop rotation and the use of resistant cultivars. Additionally, alternative methods of pest control, such as biological and mechanical options, should be used when possible;
- different kinds of cultural practices are worth developing to achieve adequate pest control, as well as finding ways to promote the presence of natural enemies.

Christine Judt (Austria), project coordinator of the EIP-AGRI OG project entitled 'Flower strips and under sowing control aphids in fava bean' presented their activities on natural pest control to prevent Pea necrotic yellow dwarf virus (PNYDV) damage in leguminous plants. PNYDV is transmitted by aphids. The principal objective of the project was to develop tailored flower strips and undersowing crops to attract natural antagonists of aphids to manage the occurrence of aphid outbreaks and the transference of PNYDV (https://ec.europa.eu/eip/agriculture/en/find-connect/projects/n%C3%BCtzlings-bl%C3%BChstreifen-und-untersaaten-regulieren.html; https://www.global2000.at/forschungsprojekt-blattlaeuse-ackerbohnen). Crop diversity, monitoring, evaluation and targeted control were the ICM pillars applied. Participating farmers were successful in establishing and managing flower strips and in undersowing crops. Also, more natural antagonists were observed in fields close to flower strips and undersowing crops compared to other fields. Natural antagonists could regulate aphids over time but not during critical periods of time in which infections occurred.

Engaging farmers in the project activities was challenging forvarious factors, including the risk of losing the faba bean harvest, the attraction of other flowers, time constraints, limited access to equipment and the absence of financial compensation. Moreover, farmers have experienced poor results in recent years, largely due to the impact of climate change. The most important steps towards becoming independent from pesticides use, according to Christine, are to:

- discover and showcase effective alternatives in the field;
- provide farmers with both financial and knowledge support to adopt and implement new management strategies;
- assist farmers in gaining hands-on experience.

Josef Ceijka (Czech Republic), farmer and agronomist with a focus on pesticide reduction by means of customised technology, presented technologies to reduce the use of pesticides, including band application of pesticides, inter-row mechanical weed control, zone applications for weed control, companion cropping and wheel rows sown with flowering plants. Application of these technologies can reduce the need for pesticides significantly, varying by crop, location and year. In order to have a successful implementation of technologies, Josef's experience is that it is:

- important to perform trials,together with research institutions;
- possible to attract new employees to work in agriculture when using high-tech technologies;
- important to plan machinery replacement well, since the cost of replacing machines is high;
- sometimes difficult to implement technologies due to incompatible platforms between different agricultural machinery manufacturers.

3.2 Voices from participants: How can one successfully implement sustainable plant protection measures in arable crops?

During this session, participants shared their most inspiring ideas and initiatives on sustainable plant protection methods in small breakout groups. Groups started with two persons and were merged with another group after each round. In this way, ideas were generated and shared among two and four participants until the group grew, eventually consisting of a maximum of eight persons. The resulting ideas were shared in plenary with all participants and ranked according to the ICM framework.

The result was an inspiring overview of ideas from participants that both farmers and advisors could apply as first steps towards sustainability. The participants' advice was to start working with methods and tools from all pillars of the ICM framework to make crop protection strategy as variable as possible. More specifically, they gave the following advice per pillar:

1. Crop diversification

Increasing crop diversification comes with advantages and disadvantages. Participants discussed crop diversification opportunities that could be implemented over time (e.g. **widening the rotation, green manure crops**) and space (e.g. **strip tillage**).

Increased crop diversification over time has benefits: it is a proven tactic for pest, disease and weed management. Many pests and diseases need a host to survive. Adding new crops to a rotation that are non-hosts will help decrease the density of pests, diseases and weeds. Increased crop diversification has disadvantages as well: in some regions it is not possible to add crops to the rotation, either as a result of a lack of market access and contractors, or due to environmental conditions (e.g. soil, climate etc.). Instead of adding main crops to the rotation, green manure crops can be used to increase crop diversification. The market access is no issue and green manure crops contribute to soil health and general biodiversity. The benefit of increasing crop diversification in space through methods such as strip tillage is that it can potentially increase the number of natural enemies through the provision of shelter and alternative food. It will also contribute to biodiversity.

The disadvantage of increased crop diversity is the potential risk of increasing the number of hosts in a field. Especially for soil borne pathogens it is important to pay attention to the host status of crops. A challenge identified by the participants with strip tillage is related to the need to adapt mechanisation and the lack of knowledge on the optimal width of strips and crop combinations[2].

2. Cultivar choice

Participants' advice was to use **resistant cultivars** when possible. The disadvantage may be that a specific cultivar sometimes has a lower potential yield. Some varieties can nevertheless be economically more viable when they have proper resistance to fungal diseases because costs for fungicides can be strongly reduced or indeed be totally avoided. It is necessary to combine the use of these varieties with proper resistance management and not mix resistant and vulnerable varieties to avoid problems with resistance developing in the pathogen populations. The disadvantage is that varieties with traits that are often demanded by the market do not have the proper resistance genes or have them only against one pest or disease. The disadvantage of resistant cultivars may be that there is not sufficient market for these varieties. In addition, participants highlighted the use of **competitive cultivars** to reduce weed populations, which are especially beneficial in cereal crops.

It was advised to use **planted crops** instead of sown crops whenever possible. In open crops, such as onions, mechanical weed control is difficult in the early stages. Onions are also a relatively less competitive crop, where weeds can do a lot of damage. The use of plants instead of seeds may give the crop a head start and enable the use of mechanical instead of herbicide control. The downside is that planting is often more expensive. Similar approaches are possible in crops such as lettuce, leek and other arable grown vegetable crops. To avoid flights of insects or the emergence of specific weeds it was advised to experiment with shifting **sowing dates**. To improve the competitive ability of crop experiments with **sowing depth** and **sowing patterns** was also advised. Participants' advice was also to use **CATT** (controlled atmosphere temperature treatment) to start with clean planting material. The downsides are the additional costs and the logistics in taking the product to the required facilities.

3. Soil Management

Several recommendations were brought forward with respect to soil management. To improve soil health and structure adding **soil organic matter** can be beneficial. It is good to pay attention to **crop residue management** to break the life cycle of pests and diseases. The use of a **stale seedbed** approach can kill emerging weeds. Adjusting **fertilisation** application schemes can help with disease control: fungal diseases such as early blight cause less damage in a healthy crop. To prevent competition for nutrients with intra row weeds, application of fertiliser in bands can be helpful. Lastly, to manage weed and fungal populations, farmers are advised to intermittently plough to disrupt the life cycle of weeds, to bury weed seeds and to experiment with **mulches** to cover the soil and prevent weed growth.

