# Learning and meaning-making in IPMWORKS hubs

Deliverable D1.2

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**An EU-wide farm network demonstrating and promoting cost-effective IPM strategies**

**Coordination and Support Action (CSA)**

**01 October 2020 – 30 September 2024 (48 months)**

# Deliverable D1.2

# Learning and meaning-making in IPMWORKS hubs

## (Lessons learnt on the impact of the demo IPM hubs on the adoption of IPM practices through the case studies)

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# Abstract

Learning is an essential process within sustainability transitions, such as the transition towards a more holistic implementation and integration of pest management practices on field, farm and landscape level. Farmers are willing to diminish their use of phytosanitary products, but often lack the knowledge and support to integrate alternative practices in their farm management. IPMWORKS Farm Demonstration Hubs (IPMWORKS hubs in short) are groups of 10–15 farmers, facilitated by an agricultural advisor, who experiment with pest management practices and visit each other's farm to learn, provide advice and support one another. These IPMWORKS hubs are an effective way for farmers to find the actionable and locally adapted knowledge and the peer support to enable transitions in their pest management.

Three of these IPMWORKS hubs served as case studies to explore how these hubs define what Integrated Pest Management (IPM) could be implementable on farms, what farmers knowledge needs are, and how farmers learn from each other during farm visits and on-farm demonstrations.

The results show that IPMWORKS hubs have the potential to create interpretations of Integrated Pest Management that are local, applied, adapted to farming context, and more meaningful in farmers' lifeworld's. This meaning-creation happens during processes of learning and community development. IPM practices and strategies are meaningful to farmers if they can be explained in relation to field ecology, if their implementation is clear, if they are feasible within a field management context, if they fit in a farm system, and if they are supported by the farming community. By engaging in different interaction patterns within the hub, farmers create learning opportunities for each other, enabling them to learn experientially from each other's and shared experiences, as also, binding them together in a supportive community. Advisors have an essential role in facilitating learning interactions and organising the hub so it can function as a platform for community development.

Policy recommendations based on our work include the need to: 1) Provide the group with the agency to define their own planning and practice; 2) Value the role of the advisors by giving them time and training in social-organisational skills; 3) Foresee resources to support farmers to experiment on-farm with different pest management practices to demonstrate to other farmers; 4) Fund experimental stations to carry out systemic and comparative trials; 5) Organise a hub of hubs and foresee resources for cross-visits between hubs; 6) Listen to the stories that emerge from the hub and use the hub as a platform for dialogue and rural proofing.



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# 1. Introduction to the report

Our project task description was to Deepen insights in the impact of IPMWORKS hubs on the changes in knowledge, mentality and behaviour of farmers regarding IPM adoption on the long term through case studies.

In the chapter 'research context & glossary' an introduction is provided on IPMWORKS hubs and on the main subject of this report, namely 'learning'. We then discuss integrated pest management (IPM) as a practice that is not easily adoptable, and that its contestable, revolutionary, and normative nature poses challenges for farmers. We go on to argue that experiential learning in communities of practice (CoP) is essential to overcome these challenges and that IPMWORKS hubs are suitable learning environments to facilitate this learning process.

The research addressed two research gaps. The first is around what knowledges farmers share in IPMWORKS hubs and how these knowledges define IPM in farmer terms. The second is the lack of research on interaction patterns between participants of IPMWORKS hubs that enable them to learn from each other during farm visits, demonstrations, and other meetings. Therefore, the two research questions that are addressed in this report are:

> **RQ 1:** Which knowledge on IPM is needed, shared, and questioned between farmers in IPMWORKS hubs that enables them to re-define IPM as a meaningful practice adapted to their farming context?
>
> **RQ 2:** Which interaction patterns in IPMWORKS hubs facilitate discussions on the practice and meaning of the demonstrated IPM practices and strategies?



Observations are done in three case study IPMWORKS hubs (a soft fruit hub and a zucchini hub in Belgium and an arable hub in The Netherlands). The analysis of these observations is presented in the two results sections. In the first results section, the topics that the farmers address, the examples that they share and the knowledge that they show and explain to each other, are reported and insights are gained around what they see as important knowledges to understand and practice IPM. Based on this, their definition of IPM as a farming practice is made explicit. In the second results section we analyse how they address questions, share examples, and open new topics in the conversations, to gain insights in the interaction patterns of IPMWORKS hubs that enable them to discuss the practice and meaning of IPM practices and strategies. Each results section includes a facilitation tool, mainly directed to advisors who facilitate IPMWORKS hubs on IPM, but also useful for policymakers and other stakeholders who are involved in IPM implementation. At the end of the report these results are discussed and recommendations are given about the different roles of advisors that have been observed in the cases and on facilitation techniques that could foster learning within IPMWORKS hubs.

The purpose of the report is to gain insights into the functioning of IPMWORKS hubs as platforms for farmer learning on integrated pest management (IPM) and their impact on the adoption of IPM by its participants. The underlying aim of this research is to open up the perspectives of what could be possible outcomes of IPMWORKS hubs and how these outcomes open up the possibility for change in general on the farm level, without quantifying the actual practical changes a farmer has made. We argue that IPM is not a one-shot change, but requires constant adaptations and innovations. It thus requires a constant learning process to improve their IPM practices and strategies.

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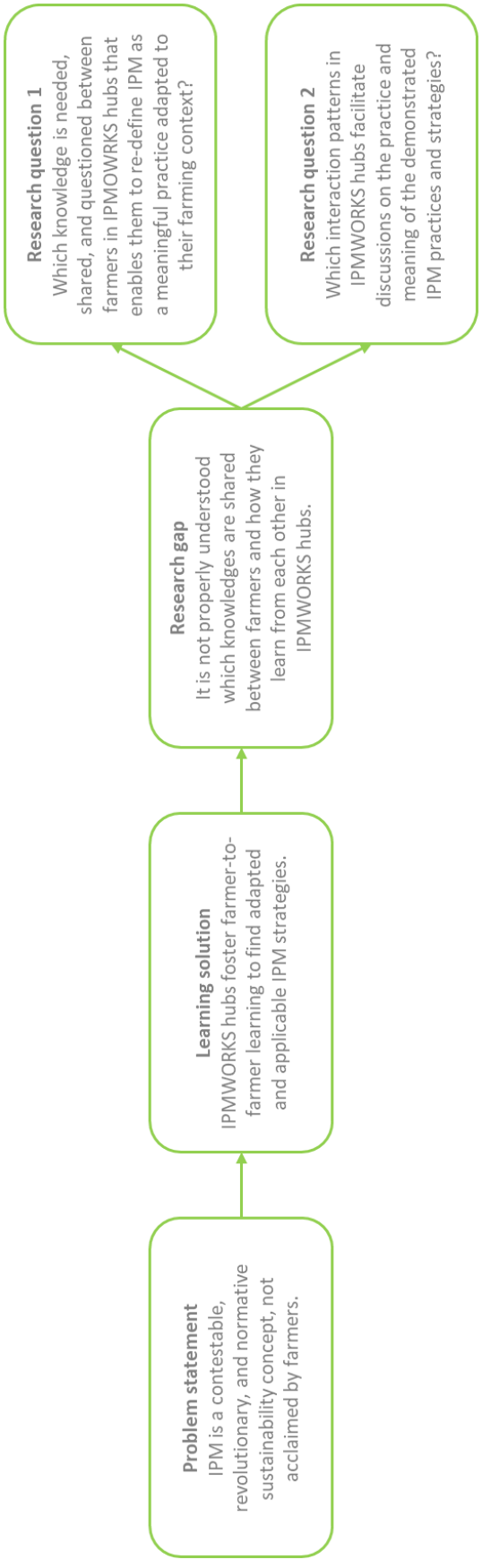


*Figure 1Structure of the deliverable.*



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# 2. Research context & glossary

Learning is frequently mentioned as an important process for finding solutions for sustainability questions (Moyer & Sinclair, 2020). Social learning is assumed to leverage the knowledge and acceptability needed to face the challenges of the contestable, revolutionary, and normative nature of sustainability questions (Loeber et al., 2009), and thus also those related to IPM. In the case of agriculture, advisors play an important role in initiating and guiding farmers' learning processes (Faure et al., 2012; Herrera et al., 2019; Ingram & Mills, 2019; Labarthe et al., n.d.; McDonagh et al., 2013; Nettle et al., 2017). To support social forms of learning, policies and advisory services in Europe are recognising a need for less top-down transfer-of-technology approaches and a move towards more participatory approaches (Faure et al., 2012; Leeuwis & Van den Ban, 2004). Farmers are not perceived any more as adopters of technologies, but as active agents that bring in their own types of knowledge which are needed to understand their environment and actions in complex ways (Bartlett, 2008; Šūmane et al., 2018). Advisory methods that are based on farmer-to-farmer interactions and on-farm demonstration are gaining popularity (Sutherland & Marchand, 2021). Based on these findings, the IPMWORKS H2020 project initiated 22 farmer 'hubs' in which farmers can learn about integrated pest management (IPM) from each other and demonstrate these lessons learned to a wider audience.

## 2.1. Preview: What is learning?

The UNESCO International Bureau of Education defines learning as "The complex and long-term psychosocial process consisting of the individual acquisition or modification of information, knowledge, understanding, attitudes, values, skills, competencies or behaviours through experience, practice, study or instruction." (Amadio et al., 2013, p. 35). Many theories exist that define learning, the learning process and the learning outcomes (Illeris, 2018). In this report we focus on experiential learning and use the Communities of Practice theory (Wenger, 1998a) to frame learning more specifically as an interaction between individual experience and social interaction.



Subsequently, our understanding of 'knowledge' in this report is not confined to individual cognitive storage of information, but to a broad spectrum of knowing that respects different kinds of knowledges, which all in their right perspective, can help to understand the world (Murdoch et al., 1994). Followingly, in this report, it is assumed that a variety of knowledge sharing activities are necessary to share a variety of knowledges (Blankenship & Ruona, 2009).

## 2.2. What are IPMWORKS hubs?

IPMWORKS hubs, referred to in the IPMWORKS project as 'hubs', can be interpreted as learning environments:

> **Learning environment:** defined as the total of the content, artefacts, places, actors, types of interactions and activities, pedagogical and instructional techniques and tools that are put in place to create a learning experience that leads to certain learning behaviours and outcomes (Wasson & Kirschner, 2020).