[2] Additional information on the host status and damage sensitivity of crops for a large number of nematode species and soilborne pathogens can be found here: Best4Soil - A network of practioners, for sharing knowledge on prevention and reduction of soil borne diseases. Other inspirational projects on increased crop diversity can be found here: Diverimpacts - DiverIMPACTS, www.Farmofthefture.nl, CropMix - Designing mixed cropping systems and transition paths towards sustainable ecology based agriculture - WUR.

4. Targeted control

The use of specific **decision support tools** when planning to apply pesticides was recommended. A good example given by the participants is the use of the blight app (www.farmmaps.net/nl/Apps/Applicatie/Phytophthora)[3].

Blight app: a decision support tool

The blight app optimises farmers' management strategies with timely preventive spray advice. It provides curative or stop spray recommendations for existing infections and guidance on tuber infection risks. Only essential spraying is advisable, promoting cost-efficiency and responsible pesticide use. The app considers crop growth, suggesting shorter intervals during rapid growth and high disease pressure. Disease pressure settings can be customised by farmers. It also accounts for fungicide properties in protecting foliage, new growth, tubers and rain resistance. This app has been tested and validated in numerous locations in Europe, South America, North America, Africa and Asia.

Some general advice is to start experimenting with **non-chemical weed** management and with **biocontrol pesticides**. The latter option is limited for arable crops, but over time the number of registrations is expected to increase gradually. The expectation is not to substitute chemical pesticide one-for-one with the biocontrol pesticide. A biocontrol pesticide often needs to be implemented within a new crop protection strategy to be effective. For fungal disease control in storage, get experience with the use of a **'humigator'** to minimise fungicide dependency: Humigator (humigatordfs.com).

Sources for integrated weed management

A point that was not mentioned by the participants: there are good information sources related to non-chemical weeding. These sources include: the description of mechanical weed management and weed management tactics, the tool sheets and the IWMTOOL on Integrated Weed Management: PRActical Implementation and Solutions for Europe (iwmpraise.eu). Farmers and advisors interested in physical weed control can also join the Physical Weed Control Forum - Deconstructing the 'Art' of physical weed control for more information and knowledge exchange.

5. Monitoring and evaluation

Explore/Search for tools that can help with monitoring the occurrence of pests, diseases and weeds. This monitoring in crops can be achieved through visual checks, but also through cameras or molecular tools. Furthermore, the use of digital platforms to evaluate the crop management results and assist in the use of monitoring data in the evaluation and design of your crop management system. An example of such a tool is **NemaDecide**, a software-based nematode advisory system for all potato growers (http://www.nemadecide.com/english/home.html), but many more can be found on the web.

4. Part III. Pro action cafés: Challenges, potential solutions and research needs

In this section of the workshop participants identified economic, ecological, technological, knowledge-based, social challenges, solutions and research needs from practice for sustainable crop protection in arable crops during four 'pro action café' sessions. Each 'café' focused on either economics, ecology, technology, knowledge sharing/training or social aspects related to sustainable pesticide use.

During the first round, participants were asked to identify challenges, in the second round to provide potential solutions to these challenges and in the third round to identify research needed by practice and related to the challenges and solutions mentioned in the previous rounds. For the second and third round, participants could move to their preferred cafés, but they could not stay in the same room. As a result, a different group of participants searched for potential solutions and research needs to the challenges raised by the first group. After a short recap by the pro action café facilitator, participants recommended a couple of solutions to the challenges faced by the individual farmers and listed research needs associated with the challenges and solutions.

[3] In addition to the decision support tool mentioned by the participants, other decision support tools are available for other crops, pests and diseases in Europe and can be found here: Home | IPM Decisions.

In the final round, participants were asked to rank and select the research needs from practice collected in round three that were best suited to assist in solving the identified challenges and to structure and elaborate on at least some of these prioritised research needs. The summary of results from each pro action café are presented below (see also **Annexes**).

4.1 Economic pro action café

During this café participants were asked to think about economic aspects that may hamper implementation of sustainable Integrated Crop Management strategies. As an example: the inclusion of new crops in the rotation may not be possible due to constraints regarding access to markets or new strategies may be more time consuming (and therefore costly).

4.1.1 Economic challenges

An important challenge participants raised is that many farmers lack **a viable business model** for IPM that can compete or be compared with the current agro-chemical business model. There is an increasing risk of yield losses caused by pests, diseases and weeds as a result of climate change, but also a lack of tools to intervene when a crop is affected. The profitability of many proposed sustainability measures is not guaranteed. It was argued that output prices need to account for the higher costs and lower yields associated with implementing these measures. Presently, there is insufficient recognition and appreciation for products produced with fewer and less hazardous pesticides. Apart from the traditional cost-production-price formula, **ecosystem and health services should also be considered in future business models**. The challenge is to develop a comprehensive approach that takes all aspects of sustainable production systems into account, including the costs incurred by farmers, yields per hectare, market access, employment and labour considerations, income and subsidies.

At a farm level, participants identified 3 challenges that limit farmers economically. The first is the **limited amount of time that farmers have to experiment** with new ideas due to their heavy workload during the productive season. The second is the **lack of room for unsuccessful trials** due to low profit margins. And the third are the **financial investments needed** for new machinery and equipment. Furthermore, it is challenging to find **dedicated green financing options** tailored to support sustainable agriculture. According to participants, competitiveness issues can arise between different types of farmers, regions and countries. It was concluded that **economic solutions must be adaptable to different farm sizes and account for other contextual differences**, and that at the moment these solutions are not yet available.

4.1.2 Solutions to economic challenges

The first solution mentioned was **to establish an insurance system that serves as a safety net for farmers** who wish to experiment with alternatives to pesticides, to make sure that they have financial room for unsuccessful trials. Enabling farmers to participate in the European Union CAP financial schemes, accessing subsidies for implementing IPM principles and mitigating potential risks and financial losses during the transition could be part of that system. Incentives should be introduced to reward farmers who apply good IPM practices and compensate them for any losses incurred during the adoption phase.

The transition towards Integrated Crop Management systems is increasingly knowledge intensive. Participants recommended that farmers undertaking this process are ensured of easy access to information on good agricultural practices. **Customised mentoring and advisory services to support farmers** in adopting sustainable practices could be a way to access information. Farmers that will not have the time to comprehend all alternatives and translate these into management strategies tailored to their farm could request the assistance of advisory services to complete this task with them.

At a more general level, some participants made recommendations to **implement an output-based business model that offers yield insurance to overcome yield losses** due to pests, diseases and weeds.

To enable true pricing, it was recommended to encourage higher product prices and **lower product taxes for sustainable agricultural products**, to develop **green brands and marketing solutions**, supported by government initiatives, to promote sustainable products in the market. Some participants suggested that supermarkets could possibly include **a dedicated section for IPM products**, increasing their visibility and consumer choice. However, other participants were sceptical that the market could accommodate additional labelling without diluting the benefits of the existing labelling options (such as organic).

To avoid unfair competition between farmers across Europe, it was advised to ensure that **funding disparities are reduced between Member States**, creating equal advantages for all EU farmers. To create a level playing field both within and outside the EU, **similar demands on imported agricultural products** should be imposed and trade agreements should be adjusted accordingly.

4.1.3 Associated research needs from practice

Participants' advice was to conduct an **analysis of the productivity and profitability of IPM strategies** at the farm level. To make that possible, recommendations were made to **gather data** at the EU level, including data from different regions and to pilot farmers. That data could also be used to assess the effectiveness of IPM strategies at the farm level and analyse the effects of IPM-based strategies on risk levels, determining whether they increase or decrease risks. Participants also made suggestions to include smart technology and online platforms that support farmer decision-making in the analysis.

Before insurance systems or financial incentives are developed, it is best to **evaluate the economic impact of implementing sustainable practices in various contexts** and crop systems. The outcome of these analyses can be used as data input for the development of support schemes. Participants spoke about the inclusion of ecosystem and health services in future business models. They argued that, when future business models need to include ecosystem and health services, the link between IPM measures and these services needs to become clear. They suggested the development of methods to calculate the environmental and health impacts of different farming systems and enable cost comparisons.

Participants recommended **conducting research to harmonise and holistically assess the impact of implementing different IPM strategies**. As an example, the link between IPM strategies and carbon sequestration and general biodiversity was put forth. They also suggested **identifying the most cost-effective economic incentives** to encourage the adoption of IPM practices that also provide ecosystem services.

To determine the costs of pesticide use, it was recommended to perform residue analysis at both the farm and crop level to understand the residues associated with pesticides used in different crop management strategies.

Lastly, participants discussed the role of start-ups. It could be beneficial to provide **support for innovative start-ups** that challenge the status quo by introducing disruptive business models. To ensure a level playing field, it was advised **to research the country-specific and EU-wide economic impact of the Farm to Fork Strategy, including its effects on crop yields and food imports.**

4.2 Ecological pro action café

During this pro action café, participants were asked to discuss potential trade- offs of sustainable Integrated Crop Management strategies with other ecological goals such as biodiversity.

4.2.1 Ecological challenges

Participants noted the **quantification of the impact of different crop management strategies on the ecosystem and general biodiversity** as a challenge. They stressed that this is of particular importance for soil (bio) diversity and health, water quality and the protection of non-target organisms. Understanding these impacts would help identify trade-offs between crop management strategies and the environment. As an example, participants talked about the benefits of mechanical (weed) management techniques and the disadvantages of these techniques, such as CO2 emissions and impacts on soil structure and erosion. They stressed that it is important to weigh up and compare the different effects of interventions.

Additionally, they identified **a lack of technical and advisory support for implementing good practices developed elsewhere, as well as difficulties accessing eco-friendly products on a large scale.** It is a challenge to **get general knowledge about plant protection measures with positive ecological impact translated to local circumstances.**

As for conventional systems, participants stated some of the challenges creating additional **market value** since there are no labels beyond organic certification that recognise the value of biodiversity friendly practices.

Next, climate change and the risk of invasive alien species were addressed. Climate change can potentially increase the pressure from pests, weeds and diseases, including invasive alien species. According to the participants, it is crucial to **understand the influence of climate change on individual species and on farm ecosystems as a whole** to develop effective strategies to mitigate these impacts.

When new plant varieties are introduced, it is a challenge to assess future impacts of these varieties on the functioning of the ecosystem, both positive and negative. Besides ecosystem impacts, socio-economic impacts can be challenging as well. New varieties usually come with an initial low **seed availability on the market**. It could therefore be a challenge to ensure access for farmers shortly after market introduction.

4.2.2 Solutions to ecological challenges

Participants first addressed the issue of translating general knowledge to farmers at a local scale. They emphasised the value of **demonstration farms** that provide practical examples to facilitate knowledge transfer to farmers. Also, it was found to be important to include local knowledge and local experience to provide context-specific local solutions. Participants emphasised the importance of providing guidance with attention to other ecosystem services, next to pest, disease and weed management.

Next, solutions for the lack of quantitative information on the relationship between ICM strategies and ecology were addressed. As a key solution for this challenge, the **improvement of monitoring practices** was mentioned. It is essential to move away from routine spraying and promote precision spraying and the use of alternative tactics and tools based on monitoring data. This includes using citizen science and digital tools as well as DNA tools. It would also help to gather data on population dynamics of pests, diseases, weeds and beneficial organisms. **Smart traps and labour-extensive monitoring tools** could also be of value for this purpose and **should be promoted.**

Participants suggested providing technical assistance in pest monitoring and identification, including the use of digital tools and putting forward **holistic management strategies such as ICM**. To sustain and promote soil biodiversity and health, **practices like crop rotation, cover cropping and organic matter management should be implemented** by farmers. Increased public funding and dedicated independent advisors are necessary to support these efforts.

It was advised to promote biodiversity-friendly labels and eco-services and to encourage the creation of labels beyond organic certification to **recognise and promote biodiversity-friendly farming practices**. This could result in higher economic value for products. Additionally, support policies that incentivise and reward ecosystem services through economic and fiscal eco-schemes were also referred to.

Another point raised was **to develop effective management strategies based on threshold levels of key pests, diseases and weeds**. Current data from threshold studies were mainly collected for chemical control methods, not for alternatives. Understanding these thresholds could help farmers implement targeted and effective alternative pest management strategies.

To mitigate the increased risk of alien pests, diseases and weeds due to climate change, a solution was sought in **enforcing legislation more rigorously to prevent the introduction and establishment of alien pests and diseases**. This includes regulating imports from outside the EU as well as trade of goods within EU countries to mitigate the spread of pests that are already established.