IPMWORKS hubs or hubs are specific learning environments which implement farmer-to-farmer interactions and on-farm demonstration to facilitate social learning. IPMWORKS hubs are groups of 10-15 farmers who

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meet regularly on each other's farms to share and learn about farming practices and strategies. Basic elements that the hubs in the IPMWORKS project have in common include:

- **Hub members:** The farmers often work in the same agricultural sector and region to enhance comparability and stimulate peer-learning. Farmers are committed on a voluntary basis to do on-farm experimentation with new IPM practices and strategies to develop applied and farmer relevant knowledge that can be shared in the group.
- **Hub coach:** IPMWORKS hubs are usually facilitated by an agricultural advisor, also called the 'hub coach'. The hub coach can have different roles and tasks depending on the needs of the group. Typical roles are the communication and organisation of the practicalities of the meetings, facilitating and encouraging knowledge sharing, fostering community development, supporting on-farm experimentation, or liaising with other hubs and external stakeholders and experts that could play a temporary role in the group. Hub coaches received training on soft skills to facilitate such hubs in the IPMWORKS project.
- **Farm visits & hub meetings:** Knowledge is shared between group members during farm visits on each other's farms. These farm visits are the main activities and aim to build tacit knowledge in the group and create discussion moments to give applied and direct peer-advice on IPM practices and strategies. The hubs can also organise other learning activities such as webinars or meetings in research institutes.
- **Demonstrations:** The hub can organise demonstrations to disseminate their knowledge to the wider farmer community. At demonstrations, one of the hub members opens his/her farm to show farmers from outside the hub their experiences with IPM practices and discuss their IPM strategies.
- **Evaluation & planning meeting:** The group is farmer-led in the sense that the farmers choose the topics and agree on the planning of the group to ensure relevance and ownership. Annually they evaluate the previous year and discuss together what they want to put on the agenda of next year. They discuss different pest, disease, and weed problems they have had and expect and who will try which IPM practices and strategies and when they can be visited. Other topics and activities, like which expert could be invited to talk about a certain topic or join a farm visit, are also discussed.
- **Cross-visits:** Since the hubs are part of the IPMWORKS project, that attempts to set-up a European hub of hubs, there is the possibility for hubs from different countries to visit each other.



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# 3. Problem statement & hypothesis: IPM, a contestable, revolutionary, and normative sustainability concept

Farmers are always searching for potential ways to protect their crops against resistant pests, new pests, higher pest pressures due to climate change, and pests for which phytosanitary products are restricted in Europe (Lamichhane et al., 2015). Farmers are also searching for potential ways to diminish their use of phytosanitary products in an economical viable way. Policies like the Farm-to-Fork targets of the European Commission and the Sustainable Use of Pesticides Directive (SUR 2009/128/EC) impose the Integrated Pest Management (IPM) framework to help farmers to manage their pesticide use (Barzman et al., 2015; Hillocks, 2012; Lee et al., 2019; Lefebvre et al., 2015). A further development and deepening of IPM strategies on farms are necessary to achieve greater effectiveness (Lamichhane, 2017). But there are several challenges to IPM that prevent this further development and implementation by farmers. As Loeber et al. (2009) explain, sustainability questions suffer from three main challenges. Firstly, sustainability does not have universally applicable solutions and so every practical attempt is contestable. Secondly, sustainability solutions are often revolutionary in nature, meaning that the implementation of solutions might require 'system innovation' and opening up unusual ways of understanding and working. Thirdly, sustainability is a normative concept with a high pressure on 'doing the right thing', but also a need of co-defining what this 'right thing' is. Translated to the case of IPM, a more advanced implementation of the IPM concept on farms is hampered by the same challenges:



**IPM is contestable.** Deguine et al. (2021) speak of an 'IPM nebula' to indicate that over 50 years from its conception, a multitude of different definitions have been drafted, all giving different interpretations of the concept. They conclude from this that IPM can be adapted to many different situations. Followingly, they state that the lack of coherence and the use of the concept by so many different actors in different ways might mean that the IPM concept has become incompatible with its original ecological sustainability objectives. Because research mainly continues to work in silos, each focussing on their specific topic in IPM, it fails to fulfil the 'Integrated' aspect of IPM, thereby ignoring the interactive effects of the multiple pests and pest management measures in the ecological complex system that a farm is (Ehler, 2006; Stenberg, 2017). Research tends to remain in a one-on-one problem-solution thinking, which does not resonate with the complexity of farming. IPM is not a universally applicable concept, because pest management strategies should be defined per farm, based on the ecology and the human capacity of farms (Barrera, 2020; J. P. Deguine et al., 2023; Wyckhuys et al., 2023). Without truly integrated research, these locally defined pest management strategies remain pragmatic and thus contestable.

**IPM is revolutionary.** In their seminal work Liebman and Gallandt (1997) refer to ecological management of crop-weed interactions as the use of 'many little hammers' instead of the use of 'one big hammer'. This means that an IPM strategy consists of many different interacting practices that directly and indirectly suppress crop-weed interactions, instead of using one herbicide. This implies an increased complexity in the management of weeds on farms, also indicating that the complexity for managing weeds and pests and diseases increases even more and might get contradictory at certain points (Bastiaans et al., 2008). As Hill and MacRae (1996) have stated, the ecological turn in agriculture requires re-design of the farm as a system.

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They envision a stepwise transition from industrialised farms that become more sustainable by improving the efficiency of their way of working and substituting several practices, towards agroecological farms that work with (and not against) ecosystems and local inputs. They righteously state that a re-design of a farm towards an agroecological farm is very knowledge and skill intensive and demands a broad focus. A re-design, but even also a step towards efficiency and substitution, might break away from usual ways of working, requires a lot of (new) knowledge, and can entail great risks of failure (Bakker et al., 2021; Burton, 2004; McGuire et al., 2013).

**IPM is normative.** Farming is trapped in an entrepreneurial model that focusses on production framed in a 'feeding the world' narrative, and on controlling ecosystems with chemical and technological innovations that are external inputs to the farm, claiming that the entrepreneur has the autonomous right and duty to do so (Emery, 2015; Hardeman & Jochemsen, 2012; Stock & Forney, 2014; van der Ploeg, 2018). For many farmers, their identities, motivations, attitudes, and norms are directed towards this model, highlighted by the fact that farmers often identify and compare themselves in terms of investments, yields and 'clean' fields (Burton, 2004; Burton & Wilson, 2006; Letourneau & Davidson, 2022). IPM strategies might have outcomes such as lower yields or accepting more weeds on the fields, harnessing what many farmers perceive as the norm of what a good farmer is (Lamine, 2011; McGuire et al., 2013). Farmers are competing for their future and believe they have a moral right to keep on producing (Bjørnåvold et al., 2022; van der Ploeg, 2020). Certain groups in society hold different opinions on this belief. The farmers protests all over Europe in 2024 triggered among other things to the withdrawal of the target of halving pesticide use by 2030 (announced by European Commission President Ursula von der Leyen on 06/02/2024). This shows that here is no normative and political consensus on how to achieve the reduced use of phytosanitary products and the protection of crops against pests, diseases, and weeds.

IPMWORKS proposes that IPMWORKS hubs can help overcome the contestable, revolutionary, and normative challenges of sustainability challenges like the implementation of IPM. By firstly finding IPM practices and strategies that are applied to the sector and regional specificities and that are adapted to farmers' needs. Secondly, by sharing applied and actionable knowledge from peers on how to re-design the pest management strategies of their farms into complex strategies based on many interacting practices. IPMWORKS hubs provide the platforms to obtain peer advice on what to learn from experiments, to learn from each other's experiences and to exchange embodied and tacit knowledge. And thirdly, by allowing farmers to compare views, values, and attitudes, to negotiate meaning, to find peer support for changes, to access positive examples, and to create positive narratives on IPM. To conclude, IPMWORKS hubs are interesting learning environments to facilitate peer learning and foster the exchange of experience-based, discuss the acceptability of this knowledge, and create pest management strategies that are defined by farmers themselves and normalised within the farmer community.



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# 4. Conceptual framework: Experiential learning in Communities of Practice

Theoretical conceptualisations of similar learning environments as the IPMWORKS hubs give insights in the learning processes and outcomes of IPMWORKS hubs that could possibly lead to overcome the contestable, revolutionary and normative challenges of IPM as proposed in the hypothesis above.

Communities of Practice (CoP) as a concept introduced by Wenger (1998), is useful to describe the above mentioned social learning processes between professionals on knowledge needed to execute their profession, as well as to stress the importance of negotiating the meaning of this knowledge to their profession, ensuring acceptability of this knowledge within their community of professionals.

As defined in literature (e.g. (Blackmore, 2010; Farnsworth et al., 2016; Illeris et al., 2009; Wenger, 1998b)), CoPs are formed by people who engage in a process of collective learning in a shared domain of human endeavour. CoPs are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly in joint activities. Through this regular interaction they develop relationships and a shared repertoire of experiences, stories, tools, ways of addressing recurring problems that enable them to learn from each other. CoPs primarily emphasize the tacit learning of collectives.



The CoP theory as proposed by Wenger (1998) puts social relations, exchanges, and negotiations within professional development on the forefront, and expands the concept of learning from an individual cognitive process to a process of social construction of meaning. Learning in CoPs assumes that knowledge and knowing are socially defined competences to participate in actions that are valued by others and so making one's experience of and engagement with the world meaningful and creating a sense of belonging and identity. Central elements of the CoP learning theory are the making of 'meaning' by interacting in a 'community' on how to improve one's 'practice'. The community negotiates the meaning of a practice while sharing and learning on it. The concepts can be defined as follows (after Wenger, 1998):

- The **'practice'** is the collective development of action trajectories and working theories that defines what is understood as practice by the community and defines the identity/expertise of a practitioner. Members of a CoP develop a shared repertoire over time, that sustains their mutual engagement and makes them 'real' practitioners. This shared repertoire are the communal resources and exists out of routines, sensibilities, artifacts, vocabulary, styles, experiences, stories and cases, tools, ways of addressing recurring problems, frameworks, and perspectives.
- The **'community'** refers to the group of practitioners bound into a community, firstly by their shared experiences of being a practitioner, and secondly by their commitment of learning together by sharing experiences. Mutual engagement of the members to participate in joint activities, discussions, helping, and sharing knowledge and competence defines how the community functions. It creates relationships that binds the members to the community and enables them to learn from each other.
- The **'meaning'** refers to how the practitioners negotiate why different perspectives on the practice and changes to the practice are meaningful and relevant in the lifeworld of a practitioner. The process of learning in a community of practice is one of defining what the practice is, understanding how to practice, but most of all a process of meaning making on that practice, which is a shared

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understanding of why to practice. Wenger introduces 'meaning' because he sees learning as a socially constituted experience of meaning making. This meaning making process can be perceived as a constant interaction between the individual practices of the community members and the other members of the community, who try to understand what the one does and negotiate this with their own understanding of the practice. The final product of this interaction is a shared meaning that binds them as a community.

In the context of farm advisory, the CoP concept was successfully applied to show that having a clear topic, purpose and common objective (i.e. a practice) is essential for farmers' engagement in the CoP and that the negotiation of the meaning of this practice is defining the space of possibility in which learning can happen (Dolinska & d'Aquino, 2016; Krzywoszynska, 2019; Madsen & Noe, 2012; Morgan, 2011). IPMWORKS hubs can be framed as CoPs because the farmers are committed to improve their practice of farming. The farmers are engaged to help each other in their learning process and together give new meanings to changes in their practice.

Additionally, in the CoP theory, the concepts of the 'experiential learning theory' as defined by Malinen (2000) are added to the framework. The experiential learning theory is used to specify the learning process within the CoPs, describing how the group can transform their experiences they have of being a 'practitioner' (i.e. a farmer, implementing IPM) through discussion and the farm visits, into rational and personal knowledge. The experiential learning theory as defined by Malinen (2000) consists of five modes of thinking: retrospective, critical, analytical, rational, and personal, that are necessary in this transformation process. These modes of thinking are defined as (after Malinen (2000)):

- **Retrospect:** Recognising a current experience as something that has been experienced before.
- **Critical:** Testing one's understandings of an experience on contradictions and false assumptions.
- **Analytical:** Searching where contradictions and assumptions came from, making knowledge gaps more concise.
- **Rational:** Searching for new insights, knowledges, and experiences to reconceptualise previous experiences and justifying these reconceptualization's as true.
- **Personal:** Giving personal meaning and relevance to the new truth.



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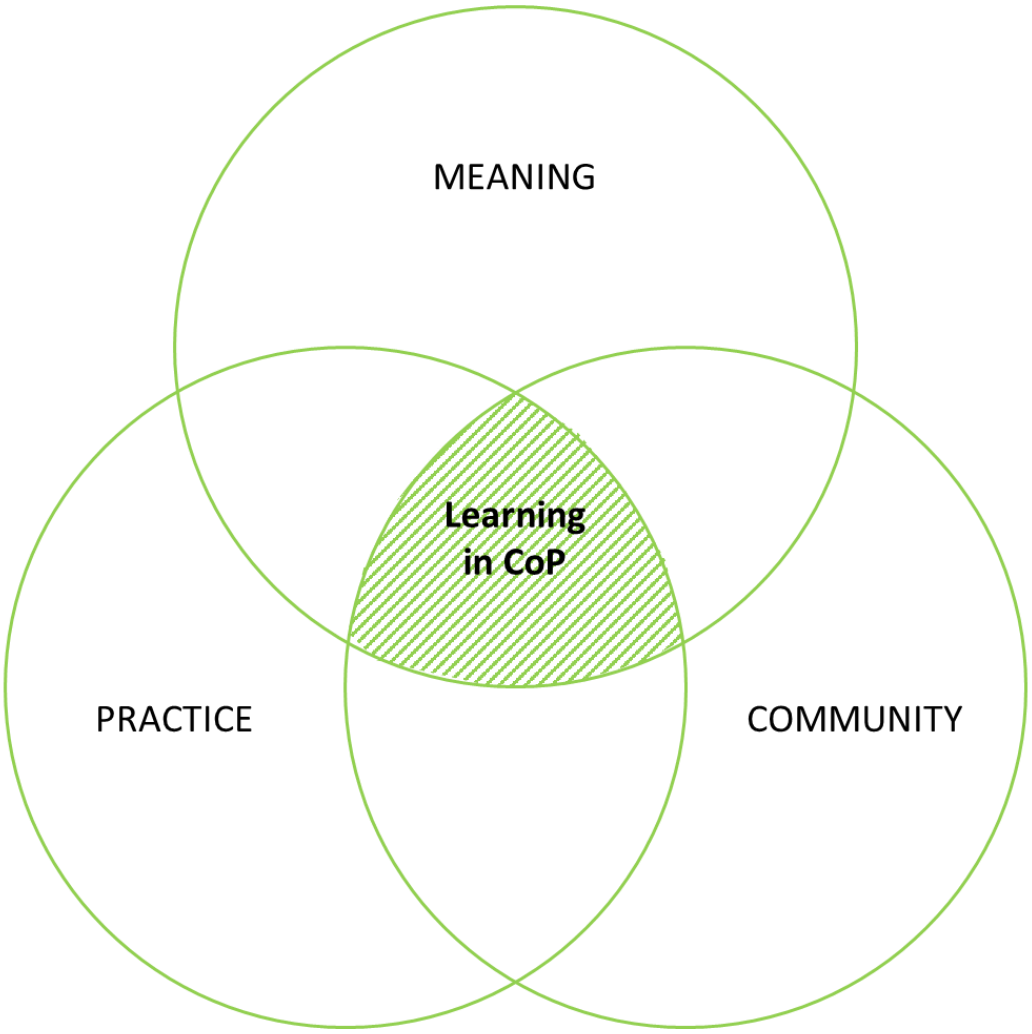


*Figure 2 Communities of Practice framework.*



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# 5. Research gaps & questions: Which meaning is shared in IPMWORKS hubs and how?

The purpose of this deliverable is to develop insights in the impact of IPMWORKS hubs and understand the learning processes within IPMWORKS hubs focussed on helping farmers overcome the contestable, revolutionary, and normative challenges of integrated pest management (IPM). Therefore, the main question is: How do IPMWORKS hubs enable farmers to define locally adapted, actionable and acceptable IPM strategies? This question is split into two main research questions:

Firstly, science and policy have proposed the concept of integrated pest management (IPM) to reach this objective, often referring to a set of 8 principles as defined in the Sustainable Use Directive (2009/128/EC) (Barzman et al., 2015), that must steer farmers' choices of which practices to use to manage their pests, diseases and weeds. The problem with the concept of IPM is that it is rather abstract and not adapted to the totality, practicality, and complexity of the management of a farm. The concept is not written in the same terms in which farmers understand their farm management and conceptualise pest management. It is not yet defined as a 'farmer practice'. From a Communities of Practice perspective, the constant process of co-defining the 'practice' enables practitioners to develop a shared knowledge from which they can learn to become better practitioners. Such shared knowledge is crucial in learning and innovation processes towards sustainable farming strategies to value farmer knowledge (Šūmane et al., 2018) as shown in research on how farmers make their own conceptions of sustainable farming (e.g. Cristofari et al., (2018); Ingram et al., (2010)). Research on farmer CoPs shows that farmers are capable of defining their own learning requirements to advance more in sustainable agriculture, which happens as a constant process that develops through defining group priorities, exchanges with advisors and scientific experts, through new entrants bringing in new insights, and generally progressing understanding within the group (Morgan, 2011; Triste et al., 2018). So far, no research or policy has defined IPM from a farmer perspective based on farmer knowledge. Therefore, farmers in IPMWORKS hubs should have the agency to define for themselves what IPM means for them, just as professionals in a CoP co-define their 'practice' themselves. Hence, the first research question is:



**RQ 1:** Which knowledge on IPM is needed, shared, and questioned between farmers in IPMWORKS hubs that enables them to re-define IPM as a meaningful practice adapted to their farming context?

Secondly, the learning process that farmers in a IPMWORKS hub are involved in by interacting with each other is described. In line with CoP theory, the hypothesis is that farmers of a IPMWORKS hub build a community by engaging in interaction patterns that provide learning opportunities for other farmers and enables them to discuss the meaning of IPM in their farm management. Research shows that learners reflect together on collective and individual experiences, by interacting and conversing, constructing new meanings on these experiences (Baker et al., 2005). 'Reflection' is not so much seen as an individual cognitive action, but as an inherent social interaction mediated by normative structures, identities, social relations, cultural artefacts, and forms of speech (Seaman & Rheingold, 2013). Therefore, reflecting and reasoning together through conversation is only possible within an agreement on how mutual interaction should proceed. Participants in IPMWORKS hubs commit to a certain reasoning, by following the speech and dialogue appropriate to that reasoning (Rips, 1998). In the context of farmer CoPs on sustainable farming practices, through conversation, farmers define boundaries around what the practice is about, have protocols on how

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to narrate an experience, know to whom to refer to and which instruments to mention to legitimise their story, and use shared conceptions of nature to argument the truth of their ideas (Goulet, 2013). The purpose is to deepen these research insights in the interaction patterns between the participants of IPMWORKS hubs, that enable them to learn and collectively argue and negotiate the meaning of what is shown and discussed during the IPMWORKS hub meetings. Hence, the second research question is:

**RQ 2:** Which interaction patterns in IPMWORKS hubs facilitate discussions on the practice and meaning of the demonstrated IPM practices and strategies?



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# 6. METHODOLOGY

## 6.1. Design

To answer the above questions, we performed a qualitative cross-case analysis based on longitudinal observational data. We opted for qualitative research to obtain a 'participant perspective' on the importance of the topics discussed and show the relevance of certain practices and knowledge in the participants' life world (Ashworth, 1997; Flick et al., 2004; Luis Small & McCrory Calarco, 2022). Longitudinal data collection was needed to first get acquainted with the different IPMWORKS hubs and their participants and to gather data from multiple meetings and activities to get insights in a variety of topics and contexts. Data were acquired through observing the interactions and contexts in which the farmer interactions happen during the IPMWORKS HUB meetings.

## 6.2. Case selection

Three IPMWORKS hubs were selected as cases (see table 1). The choice was made for hubs within IPMWORKS that were accessible distance-wise – an important practical consideration in terms of the longitudinal observations. Also, a positive contact with the facilitating advisor was needed to create a willingness to cooperate in the research. The Belgian hubs of soft fruit farmers and of zucchini farmers and the Dutch hub of arable farmers were deemed different enough to show variety in knowledge and knowledge exchange throughout different agricultural and social contexts. Also, these contexts were deemed transferable to other hubs in resource intensive agricultural contexts. It has to be noted that Europe has a wide variety of agricultural contexts, and so that the results are not transferable to the whole of European agriculture.



## 6.3. Procedure for Data Collection

Data gathering happened through observations and notetaking, with a focus on the conversations between the participants and the context in which they happened. Learning is perceived as constant and dialectic processes between individual considerations and social interactions. Social interactions like conversations are the moments where these individual considerations are made explicit. Only what is made explicit, depending on the openness of the participants, is observable. So, what can be observed during meetings of IPMWORKS hubs is only a snapshot of different processes of learning. The purpose of the research is therefore not to quantify or to explain all learning during these moments, but to explore and explain the parts of these processes that are made explicit and understandable for others in these specific contexts.

The observational notes follow the structure of the agenda of the meeting or activity. Every moment of the agenda and the informal in-between moments were noted as different parts. For every different moment we described where we were, what there was to see and how the participants interacted with the location. Attention was given to the material dimension of farm visits, questioning how surroundings and artefacts made certain interactions (im)possible, and how the participants engaged with these. The observer attempted to take notes of conversations, and described who was involved in the conversation, the topic and the prompt of the conversation, the tone of the conversation, the dialogical elements (questions, examples, opinions, comparisons, reflections, etc.), and quotes. After the meeting or demonstration, the notes were supplemented with descriptions from memory, and with more general reflections on the atmosphere and dynamics of the meeting. After some of the meetings, the facilitating advisor clarified topics that were not clear for the observer. Field notes were transcribed in different documents per meeting or demonstration. These documents were archived in accordance with privacy regulations.

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56 hours of observations were done during 17 meetings over three years (2021 – 2024) divided over the three IPMWORKS hubs (see table 2). Results were presented and discussed with the participants and facilitating advisors of the IPMWORKS hubs during their yearly evaluation & planning meetings early 2024, as a means of validation.