Additionally, a technical solution was suggested: the stepwise **development of preventive approaches for key invasive pests** that are not yet present in Europe. This involves gathering scientific knowledge about these pests in their countries of origin, including their impacts, native natural enemies and local control methods. With these actions, according to the participants it is possible to improve pest management practices, promote sustainable farming methods, protect biodiversity and mitigate the risks posed by invasive pests.

4.2.3 Associated research needs from practice

First, participants identified research needs related to monitoring and detection of pest, diseases and weeds, and the efficacy of biocontrol agents. Researchers need to actively work on **developing new and improved techniques for detecting and monitoring pests, diseases and weeds**, was one of the inferences referred to during this round. These methods include innovative approaches like DNA barcoding, which allows a quick and accurate identification of pests. Similar to Covid tests, these techniques could enable rapid identification of selected pests. Additionally, automated monitoring sensors need development to monitor and detect pests, diseases and weeds.

According to the participants, **understanding the population dynamics of bio-control agents** is crucial for effective pest management. These agents include both macro-organisms like insects and mites, as well as micro-organisms such as fungi and bacteria. By studying their interactions and reproductive patterns, researchers can support the deployment of these agents and enhance bio-control strategies in **Integrated Crop Management strategies**. This includes manipulating plants and habitats to enhance natural enemies.

The adoption of non-chemical pest control techniques and strategies can have a significant positive impact on biodiversity. A recommendation put forth was to **gather and analyse data on the impact of non-chemical control techniques and strategies on biodiversity** but also to **quantify the environmental footprint** of alternative management strategies to minimise any potential negative effects on the environment to ensure sustainable practices.

To better maintain soil health, it was recommended to develop **soil biology indicators.**

As for climate change, it would be good to focus on **models to assess and predict the impacts of climate change on crop production**. This knowledge could help farmers adapt their practices and mitigate potential risks.

Measurable and comparable farm biodiversity was another research need identified. As a suggestion, the development of a 'score card' system was made. With a scoring system, farmers could have a standardised and comparable framework to assess and monitor biodiversity on farms more effectively. By implementing such a system, farmers can track and enhance biodiversity on their farms, contributing to sustainable agriculture.

Arguments were also made for making **digital databases of European Union farmers accessible to the scientific community**. These databases should contain valuable information such as the frequency of chemical treatments, types of products used and crop yield data spanning multiple years. Sharing this information with researchers can provide valuable insights and contribute to improving agricultural practices.

4.3 Technical pro action café

During this pro action café, participants were asked to discuss the role of technical developments for sustainable Integrated Crop Management. Examples given were the speed of development of new technologies such as precision agriculture techniques, breeding techniques or biologicals.

4.3.1 Technical challenges

Participants identified several challenges of a technical nature: the **lack of bio-pesticides** for arable crops, the lack of implementation and **availability of precision farming techniques, real-time detection** of pests, diseases and weeds, harmonised **interoperable data platforms, resistant cultivars** and the lack of **5G coverage** in rural areas. Furthermore, they emphasised the increased complexity of Integrated Crop Management strategies compared to chemical-based systems. They stressed that the development and advancement of all the above technologies can support the implementation of sustainable cropping systems with a reduced pesticide dependency.

4.3.2 Solutions to technical challenges

Participants advised on **changing the regulation framework** for bio-pesticides to make it faster and affordable.

The development of DNA/RNA spraying technique applications was mentioned as a possible new non-chemical technology of interest.

To **advance precision farming techniques**, it was suggested to use navigation with RTK[4] (Real Time Kinematics) accuracy as a minimum on each machine, including planting, harvesting and spray machines and to upgrade existing equipment and machines with GPS, observation hard/software and other new technology.

Furthermore, participants emphasised the importance of controlling weeds with non-chemical methods as much as possible, of using real time imaging techniques for the detection of pests, diseases and weeds, and of identifying beneficial species and preserving biodiversity. These can be mounted on either tractor, robot or drone.

To manage agro-ecological farming systems and control pests, diseases and weeds within those systems, participants emphasised the potential benefits of **proper monitoring and data processing systems**. Participants stressed the importance of 5G coverage in rural areas, open access to relevant EU databases and to make **data platforms interoperable** to make solutions accessible to as many people as possible. Farmers were advised to make a digital twin (virtual version of their farm).

The development of **resilient cultivars** was also seen as an important solution. Examples provided are fast growing competitive varieties that prevent the need for weed control, varieties that are resistant to pests and diseases such as viruses in sugar beet. Preferably, resistance, tolerance and competitive ability against biotic stressors should be combined with abiotic stress resistance, also with respect to climate change.

All these solutions **require funding of technology development**. It was recommended that governments support individual farmers to reduce investment recovery time of equipment that aids reducing the use of pesticides and to provide groups of (small) farmers with funds for high tech machinery like drones. An option for farmers could be to organise themselves in networks that share machinery and to buy services instead of machines.

[4] A GPS receiver capable of RTK takes in the normal signals from the global navigation satellite systems along with a correction stream to achieve a 1 cm positional accuracy.

4.3.3 Associated research needs from practice

Most importantly, according to the participants, is the need to **develop agro-ecological solutions with related adapted technology**, including adapted mechanisation and diversified agro-ecosystem designs.

Next is to provide insight on the **impact of new technologies**, both in terms of efficacy as well as ease of implementation and complementarity with regular (low tech) practices. Participants further agreed on the need to develop **harmonised data platforms** that have data compatibility and facilitate the use of artificial intelligence solutions in a user-friendly way.

It was suggested not to start with technological options and their potential opportunities but with the need of farmers to the forefront instead. Participants stressed the importance of investigating the role of advisors - maybe this group needs to be actively targeted instead of the farmers themselves.

As a last point, participants' advice was to search for **new modes of actions for pests and disease control** and develop decision support systems to advance their ease of implementation by farmers.

4.4 Training and education pro action café

Sustainable Integrated Crop Management strategies come with an increased level of complexity and are knowledge intensive. During this pro action café, participants were asked to discuss the training and education needs to handle the increased complexity.