The farmers of the IPMWORKS hubs signed an informed consent form to participate in the H2020 IPMWORKS project, allowing scientific data to be extracted and used. The purpose of the observers' attendance was explained at multiple meetings.

## 6.4. Analysis related to Research Questions

To answer RQ1 every meeting was coded separately in NVivo. By this open coding, every different topic that was addressed, every reference to a previous experience that was made, every in-field observation that was shared, and every question that was posed, was coded to a thematic node (Corbin & Strauss, 1990). In a second round of analysis, these different nodes were categorised by selective coding into overarching categories that describe the knowledge shared in the different nodes of the first coding round. Followingly, interpretations were made on the knowledge needs experienced and expressed by the members of the cases. Finally, examples of observed situations and quotes were selected per category to be reported in the results, based on their representativeness for the category and completeness of the observation, as also with the purpose of showing the diversity across the cases (Corbin & Strauss, 1990).

To answer RQ 2 every meeting was coded separately in NVivo based on the categories defined in the experiential learning theory as interpreted by Malinen (2000) (i.e. retrospect, critical, analytical, rational, and personal). In a second round of analysis, all observations of different meetings that were coded to this category were sub coded in NVivo, so that sub nodes per category helped distinguish the type of interaction between participants or the type of activity organised by the advisor. Both were interpreted as facilitating specific learning modes of the experiential learning theory.



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| | Soft fruit hub | Zucchini hub | Arable hub |
|---|---|---|---|
| **Country** | Belgium (West-Flanders) | Belgium (West-Flanders) | The Netherlands (North Brabant & Limburg) |
| **# hub coaches (Institute)** | 1 (INAGRO) | 2 (INAGRO) | 3 (WUR) |
| **Linked to experimental station** | Yes | Yes | Yes |
| **Number of farmers** | 11 | 11 | 16 |
| **New hub** | Existing group with extra new members. Most hub members were part of a working group that focussed on the use of beneficials. This group was also led by Inagro. | Yes | No. Members were seeking continuation of their participation in the former Veldleeuwerik hub. Crop protection was not included in their previous group activities. |
| **Main topics** | Thematic focus on main pests and diseases (thrips, aphids, spider mite, white fly, Drosophila suzukii, root diseases, grey mold, powdery mildew), beneficials, and crop varieties. | Thematic focus on pollination, nutrients, virus, quality of starting material, work organisation, and crop varieties. | Thematic focus on integrated weed control, foliar pathogens in potato, onion and sugar beet, DSS and robotisation. |
| **Context** | Soft fruit growers with mainly strawberries, cultured in two different manners (in soil or in hydroponics); most growers deliver to the auction house, others sell on farm. | Intensive vegetable cropping systems, mostly for the auction house or the deep freeze industry. | Main crops for the province of North Brabant in 2022 were: wheat, maize, potatoes, sugar beet and onions + various vegetables. |

*Table 1 Description of case study hubs.*



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| Observations | | | | | |
|---|---|---|---|---|---|
| **#** | **Hub** | **Date** | **Location** | **Theme** | **Exposure (h)** |
| 1 | Soft fruit | 24/01/2022 | Inagro | IPM strategy & planning | 3 |
| 2 | Soft fruit | 4/05/2022 | Hub member | Flying doctors | 2 |
| 3 | Arable | 13/06/2022 | Vredepeel | Ekobot | 3 |
| 4 | Zucchini | 30/06/2022 | Inagro | Varieties, fruit set, mildew | 3,5 |
| 5 | Arable | 8/07/2022 | Vredepeel | Leaf fungi & blight app | 2,5 |
| 6 | Soft fruit | 10/08/2022 | Hub member | Drosophila suzukii | 2,5 |
| 7 | Soft fruit | 20/01/2023 | Inagro | Evaluation & planning | 4 |
| 8 | Arable | 24/01/2023 | Vredepeel | Evaluation & planning | 5 |
| 9 | Soft fruit | 21/04/2023 | Hub member | Substrate | 3 |
| 10 | Zucchini | 31/05/2023 | Inagro | Varieties, biofoil | 2,5 |
| 11 | Arable | 23/06/2023 | Hub member | Farmdroid | 2,5 |
| 12 | Soft fruit | 30/06/2023 | Inagro | Varieties, fertilisation, bankerplants | 2,5 |
| 13 | Arable | 18/08/2023 | Hub member | Leaf fungi | 3,5 |
| 14 | Soft fruit | 29/09/2023 | Hub member & WUR | IPM strategies | 5,5 |
| 15 | Zucchini | 7/12/2023 | Inagro | Evaluation & planning | 2 |
| 16 | Arable | 11/01/2024 | Vredepeel | Evaluation & planning | 5 |
| 17 | Soft fruit | 6/02/2024 | Agrotopia | Evaluation & planning | 4 |
| | | | | | |
| | | | | **Total** | 56 |

*Table 2 Description of observation moments in the three case studies.*



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# 7. Results 1: Defining a meaningful practice - Knowledge (needs) for a holistic understanding of IPM

## 7.1. Introduction

In this first part of the results, it is attempted to describe the knowledge shared between farmers in IPMWORKS hubs, to get insight in what they see as important knowledges to understand and practice IPM, with the purpose of making explicit their negotiated definition of IPM as a farming practice. Particular attention is given to knowledge needs that are expressed by farmers.

By following the conversations between farmers, listening to the ways they explain to each other what to do and how to do it, looking at what they demonstrate, we tried to define the terms, concepts, and knowledges in which farmers think when they think about IPM. Which kind of information and knowledge do farmers ask for, to understand problem situations, to understand the concept of IPM, and to redesign their pest management strategies? In this section, these different knowledges are presented as different topics with some examples observed in the different cases to clarify and contextualise the topic. We identified five 'categories of understanding' under which these different topics are presented.

From the observations it is proven that IPM as a fixed concept is not used that much in the IPMWORKS hubs, rather IPM is perceived as a logic, a way of thinking, a reasoning strategy, that helps farmers to understand if certain pest management practices and strategies are meaningful to them, to their farm and to the farms' IPM strategy. IPM as practice (and not as a 'concept'), is the reasoning strategy, the meaning structure, common to the farmers in the IPMWORKS hubs, that stems from their similar activities, from their similar way of working, from their similar way of trying to manage pests. Farmers explained new knowledge or new IPM practices within these five categories of understanding that make up the reasoning strategy. The meaning of new information, knowledge, experiences, stories, impressions, narratives, etc. on IPM practices that are presented in demonstrations, farm visits, testimonies, expert presentations, etc. is assessed by placing them in each of the five categories that form their reasoning strategy, their practice. By doing so, they assess the validity and meaning of these knowledges shared. Within each category a pre-set of knowledge is present, stemming from previous experiences and interpretations, which forms the basis for assessing the validity and meaning of that new knowledge within that category of the reasoning strategy. Circulating knowledge enables them to find meaning for the difficulties and success that practicing this practice in an ever-changing and difficult to grasp reality causes. Through circulating and assessing new knowledge they gain autonomy in their decisions on how to carry out that practice.



The five categories of understanding that make up their reasoning strategy are as follows, and are explored in more detail in the following section:

- **Understanding crop and pest biology in relation to field ecology**, in which knowledge on crop resilience, beneficial organisms, pest spreading and monitoring is shared between farmers, advisors and invited experts in order to understand the (potential) pest problem situation and the biological and ecological principles of certain IPM practices;
- **Understanding IPM practices and their implementation**, in which farmers share know-how, know-when and know-why about certain IPM practices to understand the possibilities of these practices,

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if these are suitable for and implementable in their conditions, and to improve their application of certain practices;

- **Understanding IPM strategies in field and crop management**, in which IPM is understood as all work in the field to manage multiple pests, diseases, and weeds. Farmers share information on their cultivation planning, on how IPM fits in this planning, on which decisions and priorities were made, and on how all these practices fit in an IPM strategy at the level of a field;
- **Understanding the role of IPM in the farm system**, in which a farm is perceived as a constantly evolving system with multiple actors and resources that have to be managed at different speeds and sometimes in different locations, and which are influenced by their environment and other overarching systems. Knowledge is shared on how the farmers constantly make decisions on which resources to use and how to cope with environmental variabilities in order to grow crops and make a living;
- **Understanding IPM in the farmer identity and community**, in which narratives are shared on farmers' social and political identities, and on how certain IPM practices and policies relate to these identities, and so, if these practices and policies should be accepted by the farmer community? In essence, opinions are shared on what it means to be a farmer and to farm.



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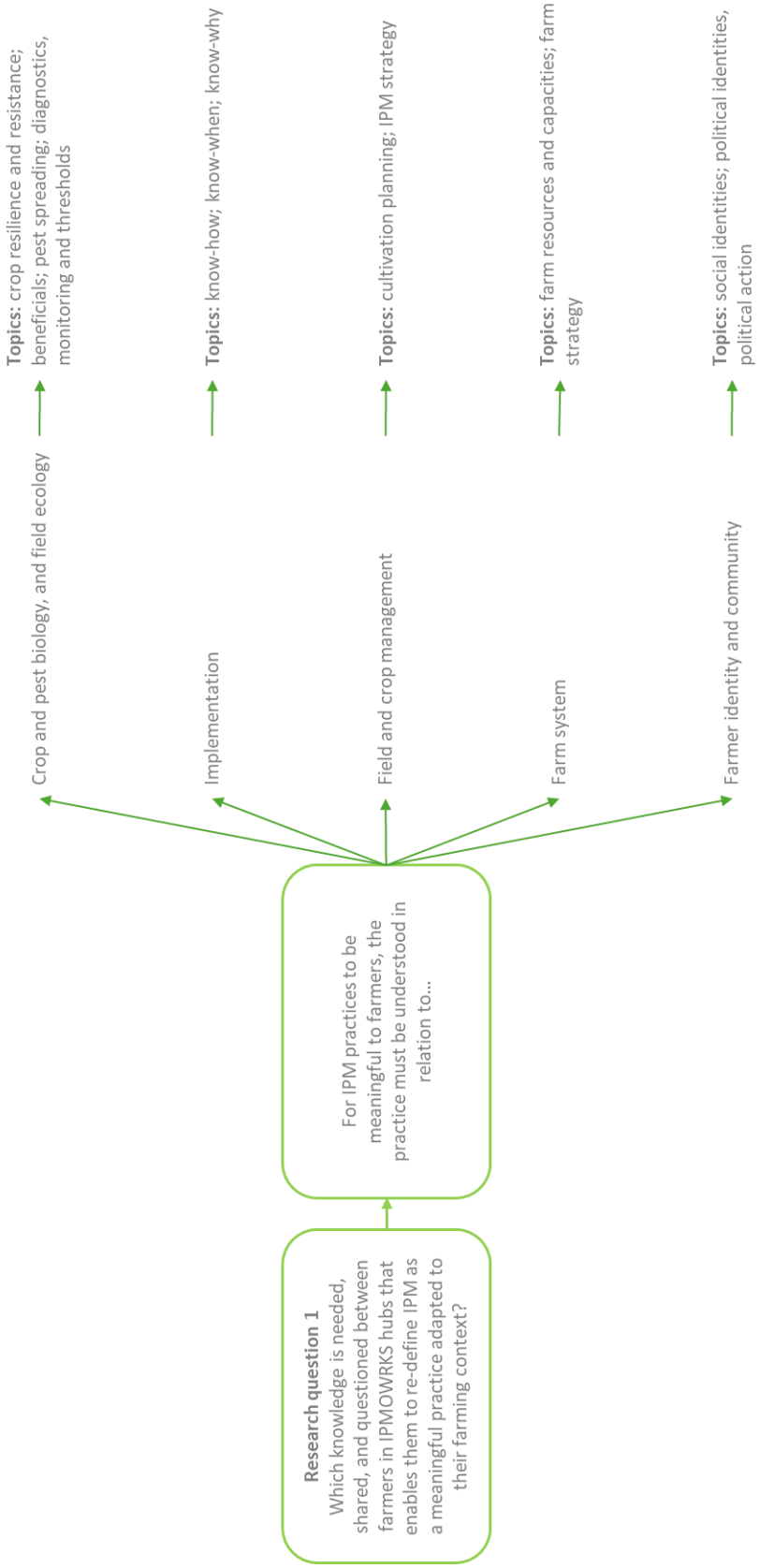