4.4.1 Training and education challenges

Exchange of information between different stakeholders is crucial for effective knowledge dissemination and collaboration. This involves **connecting individuals who possess specific knowledge with those who require it**, recognising that each stakeholder may have different knowledge needs. Finding ways to involve multiple stakeholders in training and education programmes is essential to foster knowledge sharing and transfer. However, linking education systems, particularly high schools that provide initial training and introduction to new technologies and practices, can be challenging due to differing views among teachers. The dynamic nature of information further complicates the decision-making process on which information is most relevant. Participants emphasised that it is important **to gather knowledge from advisors, researchers and authoritative sources**, treating each piece as a valuable contribution that fits together like pieces of a puzzle.

Establishing a common language is challenging but necessary for effective communication among stakeholders. It is crucial to avoid overly scientific terminology when engaging with farmers, ensuring that information is accessible and easily understood. Identifying suitable communication channels that resonate with different stakeholders is key to successful knowledge dissemination.

Convincing farmers to change their behaviour based on research **findings requires finding persuasive and relatable ways to present the information**. The **design and timing of training sessions** play a significant role in their effectiveness. Training should be conducted at appropriate times of the year, aligning with the specific needs and demands of farmers. Engaging farmers as a group, fostering a sense of belonging and shared experiences can enhance the impact of the training. Interactive activities that count as training help to create an engaging learning environment. Additionally, training farmers on how to restore and preserve endangered agricultural biodiversity is important for sustainable agricultural practices. Considering the time constraints of farmers, it is crucial to select the right training period that accommodates their busy schedules. Training should also be tailored to fit the specific conditions and challenges faced by individual farmers, acknowledging site-specificity.

Participants also noted that achieving **independence** in knowledge acquisition and decision-making is essential. Hierarchies and power relations can influence the level of trust among stakeholders, which in turn affects the uptake of knowledge. Promoting an environment that encourages independent thinking and decision-making helps to foster a culture of self-reliance and confidence in utilising acquired knowledge. Building trust and equalising power dynamics among stakeholders support effective knowledge transfer and uptake.

4.4.2 Training and education solutions

Three categories of solutions were mentioned by the participants: approaches to training, training of different stakeholder groups and the different modes of learning. Various approaches to training were advocated to enhance knowledge dissemination and skills development among farmers. Demonstration farms which are relevant for farmers of all ages and experiences create a learning environment where farmers can share their own experiences and network with each other. **Peer-to-peer knowledge exchange** at the local level encourages collaboration and sharing of expertise among farmers. Training based on **quantitative data from real farms** provides practical insights and evidence-based approaches. Developing **user-friendly tools** that farmers can easily implement helps in the adoption of new measures. Creating inventories and integrating tools that **store data and success stories** facilitate access to relevant resources. Developing a common platform involving all **stakeholders**, including researchers, farmers, advisors, policy-makers and institutions, promotes **collaboration and knowledge sharing**. Implementation of a **common EU digital platform** for both theoretical and practical education can facilitate widespread knowledge dissemination. Developing **training courses focused on agrobiodiversity** enhancement in rural areas helps raise awareness and promote sustainable practices. Utilising platforms such as YouTube or podcasts allows farmers to access knowledge at their convenience, with algorithms suggesting similar videos or training. Offering a variety of training formats on similar topics **accommodates different learning preferences and needs.**

According to the participants, training programmes should target different stakeholders to ensure comprehensive knowledge dissemination and skills development:

- **Exchange programmes similar to Erasmus** can be created specifically for farmers, enabling them to share their experiences and knowledge with one another.
- **Organising seminars at the local level, combined with social events**, provides opportunities for networking and knowledge exchange.
- **Identifying pioneers in sustainable practices and training them** can help spread their expertise to other farmers, facilitating continuous learning.
- **Training scientists** to present the results of projects or trials in an appropriate and accessible manner ensures more effective communication of research findings.

According to the participants, the use of different modes of learning is important in ensuring effective knowledge dissemination and engagement:

- **Establishing advisory committees** with elected representatives, including local farmers, ensures diverse perspectives and expertise.
- Providing an **effective extension service** that offers support, guidance and practical advice to farmers assists in knowledge transfer.
- Conducting **attractive and engaging training** that captivates participants' interest encourages active participation and enhances the learning experience.

Research can help implement user-friendly and accessible educational approaches to enhance knowledge transfer and engagement among farmers by **simplifying messages** for farmers, ensuring clear and understandable communication. Researchers can **break down information** into short, focused questions with visual aids, making knowledge transfer more accessible. Research entities can offer **short courses instead of full-day conferences**, allowing for more focused and digestible learning experiences. Meeting with farmers in the field and providing **hands-on learning opportunities** and practical demonstrations to farmers can assist knowledge transfer.

Researchers can also **utilise demonstration farms** as hubs for discussion and learning, showcasing practical examples that farmers can relate to.

4.4.3 Associated research needs from practice

In this café session suggestions were made on **trustworthy data, courses tailored to specific, easy to answer questions, up to date education programs, capacity building, evaluation benefits** and finally improved **collaboration between researchers and farmers**. To optimise education and training for sustainable pest, disease and weed management in practice, the group made a recommendation **to gather robust and trustworthy data** from field trials, ensuring the reliability of research findings.

According to the participants, important aspects that can help improve education on sustainable pest, disease and weed management, are updated and included in innovative educational programs: Analyse and update educational content to **include new challenges and emerging issues**. Develop educational courses dedicated to **showcasing the latest solutions**, available on learning platforms. Tailor courses to **address specific needs** of different groups within the agricultural community. Create and provide **digital tools** for farmers to address problems and facilitate knowledge exchange through country or region-specific forums.

According to participants, it is good to implement survey and case-control monitoring to **identify knowledge gaps**: Analyse the current knowledge level of farmers to identify gaps and areas for improvement. Deliver tailor-made solution packages, involving farmers and IT experts to address specific needs.

To support capacity building, to teach and train effectively, participants emphasised the need to create and deliver **one-to-one mentoring programs** for long-term knowledge transfer and support, and to **build the expertise and skills of education professionals** to effectively train and engage farmers. In addition they emphasise the requirement to develop training programmes supported by education experts, **ensuring high-quality delivery** and impactful learning experiences.

It was found **useful to conduct evaluations** of the educational programs evaluating the benefits derived from educational programmes through feedback and input from farmers and establishing exchange channels and exploring different education methods to foster continuous improvement and effectiveness.

Participants' advice was also to **encourage collaboration** between researchers and farmers by bringing researchers into farms, promoting partnerships and knowledge sharing. This will allow for practical application of research findings and facilitate the transfer of scientific knowledge to real-world agricultural practices.