*Figure 3 Results on the knowledges for a holistic understanding of IPM.*



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## 7.2. Understanding crop and pest biology in relation to field ecology

Knowledge of crop resilience, beneficial organisms, pest spreading and monitoring is shared between farmers, advisors and invited experts to understand the (potential) pest problem situation and the biological and ecological principles of certain IPM practices

### 7.2.1. Crop resilience and resistance

**Crop resilience** is interpreted as the ability of crops to adapt to (a)biotic stresses. The crop-field-climate interactions that makes plants more resistant to pest and disease attacks was touched upon in all three hubs, but it was mainly in the arable hub that is was mentioned as an explicit part of IPM strategies by the hub coach or by invited experts/advisors who presented specific IPM practices that have an improvement of plant health as a (side)effect. Crop resistance was mentioned occasionally by the growers when they could observe differences in the plant's vitality related to the growing conditions or to IPM practices or field works they implemented. They evaluated the plants during field visits when the growers compared and evaluated the crop growth at a field by observing, for example, colour, size, leaf growth, etc. and comparing this to their experiences of how the plant should look like at that stage of development. An example, of how farmers refer to crop resilience happened during a field visit where a farmer experimented with the use of green manure instead of synthetic fertilisers. He explained that green manure renders more vigorous crops, but also more vigorous weeds and that it is therefore not a useful IPM practice. While advisors and invited experts explain crop resilience based on knowledge of the crops' physiology, farmers explain crop resilience based on the growing conditions and field works that made it possible for the crop to develop healthy and therefore more resilient than crops grown in bad conditions. There is a need for bridging these two complementary types of knowledges on plant resilience to be able to make effective IPM strategies on farm.

**Crop disease resistance** is the plant's resilience against a certain disease due to physiological properties that reduces the growth of that diseases on the plant. Knowledge on crop disease resilience was shared during conversations on crop choice or on specific diseases. Knowledge on which varieties are more resistant or susceptible to specific diseases was shared in all hubs between growers, based on experience, or between hub coach, invited experts and growers based on trials. The most interaction between the growers on this topic was when the host or trial field had different varieties and the presence of the disease in the field, so that differences in crop damage due to the disease were observable in the field. Crop disease resistance was only explained as a physiological functioning of the crop in the arable hub when experts on sugar beets and leaf diseases were invited – and even then it related to other IPM practices as different parts of a crop protection strategy. Based on the many questions from growers on variety resistance, together with their fear of losing the resistant varieties, and the interactions that experts on disease resistance provoked, highlights farmers' knowledge needs on crop disease resistance as a physiological principle and biological property of crops and the importance this property has in an IPM strategy.



### 7.2.2. Beneficials

Beneficial organisms are organisms that have a positive function in farm management. The type of beneficial organisms mostly discussed, are **predatory insects**, which are insects that feed or multiply on pest insects and can thus control pest pressure as a part of an IPM strategy. This topic was mostly discussed in the soft fruit hub and was one of the main topics of the hub, as many of the growers have IPM strategies based on predatory insects. The growers discuss when to implement the beneficials in relation to the pest pressure, thresholds and up to which point it is an effective strategy. They discussed about commercially available beneficials and not about naturally present beneficials. The growers do advise each other on the implementation of these beneficials and they keep putting such topics on the agenda during the planning of hub meetings, which shows that there are knowledge needs on the functioning, use and implementation of beneficials.

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Another common topic discussed in relation to beneficials is the **compatibility** of this IPM strategy with the use of phytosanitary products, with the main question being which phytosanitary products can be used without damaging their beneficials? These questions show that they have knowledge needs on the functioning of different products and on how and why biological and chemical based IPM strategies are or are not compatible.

Subsequently, a rather new topic in the soft fruit hub is the topic of **banker plants** that must serve as **habitats** or feeding places for the beneficials, helping them to survive when there are no pests available to predate. The topic was brought up by the hub coach who did trials at the experimental stations and saw examples at a field visit in Almeria (Spain). The growers showed interest and put it on the agenda at the latest evaluation and planning meeting, showing a knowledge need on habitats, life-cycle and multiplication of beneficials in general.

The topic of predatory beneficials was much less discussed in the zucchini hub and the arable hub. In the arable hub, it was brought up only once when a grower explained the effects of a flower strip he trialled and once when growers from another hub were invited from which there were some growers with experience in IPM strategies based on beneficials. In the zucchini hub, beneficials were used in the trials. The explanations on beneficials did not evoke many reactions, except for questions on costs and if the population maintains itself. However, some of the growers showed interest in beneficials, as one of the growers asked the hub coach during the demonstration of a UV-robot against blight if it would kill beneficials. In both arable and zucchini hubs, there was an interest in beneficials and an openness for knowledge on their functioning when related to specific IPM strategies.

A beneficial that stirred more conversation in the zucchini hub were pollinators. **Pollination** is the movement of pollen to the female parts of plants, causing fertilisation and the forming of seeds. This topic was only discussed in the zucchini hub, where the growers have a problem with pointed fruits, which are not marketable at normal prices. One of the major causes of pointed fruits is poor pollination. Growers discussed this with the hub coach when the (bumble)beehives in the experimental station were demonstrated, when data was shared on pollinator activity, or when the growers brought up the topic of synthetic growth regulators. The growers questioned why pollination is not happening as it should be. This indicates knowledge needs on pollinators, as well as knowledge needs on the biological causes of pointed fruits and of the importance of pollination in IPM strategies.



A final topic related to beneficials is **soil biodiversity**, which is the diversity of organisms that live in the soil. The topic of soil was discussed in general in the arable hub, related to topics of fertilisation, water management, or the difficulties that different soil types pose on work in the field, but growers rarely mentioned their concerns about soil life. When they did, soil life was linked to fertilisation techniques or to damage to soil life through the use of phytosanitary products. However, it was not linked to for example soil borne diseases or plant health, as it was discussed only once in the soft fruit hub during a meeting on substrate choice, soil borne diseases and the use of Trichoderma trialled on farm. This shows knowledge needs on the use of soil health and soil life in IPM strategies.

### 7.2.3. Pest spreading

Pest spreading is the multiplication and propagation of pests, diseases, and weeds. Both in the soft fruit and in the arable hub the growers questioned where these pests, diseases and weeds come from, or what the problem **source** was. This question was mainly posed by growers when they observed a sick plant during a farm visit, or when there was a high pest pressure in the area, or when they discussed the causes of a sudden pest outbreak in a field. The growers mainly point to imported pests via plants they bought or to a high pressure in the area or in neighbouring fields to explain the source of pest spreading. Often there were surprised reactions and lack of clarity on the origin and movement of pests, diseases, and weeds. This shows the farmers' knowledge needs on sources, hibernation, and different habitats of pests.

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Advisors or invited experts sometimes linked pest spreading with the presence of **host plants** for pests and diseases, which can be crops, but also other plants in the surrounding landscape that make it possible for these pests and diseases to survive and migrate. In the arable hub, the interactions between fields were discussed in the realm of crop disease resistance, which raised concerns for the growers on how to plan their crop rotation between different fields.

Moreover, advisors and invited experts link the spreading of pests, diseases, and weeds to favourable **climatic conditions**. This was sporadically discussed between growers in the soft fruit and zucchini hub when they shared information about a specific pest or disease or on the effectiveness of IPM practices, but these conversations were not as elaborate as in the arable hub. In the arable hub, it was always discussed in relation to practices to manage these conditions, to the development stages of the crops and how this creates microclimates, and to monitoring these conditions to predict and prevent outbreaks. The knowledge on the favourable conditions was mostly brought in by invited experts, hub coach or by monitoring systems, but was often complemented with the growers' own experiences on this matter. The discussions, questions and diversity in experiences shows a knowledge need in understanding the favourable conditions of pests, diseases, and weeds to develop in order to estimate the risks of outbreaks and a knowledge need on management practices to control these conditions.

Occasionally, the spreading of pests was explained by the advisor or invited expert based on the **life cycle** of a pest. The life cycle was visualised on a flipchart or poster, showing the different stages of pest development and reproduction. This enabled conversations on the ecological conditions of each stage and which IPM practices could prevent further development and spreading per stage. There is a knowledge need on this life cycle perspective for different pests.

### 7.2.4. Diagnostics, monitoring and thresholds

Diagnostics, monitoring, and thresholds are essential parts of IPM strategies to know which pests, diseases and weeds are present in the field and which risks they pose to the harvest and economic viability of the farm. In all three hubs, growers showed difficulties with diagnosing observed pests, diseases or weeds. On one occasion they expressed a problem with crop growth, linking it to an inherent problem of the variety, instead of considering the option that the problem originated from a disease. They shared these observations at informal moments between each other or with the hub coach. The topic of monitoring was only seldomly discussed between growers in the soft fruit hub. Most fruit growers hire advisors or external staff to do the monitoring of pests for them in relation to a IPM strategy based on beneficials, and so they outsourced this knowledge need. On the contrary, they do have questions on the monitoring of pests and diseases that are difficult to spot or that they do not know, and they do have interest when the hub coach gives explanations on how to recognise new pests. In the zucchini hub, monitoring was also only sporadically discussed between growers and between the growers and the field manager of the experimental station. It was also always discussed in relation to decisions in treatments and field works. Observing, monitoring and intervention thresholds were discussed the most vividly in the arable hub. The effective observation of pests and diseases in the crops was only explained when an invited expert showed how to recognise the different stages of the disease on the plant. But the growers mentioned observation as a regular activity. The topic of monitoring conditions and pest pressure was mostly brought up by invited experts or the hub coach and related to monitoring and decision support systems. Both in the soft fruit hub and the arable hub, growers had questions on how to link observations to thresholds and intervention decisions. So, there are knowledge needs on diagnosing crop problems, recognising pests, diseases and weeds in different life stages, and on thresholds for intervention.