4.5 Sociological pro action café

Sociological aspects may hamper the development or use of sustainable Integrated Crop Management strategies. The perceived increased risk of strategies with reduced (or not) pesticide use or the individual values and perceptions of farmers may influence their preferred farming methodology. During this pro action café, participants were asked to discuss the sociological issues that may hamper the transition towards sustainable management of pests, diseases and weeds.

4.5.1 Sociological challenges

Participants discussed challenges such as "How can we effectively engage with large groups of conservative farmers, including those who firmly believe in the status quo and resist change?" This resistance to change is, according to the participants, influenced by factors such as age and generation. Many farmers have been trained in conventional agricultural practices that heavily rely on pesticides, which reinforces their reluctance to change. There is generally a **low willingness among farmers to adapt or change behaviours** that have been working for them in their farming operations.

Another challenge raised during this session was the bad reputation of farming, which hampers farm succession, and, as a result, there is a shortage of new people entering the agricultural communities. In numerous EU regions, farming is not considered as an attractive occupation. Participants asked themselves "**How can we ensure a smooth transition from one generation to the next** and convey the message that farming is a rewarding career choice?" Nowadays, in many cases, becoming a farmer is actively discouraged.

Implementing on-farm changes encompasses various aspects, such as technical upgrades, management practices, contracting arrangements and work methodologies. However, **change is inherently difficult and requires significant effort and adjustment** from farmers.

Participants emphasised that **fair pricing of food and agricultural products**, particularly in relation to IPM, also presents a complex challenge. This involves considerations such as taxes, raising awareness among the public and policy-makers, establishing true pricing mechanisms, effective marketing strategies and meeting the changing demands and expectations driven by rural-urban shifts. For instance, urban people relocating to the countryside may demand different agricultural practices and ask new questions. It is crucial to manage food prices and availability while also aiming to increase the market share of organic or IPM products by influencing consumer behaviour and their willingness to pay for the associated additional production costs. A question raised in this context was: "How can we effectively target a new generation that genuinely desires healthier products?"

Data sharing plays a vital role in scaling up IPM practices, but several sociological aspects hinder collective learning among stakeholders. Limited data sharing is influenced by concerns about trust (how will my data be used?), privacy considerations, competition (reluctance to provide to a competitor with an advantage), and issues of ownership and data management.

The sociological dynamics surrounding safety and security procedures are important when attempting to change agricultural practices. Within agricultural communities, there can be **significant peer pressure** and individuals risk being ostracised if they deviate from established norms. There are even cases where implementing change can lead to personal safety threats and sabotage. It is essential to have support from supply organisations and insurance companies to ensure a safety net during the change process.

4.5.2 Solutions to sociological challenges

Regarding the low incentive to change, the advice of some participants was to use a **balanced approach to promote change, combining both obligations and nudging behaviour**. Obligatory measures are effective in reaching a large group of more conservative farmers who generally comply with laws and regulations. Nudges and behavioural changes can be facilitated by living labs and participatory approaches, drawing on the experiences of farmers. It is important to find both "sticks" (strong motivators) and "carrots" (positive incentives) to encourage change. Modifying insurance approaches/systems to **provide support for farmers** during the process of change is essential. By ensuring farmers feel supported and protected, they are more likely to adopt new methods and practices.

The second suggestion of the group was to **use education** on Integrated Crop Management techniques to drive changes in agricultural practices. Additionally, information and research results are needed to address and co-ordinate social changes effectively. Demonstrating **proven solutions that bring benefits** to farmers can be impactful. Creating spaces for demonstrations where farmers can learn from practical examples and consumers can learn about old and new agricultural practices is also beneficial.

The third set of solutions were related to the challenges brought about by the bad reputation of the farming occupation. To **create a new agricultural identity and language**, participants thought it may be worthwhile to use ambassadors, model farmers, who can serve as influencers for new generations. Making farming more attractive through incentives and finding the right language and media to address issues for different target audiences and age groups is important. It was found necessary to shape a different narrative and storytelling around agriculture, emphasising the identity of the "good farmer" and leveraging the culture within agriculture.

Participants' advice was to **use bottom-up, farmer-centric approaches in communication**. Instead of focusing solely on problem-oriented conversations, starting with positive aspects and building upon them can be more effective. Clear policies with readable intermediate goals that are owned by all stakeholders are crucial. Creating new or integrated value chains and involving all relevant stakeholders are key elements of this approach.

Participants discussed different governance structures and farmer-citizen relations. They concluded that **exploring alternative models** such as citizen-owned farms, community-owned farms, farm associations, and collectives, **can lead to positive change**. Emphasising short-chain approaches can also contribute to addressing challenges related to governance, education, identity, citizen engagement and sociological safety.

And lastly, the importance of **data sharing** was raised by participants, as it also was in previous café discussions. By following established guidelines and principles, data sharing can be facilitated, enabling joint learning among stakeholders and overcoming obstacles related to trust, privacy, competition, ownership and data management.

4.5.3 Associated research needs from practice

Participants argued that it is important to **develop and present different discourses and frames for discussing IPM**, including connecting it to broader challenges such as climate change and economic insecurity to communicate the benefits of changed practices. They emphasised the importance of exploring various farmer reasoning and beliefs on sustainability and understand what motivates farmers to change their practices. It was advised to investigate the factors that make farmers willing to change or partially change their practices, to explore what farmers need to feel co-ordinated and reassured to start changing their practices, including examining ways to enhance co-ordination among farmers, creating safe spaces for exchanging practices through farmers' groups, and identifying the necessary learning programmes to support change.

Furthermore, participants mentioned the following research needs from practice: to support farmers in the change process, **develop harmonised insurance criteria for sustainable farm practices**, incorporating sustainability evolution into insurance policies to lower premiums for farmers based on standardised criteria. Assess the impact of the insurance systems on the adoption and implementation of best available practices. Investigate how these insurance systems can be integrated into policies and established as permanent frameworks. Develop scenarios that **compare common practices with known sustainable practices in terms of economy, safety and well-being**. Explore different agro-economic systems that are attractive to young farmers, considering farming system types, agro-ecological practices, diversification, on-farm biodiversity practices and their impact on farmer well-being. Study the well-being of farmers, considering different farming system types and practices, including aspects of health and personal satisfaction.

In addition, the role of **Agricultural Knowledge and Innovation Systems (AKIS)** in facilitating and accelerating change to IPM was discussed. It was suggested **to analyse** factors needed for successful transition and for understanding how to effectively reach farmers. It was also mentioned to improve primary and secondary school education regarding agriculture, farming and the rural-urban relationship, raising awareness, knowledge and appreciation for primary production and nearby rural areas.

Participants also made suggestions to investigate which incentives are most effective in increasing the societal value and recognition of farmers, testing different types of incentives and developing education and communication campaigns based on the findings.

It is important to note that some research needs are inter-connected and can be linked to multiple solutions, as outlined in the training and education pro action café.

5. Part IV: Opening the door to the future

The second day of the workshop was devoted to future collaborations and networking.

5.1 Overview of EU research & innovation opportunities

After a short re-cap of the first day event, Gisela Quaglia, research programme officer at the European Commission, presented an overview of EU research & innovation opportunities for healthy crop systems within Horizon Europe, from 2021 to 2027. Funding is divided into 3 pillars:

- Excellent science
- Global challenges and European industrial competitiveness
- Innovative Europe

Gisela Quaglia invited the participants to have a look not only at Pillar II Cluster 6, which encompasses funding opportunities related to **Food, Bioeconomy, Natural Resources, Agriculture and Environment,** but also, for example, in Pillar III, notably for innovations close to the market. Gisela Quaglia highlighted that Cluster 6 has a considerable budget for the period 2021-2027 of 9 billion euros, covering issues of particular interest for the participants.

She presented the four research and innovation priorities for plant health:

- enhance capacities to prevent, monitor and control plant pests;
- develop safe and environmentally friendly methods for plant protection (IPM) and weed control;
- increase the resilience of plants to biotic and abiotic stresses by bringing more diversity into farming and forestry systems and provide farmers and other actors in value chains with better-adapted crop varieties;
- improve conservation, management and use of plant genetic resources, thereby preserving and enhancing agrobiodiversity.

Several projects on this thematic area have already started from the 2021 and 2022 call, others are scheduled for this year (the call of 2023 just closed). Results will be known by the end of the year. The call for 2024 opens on 17 October 2023[5]. These include topics for:

- tackling outbreaks of plant pests;
- promoting minor crops in farming systems;
- promoting pollinator-friendly farming systems;
- reintroduction of landscape features in intensive agricultural areas;
- increasing the availability and use of non-contentious inputs in organic farming;
- thematic networks (connected to operational groups).

Horizon Europe has new instruments, namely **co-funded partnerships** with member states and associated countries. Two of them could be of interest to participants in the future: Partnership on agroecology (europa.eu), and ec_rtd_he-partnership-agriculture-data.pdf (europa.eu). She highlighted two new Horizon Europe projects: the **EU-FarmBook** project (eufarmbook.eu), an open-source platform which will gather and share knowledge created by Horizon and other projects, led by Ghent University; and the **SUPPORT** project (www.he-support.eu), which will develop relevant and actionable knowledge to be used in co-creation design with actors of public policies and private sector strategies, led by Wageningen Research.

Lastly, Gisela Quaglia promoted the **2023 EU AgriResearch Conference**, which took place on 31 May and on 1 June (all materials are accessible here: https://agriculture.ec.europa.eu/events/eu-agricultural-research-and-innovation-conference-2023-05-31_en).

Subsequently, Suraj Jamge presented the role and functioning of National Contact Points (NCP) for Horizon Europe using the Dutch one as an example. He invited people to reach out to national NCPs to assist on future calls.

5.2 Idea and project exchange market

In the final interactive session of Open Space, participants were asked to bring forward their future project ideas. Next, the ideas were discussed in break-out rooms to develop project ideas further and to identify joint actions. Participants were asked to join the 8 ideas that inspired them the most:

- Boosting code of practices for plant protection products (PPP);
- Technical aspects to reduce pesticides;
- Collaborate with other countries on crop protection systems;
- European Network of integrative technologies for sustainable farming (for reducing pesticides);
- How to reduce the use of PPPs in a realistic way, new IPMWORKS demo-farms network in your country or region;
- Thematic Network on Insects problems across the EU (there is low number of conventional solutions);
- Create link between legislation makers and end users (producers) (practical experiences and actual feedback to policymakers);
- Economic and social indicators of sustainable pesticide use innovation.

Participants worked together on developing ideas for these topics and formulated follow-up actions. Some of the groups will ask NCPs to support their idea, as currently there is no funding opportunity in the near future. Others were to contact the NCPs to look for demonstration farm programmes. A third group's action was to engage discussions with local policy-makers to organise funding that enables participation in IPMWORKS demo-networks. Others simply agreed to stay in contact.

[5] For more information you can visit: Funding & tenders (europa.eu)

What will you take home?

"tons of ideas to empower farmers"
"there is no single solution"
"opportunities for cooperation"
"examples of what is possible!"
"a desire to work together and collaborate"
"the need to work in a realistic way"

After participants shared their take-home messages, the workshop was closed by **Magdalena Mach**, Policy Officer at the European Commission, DG Agriculture and Rural Development, who pointed out that the workshop results clearly indicate the need for farm-specific support and collaboration between farmers and researchers to reach Farm-to-Fork targets linked to the reduction of pesticides. In conclusion, she reminded everyone that the EU CAP Network - Innovation, knowledge exchange and EIP-AGRI, keeps on supporting farmers on their way to achieving these targets by offering opportunities to exchange knowledge and experiences.

6. Annexes

6.1 Summary of the economic pro action café

	Challenges	Solutions
Economic challenges hampering individual farmers	Individual farmers have limited time to experiment	Provide customised mentoring and advisory services
	Lack of financial room for unsuccessful trials	Establish an insurance system that serves as a safety net for farmers
	Investments in equipment are too high	Establish dedicated green financing options
Economic challenges hampering general implementation	Lack of a replicable, viable business model for IPM that accounts for yield losses	Implement an output-based business model that offers yield insurance to overcome yield losses and reward ecosystem services delivered
		lower product taxes for sustainable agricultural products
		Develop green brands and marketing solutions
	Competition between farmers in different contexts	Reduce all funding disparities between Member States
		Impose similar demands on imported agricultural products

Research needs

- Analyse the productivity and profitability of Integrated Pest Management (IPM) strategies at the farm level.
- evaluate the economic impact of implementing sustainable practices in various contexts.
- Conduct research to harmonise and holistically assess the impact of implementing different IPM strategies.
- Identify the most cost-effective economic incentive.
- Support innovative startups that challenge the status quo by introducing disruptive business models.
- Research the country-specific and EU-wide economic impact of the Farm to Fork strategy, including its effects on crop yields and food imports.