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## 7.3. Understanding IPM practices and their implementation

Farmers share know-how, know-when and know-what about specific IPM practices to understand the possibilities of these practices, whether they are suitable and implementable in their conditions, and whether their application can be improved.

### 7.3.1. Sharing Know-how

Farmers share knowledge on how to implement an IPM practice. To share know-how on the implementation of practices, farmers demonstrate how practices are applied. They explain why these were applied that way, giving detail on the exact execution, and suggest each other adaptations of these practices. This know-how is shared 1) when a specific practice is demonstrated; 2) when farmers ask each other how certain practices were executed; 3) when innovations are discussed; and 4) when they try to analyse why a practice was a success or a failure. Several examples of how this know-how was shared were observed: In the soft fruit hub the use of new substrate was demonstrated and farmers started to mention their problems of substrate shrinking during the season. This opened a conversation on how to fill, brush and press substrates in a pot. In the zucchini hub during a trial on varieties, the farmers got interested in how the plants were supported with hanging ropes from the ceiling of the greenhouse and they started to show pictures on their phones to each other on how they attach the rope to the plant. When they went to a trial outside, one farmer noticed that the ridges on which the plants grow were too hard and questioned how this could happen. The host farmer explained what he did to make the ridges and what he thought had gone wrong. Other farmers then started to share how they make ridges. In the arable hub for example they discussed how to correct an irrigation sprayer with a sensor that measures air humidity to avoid phytophthora.

A practice that was discussed quite often in all three cases is how to spray phytosanitary products. They discussed the choice of product, the timing, frequency and dose of application, how to spray, the combinations of products or the combination with other IPM practices that can be made. The sharing of know-how was the most interactive when practices were demonstrated. Also, when field visits in experimental stations happened, it was important to involve the field manager or field worker who did the actual field work, to answer questions on how practices were implemented, and unforeseen adaptations were done in-field.



Questions about how practices were implemented was one of the most frequently posed questions, and the discussions following these questions the liveliest. This shows that farmers have great interest and knowledge needs on how to implement IPM practices in the field, which is knowledge that was only shared between farmers.

### 7.3.2. Sharing know-when

Sharing of know-when, which is related to the right conditions for implementing a practice, was often discussed in all three cases. For example in the soft fruit hub they discussed when it gets too cold during the season for beneficials to be effective against aphids, or that flying doctors (bumblebees that carry a product against botrytis that is applied on the strawberry flower when the bumblebee collects the pollen) are only effective in spring when the weather is dry, botrytis pressure is low and the plants are 'not too heavy' in terms of the density of foliage. In the zucchini hub, a UV robot against mildew was demonstrated. One of the farmers asked why this robot must run at night, to which the advisor responded that at night the humidity-level is better and only the blue light of UV should reach the mildew to destroy its DNA. In the arable hub, they discussed what the right parameters were in pest pressure, crop growth and weather conditions to know when to spray, and what the right soil conditions are for when to carry out ploughing, and when to sow crops and green manures. Discussions adressed in which contexts and under which conditions a practice works best, a machine is applicable, a strategy is suited, a variety is viable, etc. These discussions therefore considered the situatedness and context dependence of practices. Since farmers are very much dependent

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on the natural situation and climatic conditions, which are changing constantly, they have knowledge needs on when it is possible and advisable to implement certain practices.

### 7.3.3. Sharing know-why

Sharing of know-why relates to understanding what an IPM practice actually is, and therefore why it should or should not be implemented. This know-why comprises knowledge on the **purpose and function** of practice. For example, during a hub meeting a farmer of the arable hub explained that he wanted to test a practice that crumbles the top layer of the soil to prevent a chimney effect of the wind over the soil pores to keep moisture in the soil, and to make a false seedbed as weed management practice. Another example was that of the farmer family who tested an autonomous weeding robot, who explained how the robot sows based on GPS location of the seeds and so knows how to hoe between the plants, which is a different functioning than weeding robots based on plant recognition and so has certain advantages on this technique. In these examples the farmers explained the practices, their objectives, how to reach these objectives. Such understanding provides insights into how, when and why to use a certain practice. However, this knowledge was not shared as often as could have been expected. It happened only when a certain innovation was demonstrated, when a farmer took a special interest in the practice or when the product developer was present in the conversation.

When the farmers understand what an IPM practice is, it becomes possible to **compare** this practice with other practices that have the same purpose. The qualities, functionalities, efficacy, and efficiency of these practices are discussed and compared to be able to make choices on which practice would be the best to implement. For example, in the zucchini hub synthetic foils that are used to cover the ridges in which zucchini's are planted, were compared with bio foils that are supposedly compostable. It was found that with the bio foils the soil dries more, but that they did not have to be removed before planting green manures, hence saving time and costs. The modus operandi of the two different types of foil, the basic characteristics and qualities defining what each foil is, were compared and weighed to be able to make a decision about which to use.



Finally, the farmers discussed the **effects** of a practice on other practices and aspects of crop cultivation. Are there (unwanted) effects of a practice or strategy that go beyond the actual purpose for which the practice or strategy was implemented, and does it lead to synergies or trade-offs? For example, the farmers who tested a weeding robot experienced that when a robot is used, it is not possible anymore to use a tractor in that field at the same time, because the tractor makes trails that are too deep for the robot to get through. This means that the use of a weeding robot excludes certain other practices. In the soft fruit hub, this conversation was mostly on the compatibility of chemical and beneficials based IPM strategies, and whether the use of phytosanitary products has negative effects on the beneficials or not. In these examples the 'what', the basic functioning of different practices is analysed and compared to see whether they are compatible or exclusive.

These examples show that farmers need knowledge to understand what an IPM practice actually is, how it functions and what its basic qualities are to be able to make decisions on this practice.

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## 7.4. Understanding IPM strategies in field and crop management

Cultivating a crop from preparing soils to harvesting involves a whole range of field works (that can be more or less related to IPM), and comprises managing multiple pests, diseases, and weeds in the same field. As such, farmers shared information on their cultivation planning, how IPM fits in this planning, which decisions and priorities were made, and how all these practices fit in a IPM strategy at the field level.

### 7.4.1. Cultivation planning

When the farmers explained their cultivation planning of a crop to each other, they systematically explained the **process of cultivating** a crop from preparing, to seeding, growing, caring, harvesting, and storing. They detailed the why, how and when of each practice per development stage of the crop. This entailed explaining the field history, including the practices that have been used in the current and previous seasons and sharing their observations of how the crop developed. Also, they detail when which choices had to be made during the cultivation process, and explained why, based on what data and arguments, decisions were made. This means interpreting cultivation as a constant process of **decision making**, in which each decision has priorities, trade-offs and path-dependencies for future decisions. In the soft fruit hub and the zucchini hub, the hub coaches tried to facilitate a conversation based on a **schematic representation** of the cultivation planning by drawing a timeline on a flipchart, because it appears to be difficult for the farmers to structure such a planning as a testimony. Visualising the cultivation planning on a timeline enables the group to systemically discuss the different steps, and helps to keep focus, because conversations tend to quickly go into technical detail, which makes it difficult to compare the general planning between farmers. When innovations are presented, the farmers focus more on the total planning in their questions and conversations. For example, in the soft fruit hub a trial with everbearing strawberry varieties was done in the experimental station. The farmers questioned when the planting was done, when the first harvest peak was and if heating the trays in which the strawberries grow has an impact on when this peak comes. In the arable hub a hub member tested a weeding robot on his farm. When the other farmers visited him, his son, who has been experimenting with the robot, gave a testimony, explaining quite exactly when they planted, when they hoed, when they irrigated, etc. They discussed how the different timings that are possible with a robot give an IPM advantage, as for example one farmer noticed that seeding earlier has an advantage for the crop in comparison to weeds. So, there is a need to make explicit and discuss when and why which practices were implemented and based on which parameters to make choices in this planning.



### 7.4.2. IPM strategy

An IPM strategy is a plan of which combination of pest management practices that can be implemented against (un)expected pests, weeds and diseases to prevent crop damage or loss. In the hubs, IPM strategies were discussed on two different levels: Firstly, there is the level of the pest, disease or weed, for which the combination of practices to keep one particular pest, disease or weed under control was discussed. For example, at the experimental station of the soft fruit hub, the advisor explained that they control aphids by implementing hoverflies, lacewings, and ichneumon wasps, and installed banker plants for these beneficials to survive over the season. These are four different practices that are integrated to control one particular pest, aphid. Secondly, there is the level of the field, in which a multitude of pests, diseases and weeds can be expected and so a strategy is needed, composed of different practices for which some are specific for one of the pests, some are multifunctional and control different pests, and some combinations of practices have an added control effect. In the first level an integration of practices is done for one pest, disease or weed. In the second level, and integration of integrated practices must be done for multiple pests, diseases and weeds. In the soft fruit hub, the hub coach takes substantial time with the host farmer to prepare their testimony on his/her IPM strategy.

For a long time, it was conventional that a pest management strategy almost solely existed out of a **spraying scheme**, dictating which phytosanitary products had to be sprayed on which date against which pest, disease

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or weed. Spraying schemes disregard all contextuality of the crop and does not take into account the real pest situation in the field. Both in the soft fruit hub and the arable hub such spraying schemes were discussed and compared to see which sprayings could be replaced with other IPM practices. In the arable hub, farmers questioned each other who “still sprays on date?”, to which they discussed that the dates are a handy reference, but that they go into the fields to see whether spraying is necessary or could be confined to a specific part of the field. So scouting, monitoring, adapting doses and geographically phasing product applications are all practices that are part of their IPM strategy.

In all hubs, the farmers had questions on the practices that can be combined in a strategy to reach a sufficient effectivity against pests. They also raised questions on how to adapt strategies to different contexts, such as in different soils (sand vs clay) or different production systems (tunnels and soil vs greenhouse and substrate). There are knowledge needs on how to design an effective IPM strategy, which IPM practices can be combined, and how strategies can be adapted to local conditions.



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## 7.5. Understanding the role of IPM in the farm system

A farm can be perceived as a constantly evolving system with multiple actors and resources that have to be managed at different speeds and sometimes in different locations, and which are influenced by their environment and other overarching systems. In a system, every action is an interaction, defining the possibilities of other actors and resources in that system. Farm systems are part of wider systems which are susceptible to great variability and unpredictability, like the climate, ecosystems, markets and agricultural policies. A farmer has to constantly make decisions about the resources to use and how to cope with these variabilities in order to grow crops and make a living. A farm strategy can guide these decisions.

### 7.5.1. Resources and capacities on the farm

The resources and capacities in the farm system that make it possible to implement an IPM practice or strategy that are shared and discussed in the hubs are in the first-place **material resources** such as fertilisers, infrastructures, land, machinery, phytosanitary products, seeds, seedlings and plants, substrate, water, and energy. The farmers mainly discuss the (dis)advantages of different products and suppliers, such as discussed in the soft fruit hub, which suppliers has the best plants for the best price and with the least danger of importing pests. In all hubs, the loss of availability of phytosanitary products due to regulations is often mentioned.

The hubs also discussed the human resources, and more specifically, the availability and organisation of **labour and skills**. A first source of labour discussed was the work done by themselves, their families and staff. The farmers shared the difficulties of organising the work on the whole farm in a day-to-day planning and in a seasonal planning to manage the functioning of the whole farm system. When new practices are demonstrated, the farmers also question how much extra workload this practice will bring and when in the season this work must be done. In the soft fruit hub, they discussed that an IPM strategy against the suzukii fly should include 'hygiene' measures (cleaning prunings etc.), and that these measures are "theoretically possible", but in practice are too time consuming. All practices and strategies mean work that must be done by someone, within the limited time of a day-to-day and seasonal work planning. Farmers literally asked how many hours it takes to execute a task. Therefore, they also often questioned the **ease-of-use** to implement and execute a practice. Are practices tailor-made to the specific farm context, or is it instead a standard solution in which the farmer must invest time to adapt it to the own farm context? Both in the soft fruit hub as in the zucchini hub the 'ease of harvest' of a certain variety is a major factor in their decision, so harvest can be done as fast as possible, with the least amount of work. In the arable hub, the hub coach asked who is using a certain app to monitor phytophthora, to which the farmers replied that the app is not easy to use, that it takes too much time to fill in data and that it has no added value as compared to just monitoring it themselves.



Besides their own labour, they also discussed the accessibility, availability, affordability, skill, and organisation of seasonal workers and advisors. Regarding the **seasonal workers**, they mainly discussed difficulties in communication, in directing and training them, and organising their availability on the right moment in the season. In the soft fruit hub, the topic of seasonal workers was discussed informally very often between the farmers, claiming that it is difficult to motivate the workers, to know which work they can do, when they need surveillance, that they do not have the right skills, and that there are too many controls and fines on the administration of the workers. They stated that it would be useful to have a hub on how to manage seasonal workers and that they would consider the cost of investing in harvest robots if they existed. In the arable hub, the consideration between the cost and precision of weeding robots and hand weeders was a topic. Regarding the **advisors**, they exchanged who does 'good work', who has the right knowledge, who they can consult with questions and in emergencies, who can help to guide the installation of new practices and strategies. In the soft fruit hub, farmers shared which advisors are precise when doing monitoring, which ones think too much in terms of standard solutions, which are difficult to communicate with and which push too much to use certain commercial products. In the arable hub, the issue of advisory

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services was discussed more in the light of innovations like the weeding robot, e.g., when product developers claim that something is ready for in-field application, but that the farmers think that these developers and advisors should stay more involved to help and advise in the first stages of implementation.

In addition to materials and resources and labour and skills, a third form of resources discussed were **financial resources** and economic balance of the farm. This included on the one side the cost of production inputs, often expressed as price/input * input/ha (or /m), or the investment cost to implement new practices, and on the other side the revenue of the final product, for which they discussed the estimated impact of IPM practices on the quantity and quality of crop production, the amount of the crop that is damaged or lost due to pests, and the price of products offered in different market channels (auction, contract, direct sale, etc.). Subsequently, the efficiency and efficacy of practices was discussed, considering the resources and capacities that are available on the farm and in comparison to alternative practices. With efficiency they refer to how much work can be done by one technology with respect to the use of time, energy, investment? With efficacy they refer to: is one treatment sufficient or will multiple treatments be necessary? To what extent do practices or strategies take away the risk of crop damage or loss? Do they work in all stages of pest, disease and weed pressure? In the zucchini hub for example, at the demonstration of an UV robot they questioned whether the robot could do a whole hectare autonomous, how much time it takes to do that and what the cost is of a robot relative to the cost of a tractor and the hours it takes to do the same work with a tractor.

### 7.5.2. Farm strategy

A farm strategy is the set of **principles** that directs farmers in how to farm and the **decision-making logic** to achieve certain **goals**. New IPM practices have to be in line with the general way of working on the farm and have to contribute to the future perspectives and goals of the farmer. Since a farm is a system within systems, which are all changing constantly, strategies are important to handle this complexity on the basis of some decision-making rules and principles that can guide farmers towards their objectives or to stay in line with their values. Farm strategies were the most prominently discussed in the arable hub, as they met regularly on the experimental station where a comparison was made between 'conventional' farming and farming following the principles of 'integrated crop management', and where discussions also often referred to the principles of organic farming. Some decisions direct farmers into a certain strategy because they create **path dependencies**. Examples are the decision to specialise in a certain crop, or the decision to introduce no-till, or the decision to invest in certain technologies, which are decisions to which the general way of farming has to be adapted in line with the farmer's objectives.

The farmers also discuss future **evolutions**, developments and opportunities like climate change effects, advances in crop recognition, nitrogen and nature regulations, and announced policies and subsidies. They discussed what the best strategy was to anticipate and deal with these evolutions. Many farmers expressed deep uncertainties regarding the future and were in need of insights in how these factors would develop further and what possible strategies could be to cope with these developments.



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## 7.6. Understanding IPM in the farmer identity and community

During hub meetings, narratives were shared on farmers' social and political identities, and on how certain IPM practices and policies relate to these identities, and so, if these practices and policies should be accepted by the farmer community? In essence, opinions are shared on what it means to be a farmer and to farm.

### 7.6.1. Social identities

The farmers sometimes referred to their social identities (i.e., to which group they (do not) identify with) as an argument for why they think some practice is or is not acceptable, for example, whether they identify themselves as an organic farmer or not, a strip cropping farmer or not, or an entrepreneur. A major identification was whether you are an organic farmer or not. Some practices are mocked by 'conventional' farmers as practices for organic farmers. In the arable hub, the farmers' identity as entrepreneurs was the most pronounced, as they stated that they see the challenge to save on spraying from an entrepreneurial pespective. In some cases, the farmers' social identity was linked to specific persons, peers with a certain social status that they found corresponded to their identity. For example, one of the farmers who experiments a lot with new practices and technologies often referred to specific farmers from America or Canada he had met or watched online videos of as his inspiration.

A major part of this social identity of farmers is their **work ethos**, which means that they adhere to the image that good farming equals working hard. They often mentioned how much time some work on the farm takes, how much work pressure there is, and that they prefer to do something in the right way, rather than doing 'half work'. This ethos was captured best during a demonstration of a weeding robot in the arable hub, where one farmer stated that he would rather do something himself, than watching something work. In this example, the work ethos was a major factor determining whether the farmer would adopt this new practice or not.



Another crucial part of the farmers' social identity was their particular idea of **aesthetics** (i.e. opinions on the beauty of things). When they saw a field without weeds or a mowed and pruned front garden, they judged it as 'clean', and when they referred to spraying phytosanitary products they used the term 'cleaning'. When they dug out a beet or potatoes, or evaluated different strawberry varieties and these were free of disease and big with a regular shape, they called it 'beautiful'. When they saw that a crop is planted on a perfect linear row, they stated that it is 'nice work'. Practices that for example might not harm crop health, but that are not in line with these aesthetic standards, could be difficult to accept by the farmers.

### 7.6.2. Political identity

The farmers expressed a political identity, (i.e. they identified as a group that is engaged in political power struggles and future perspectives of society). They discussed how political struggles enable or disable them to deepen their IPM strategies while maintaining a viable farming business. There are many politics and policies with appended rules and regulations that impact the ways farmers can implement IPM, by directing what they can or cannot do. The farmers are very frustrated, because they have the feeling that they are excluded from the political arena where these policies, rules and regulations are drafted, and even more that this the political arena is detached from the farming practice and has no link to the daily reality of farmers.

Specifically on pesticide regulations, for example, legal actions are started by city dwellers that migrate to the countryside, against farmers who spray phytosanitary products. In that case, the judge called for an immediate stop of spraying to have more time to investigate, but this was received by some of the farmers with pure fear over what the verdict would be. The farmers thought that it was something typical for people from the city that come to live in the countryside, but who have no idea what the consequences are when a farmer cannot spray anymore. The farmers also had many questions on how the regulation on pesticides, the candidates for substitution and exemptions are decided at the European level. They hold the opinion that these regulations create paradoxes, future problems and are often contradictory with other regulations or with what is possible in practice. One of the most used arguments is that by confining the spectrum of

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phytosanitary products that can be used, pests, diseases and weeds are growing resistant to the products that are still on the market. Regulations are also often perceived as inconsistent and not well communicated. During a farm visit in a raspberry farm, the farmers and advisor had a discussion on a specific product, and whether it could still be used or not. They searched for the information in a specific app developed to help farmers with these regulations. On the app, it appeared that this particular product was registered for strawberries, but not for raspberries. Raspberry is not as a big a sector as strawberry in Flanders and therefore the cost and efforts have not been made to start the procedure for regulating and registering that product for raspberry. As another example, the farmers and an external expert were discussing that a certain foliar fertiliser could also be used to protect the plant, but that this was not the official use of those foliar fertilisers and that it was therefore not clear if the use of this product had to be registered by the authorities. These examples show that inconsistency in regulations is pushing farmers unwillingly and often unknowingly into illegality. This was literally expressed by a farmer external to the hub, that in the case of the nitrogen debate, the absence of regulation is demotivating entrepreneurialism, and that is was even pushing them into illegality. Additionally, the farmers state that often there are no alternatives presented for farmers when a regulation is introduced that confines their usual way of working. They also expressed that knowledge is lacking for all parties involved on how to comply with the regulation. For example, one of the farmers asked an expert if when you are in a groundwater protection area, should you mix the products to have only one spraying application, or should you spray multiple times with the products separately, to spread the doses over time, to which nobody had an exact answer. In the soft fruit hub a farmer stated that more money is needed for research to advance in IPM, because not enough is known to fully apply IPM.

The farmers gave numerous examples of bad governmental management, lack of regulatory room to change, and regulatory instability, hampering farmers' attempts in different sustainability transitions. Subsequently, the feeling of being an overruled political minority was enforced by the fact that not only politicians, government employees and protest groups are involved in the power struggles, but also actors from up-and-down the agro-food chain, protecting their profits. On the one hand there is the power of the suppliers of resources and technologies necessary to grow and protect crops. They also often feel cheated by these companies who claim to develop new products that could help them in the absence of phytosanitary products. They even feel abandoned by the global market as they explain that big companies who develop new phytosanitary products do not even bring their products anymore on the European market, because the process of regulating is too expensive and takes too long. On the other hand, there is the power of the supermarkets and processing industries. Sharing examples on these power plays between the farmers gives them political awareness and helps them to understand their position in the political and economic arena. Implementing IPM practices or complying with IPM regulations is not only an environmental or technical action, but also a political action, in the sense that they can also take political action to change these policies and regulations to alter their options to implement an IPM that they find feasible. They could step in the power arena and argue for different future perspectives and different rules, which would make different IPM practices possible.