6.2 Summary of the ecological pro action café

	Challenges	Solutions
Ecology and sustainable pest, disease and weed management	Quantitative information on the relationship between ecosystem services and pest, disease and weed management strategies and tactics	Develop new and improve existing monitoring practices
		Use smart traps and labour-inexpensive monitoring tools
		Develop effective management strategies based on threshold levels of key pests, diseases and weeds
	Increased risk of alien pests, diseases and weeds on individual farm ecosystems	Enforce legislation to prevent the introduction and establishment of alien pests and diseases
		Develop preventive approaches for key invasive pests
	Local conditions require a good translation of general plant protection measures with positive ecological impact	Establish demonstration farms that provide practical examples and facilitate knowledge transfer to farmers
		Include local knowledge and experience for effective and context-specific sustainable farming practices
	Biodiversity friendly practices are not valued in the market	Encourage the creation of labels beyond organic certification that value biodiversity friendly practices

Research needs

- Develop new and improved techniques for detecting and sampling pests, diseases and weeds
- Understanding of the population dynamics of bio-control agents, both micro- as well as macro organisms.
- Develop integrated crop management strategies, based on biocontrol agents.
- Gather data on the impact of non-chemical control techniques and strategies on biodiversity.
- Develop soil biology indicators to better manage soil health.
- Develop models to assess and predict the impacts of climate change on crop production.
- Make farm biodiversity measurable and comparable.
- Make digital databases of (anonymous) European Union farmers accessible to the scientific community.

6.3 Summary of the technical pro action café

	Challenges	Solutions
Technology and sustainable pest, disease and weed management	Lack of bio pesticides for arable crops	Make regulation framework for bio-pesticides fast and affordable
		Develop new biocontrol pesticides, e.g. DNA/RNA techniques
	Data is scattered and data platforms are not compatible with equipment, or each other	Create harmonised and interoperable data platforms
	Monitoring and detection of functional biodiversity, pests, diseases and weeds is time consuming	Develop real time monitoring detection techniques
	Agro ecological farming systems are hard to manage due to all processes and scales involved, and costs of equipment high	Develop proper data processing systems that are interoperable with precision mechanisation
	Costs of investments are high	Increase funding options for farmers
		Buy services, not machines
	Lack of resilient cultivars	Develop resistant, tolerant and competitive cultivars
	Internet accessibility is low	Stimulate 5G coverage in rural areas

Research needs

- Develop agro-ecological solutions with related adapted technology.
- Analyse the impact of new technologies on their efficacy.
- Develop harmonised data platforms.
- Investigate the potential of genetic resources, e.g. new varieties developed with new breeding technologies, DNA based monitoring of pests and diseases, and the use of satellite imaging for detection.
- Develop models that can predict crop, pest, disease and weed population growth.
- Do NOT start with technological possibilities, but START with the need of farmers instead. Investigate the role of advisors. Maybe they need to be targeted, instead of the farmers themselves.
- Search for new modes of actions for pests and disease control, and develop decision support systems.

6.4 Summary of the education and training pro action café

	Challenges	Solutions
Education adn training for sustainable pest, disease and weed management	Connecting individuals who possess specific knowledge with those who require it	Stimulate peer-to-peer knowledge exchange Use quantitative data from real farms in attractive and engaging training Collaborate and share knowledge amongst all stakeholders to convey a similar message Accommodate different learning preferences and needs with a variety of training formats Exchange programmes similar to Erasmus for farmers Train scientists to present the results in an appropriate and accessible manner Provide an effective extension service
	Finding persuasive and relatable ways to present the information	
	Design and timing of training sessions tailored to farmers needs and demands	
	Independence in knowledge acquisition and decision-making	

Research needs

- Simplify messages, break down information, offer short courses and use demo farms for hands-on learning opportunities for farmers.
- Develop updated and innovative educational programs, including new challenges and emerging issues, showcasing the latest innovations, addressing specific needs using digital tools.
- Identify farmers knowledge gaps and specific needs for tailor made education and outreach programs
- Encourage collaboration between farmers and researchers.

6.5 Summary of the societal pro action café

	Challenges	Solutions
Societal aspects and sustainable pest, disease and weed management	Low willingness among farmers to adapt or change behaviours	Use a balanced approach to promote change, combining both obligations and nudging behaviour Ensure a smooth transition from one generation to the next
	Change is inherently difficult and requires significant effort and adjustment	Use education on integrated crop management techniques to drive changes in agricultural practices
	Bad reputation of the agricultural sector	Create a new agricultural identity and language to mitigate the bad reputation, use farmer role models
	Fair pricing of food and agricultural products	Exploring alternative governance structures and farmer-citizen relations, such as citizen-owned farms
	How to target a new generation that genuinely desires healthier products	
	Significant peer pressure	Provide support for farmers during the process of change
	Concerns about trust, privacy considerations, competition and issues of ownership and data management hamper data sharing	Establish guidelines and principles to facilitate data sharing, enabling joint learning among stakeholders and overcoming obstacles related to trust, privacy, competition, ownership, and

Research needs

- Develop and present different discourses and frames for discussing IPM, connecting it to broader challenges such as climate change, to communicate the benefits of changed practices.
- Investigate the factors that make farmers willing to change or partially change their practices
- Develop harmonised insurance criteria for sustainable farm practices
- Develop scenarios that compare common practices with known sustainable practices in terms of economy, safety, and well-being.
- Explore different agro-economic systems that are attractive to young farmers, considering farming system types, agro-ecological practices, diversification, on-farm biodiversity practices, and their impact on farmer well-being.
- Study and publish about the well-being of farmers, considering different farming system types and practices, including aspects of health and personal satisfaction.
- Analyse use of Agricultural Knowledge and Innovation Systems (AKIS) to facilitate knowledge sharing and accelerate change, including identifying AKIS success factors and understanding how to effectively reach farmers.
- Improve primary and secondary school education regarding agriculture, farming, and the rural-urban. relationship, raising awareness, knowledge, and appreciation for primary production and nearby rural areas.
- Investigate which incentives are most effective in increasing the value and recognition of farmers.

Innovation & Knowledge Exchange | EIP-AGRI
Koning Albert II-laan 15, 1210,
Brussel, België
+32 (0) 2 548 12 87
innovation-knowledge@eucapnetwork.eu

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