### 7.6.3. Political action

This political identity does lead to political action to claim their space in the political arena and get involved in the power struggles. The hubs were places of debates on the value, freedom and future of farming and foster the development of political thought and engagement.

The first form of political action that the farmers of the hubs take are the actions of **debating and creating platforms for discussion**. For example, the farmers of the soft fruit hub were very willing to open their farm for a demonstration to which only policy makers and other stakeholders would be invited to open debates. Or the other farmer of the hub who went to a testimony in the European parliament in the debates on the revision of the pesticide regulations. The farmers are very motivated to build a **narrative** with what in their eyes is the right contextualisation and communicate this publicly. They see a need to communicate that they are making efforts to diminish the use of phytosanitary products, but they are also afraid of showing good

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examples, because they fear that these would be picked-up by policy makers and become mandatory. Instead, they want the freedom to choose themselves to adopt a certain practice and adapt it to their context and needs. This was also explicitly exemplified when at the yearly evaluation and planning meeting the advisor presented some results on field experiments they did. This opened fierce debates on how to interpret and rightly contextualise these results before they become public, explicating the wish to let communication that goes outside the group pass by a famers committee. Subsequently, they find it important to **inform** and to bring in what they think is the right information and knowledge in the debates. They therefore also do an appeal to scientists, as in the zucchini hub they stated that the experimental institute could do more to correctly outline the problem of pointed fruits, or in the arable hub they asked to substantiate IPM transitions with what is and is not possible. Reversely, one of the motivations of the farmers to join the hubs is to stay informed about new regulations. Followingly, the farmers want to reinvest in **lobbying and networking**. Another political strategy that they displayed in their actions was to **unite** farmers under sector-wide topics, instead of letting each sector address their specific problems. On this part they were quite disappointed in a Europe wide farmer unification, as they claim that not many countries have the same intensive agriculture as in The Netherlands or Belgium and so that these countries will not make for example the restrictions of products a political topic. At last, farmers and experts are putting topics on the agendas of political institutions, proposing alternative measures or **engaging** in local councils, as an expert claimed that he proposed a geographical pre-sorting of who can use which products and urges them to address this topic in different institutions. Or the farmer who is part of the council and debriefs to the other farmers that he has put forward following point on the meeting “when it is about crop protection, there is the principle that the farmer chooses”. Farmers share knowledge on how to take political action and emancipate themselves as a political group to co-define which IPM goals and regulations are worth pursuing as a society.

## 7.7. Conclusion & discussion



In this first results section, five categories of understanding were presented:

- Understanding crop and pest biology in relation to field ecology;
- Understanding IPM practices and their implementation;
- Understanding IPM strategies in field and crop management;
- Understanding the role of IPM in the farm system;
- Understanding IPM in the farmer identity and community;

Each category of understanding represents a specific type of discussed topics and shared knowledges between the farmers in the hubs. Together, these five categories make both the definition of how farmers understand IPM as their practice and a meaning structure in which new knowledge and new IPM practices are placed and get meaning in their overall practice. By looking with a CoP perspective at the results, they suggest that the farmers’ definition of IPM as a practice goes beyond the classical definition and its principles, as used often in science and policy. Defining practice as a reasoning strategy, in which new knowledge based on experience through practicing, constantly circulates, defines both community and meaning. The reasoning strategy is the common practice that binds them into a community. The circulating knowledge is the constant search for meaning that motivates them to learn from and with each other within this community.

We claim that the different knowledges that farmers shared, enable them to take autonomous decisions on their pest management, and that the five categories of understanding provide a reasoning strategy that could guide the re-design of their IPM strategies. We argue that the first category, understanding crop and pest biology in relation to field ecology, provides the hub and the farmers with the right contextuality and reference base to overcome the **contestability** challenge of IPM. Knowledge on crop resilience, beneficials, pest spreading, backed-up with data from monitoring, could be perceived as the scene setting in which a locally adapted IPM strategy has to be designed and adapted. The following three categories of

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understanding: understanding IPM practices and their implementation, understanding IPM strategies in field and crop management, and understanding the role of IPM in the farm system, provide the knowledges to overcome the **revolutionary** challenge of IPM. Because this is the knowledge a farmer needs to be able to implement IPM practices, on how they can be combined in IPM strategies and to assess if certain IPM practices and strategies are applicable, achievable, desirable and possible on their farm. With these knowledges, a farmer can evaluate how much change a change entails, and how this might change the farm strategy. The last category of understanding, understanding IPM in the farmer identity and community, might enable the hub to overcome the **normative** challenge of IPM by finding new identities in which new IPM practices fit, or to negotiate possible futures in which their norms are more respected. The impact of IPMWORKS hubs is their potential to overcome these challenges by creating a platform for farmers to share knowledge, and to discuss and negotiate the meaning of IPM as a practice, with the potential result that some new knowledge might be perceived as meaningful and motivates farmers to make changes to their IPM strategies. I argue that the more topics under these five categories of understanding are addressed in the hubs and the more platform is created to discuss these topics between the farmers, the more holistic their understanding of IPM will be and therefore the more capable they are to design an effective IPM strategy.

Based on the results described above, we developed a tool (table 3) to help advisors who facilitate a IPMWORKS hub on IPM when planning the topics of different activities, as well as to deepen discussions during these activities. This tool could also provide guidance to policymakers and other stakeholders, following the rural proofing principle, stating that if they are not capable of answering all the topics addressed, there is a great likeliness that the policy or measure is not yet ready to be implemented by farmers.



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| **Defining a meaningful practice: Knowledge (needs) for a holistic approach on pest management** | | |
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| **Goal:** The assumption is that the more topics are discussed and demonstrated between the farmers in Farm Demonstration Hub, the more holistic their understanding will be on IPM, and the more experience they have to adhere meaning to IPM practices and strategies. The goal is thus to discuss as many topics as possible.<br><br>**Method:** Ask the group during an annual planning meeting which topics they would like to discuss, and which knowledge needs they have in this topic. During farm visits and demonstrations, introduce which topics will be discussed and make the learning goals explicit. In general, make sure to discuss a diversity of topics and knowledge needs. | | |
| **Category of understanding** | **Topic** | **Knowledge need – What to discuss and demonstrate?** |
| Understanding crop and pest biology in relation to field ecology | Crop resilience and resistance | Explain crop resilience both from the crops' physiology and from growing conditions and field works. |
| | | Explain crop disease resistance as a physiological principle and biological property of crops, and discuss the importance this property has in a IPM strategy. |
| | Beneficials, Banker plants & habitats | Demonstrate the functioning, use and implementation of beneficials. |
| | | Explain the functioning of different products and discuss how and why biological and chemical based IPM strategies are or are not compatible. |
| | | Show a life-cycle perspective on habitats and multiplication of beneficials. |
| | | Discuss and demonstrate the importance and functioning of beneficials (predatory insects and pollinators) in IPM strategies. |
| | Pest spreading | Explain and observe the sources, hibernation, and different habitats of pests. |
| | | Link the favourable conditions of pests, diseases, and weeds development to a life-cycle perspective and demonstrate in field. |
| | | Estimate the risks of outbreaks. |
| | | Demonstrate IPM practices to manage favourable pest development conditions. |
| | Diagnostics, monitoring, and thresholds | Diagnose crop problems, recognising pests, diseases and weeds in different life stadia. |
| | | Discuss thresholds for intervention and explain DSS logics. |



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| Understanding IPM practices and their implementation | Know-how | Let growers explain and demonstrate how to implement IPM practices in the field, giving detail on the exact execution, and let them suggest each other adaptations of these practices. Let growers explain why IPM practices were applied that way. |
| | | Demonstrate how to spray phytosanitary products. Discuss the choice of product, the timing, frequency and dose of application, the combinations of products or with other IPM practices that can be made, and how to spray. |
| | Know-when | Discuss when, in which ecological and climatic conditions, it is possible and advisable to implement certain IPM practices. |
| | Know-what | Discuss the purpose and function of an IPM practice, ie how it operates to reach its objective, and how this directs how, when and why to use that practice. |
| | | Compare practices with other practices that have the same purpose. Discuss the qualities, functionalities, efficacy, and efficiency of these practices. |
| | | Discuss the (unwanted) effects of a practice on other practices and aspects of crop cultivation. |
| Understanding IPM practices in field and crop management | Cultivation planning | Visualise the process of cultivating a crop from preparing, to seeding, growing, caring, harvesting, and storing on a timeline, indicating the different development stages of the crop, and discuss why, how, and when each IPM practice was implemented. |
| | | Discuss priorities, trade-offs, and path-dependencies between different practices. Make explicit and discuss based on which parameters to make choices in this planning. |
| | IPM strategy | Discuss and demonstrate the combination of IPM practices to manage one particular pest, disease or weed. |
| | | Discuss and demonstrate the combination of IPM practices to manage the multitude of pests, diseases, and weeds in a particular field. Discuss which practices are multifunctional and which combination of practises have a multiplier effect. |
| | | Discuss and demonstrate how to design an effective IPM strategy, and how strategies can be adapted to local conditions. |
| Understanding the role of IPM in the farm system | Resources and capacities on the farm | List the material resources needed to implement IPM practice. |
| | | Discuss the skills needed and how to organise the labour of the farmer, seasonal workers, and advisors, to implement IPM practices and strategies. Discuss the ease-of-use of that practice and estimate how many hours it takes to execute a task. Address administrative tasks related to practices. |



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| | | Discuss the financial balance, weighing cost of production inputs (price/input * input/ha (or /m)), or the investment cost against the revenue of the final product. Discuss the estimated impact of IPM practices on the quantity and quality of crop production, weighing it against the amount of the crop that is damaged or lost due to pests, and the price of products. |
| | | Discuss the efficiency and efficacy of IPM practices and compare this with alternative practices. List all the risks of (not) implementing a practice and compare them with the (dis)advantages of that practice. |
| | Farm strategy | Let farmers share on their decision-making logic and their farming principles, and how these help to reach their personal farm goals. |
| | | Do trials holistically comparing different farm strategies. Refer to other farm strategies and their farming principles. Condemn stereotypes and stress that there are mutual learning opportunities between different farming strategies. |
| | | Discuss systemic evolutions like climate change or free trade agreements, and discuss possible strategies to cope with these evolutions. |
| Understanding IPM in the farmer identity and community | Social identities | Discuss the acceptability of IPM practices for the farmer community. Take arguments on farmer identity and on aesthetics seriously and give farmers room to elaborate. |
| | | Question what respected innovative peers would think of an IPM practice. Identify acknowledgeable peers with a high status in the IPMWORKS HUB or in the farmer community and involve them actively. |
| | Political identity | Discuss how political struggles enable or disable them to deepen their IPM strategies while maintaining a viable farming business. Question who has the power to change things in IPM transitions? Qui bono? |
| | Political action | Discuss the possibilities of the group to create platforms for discussion, build a narrative, inform stakeholders, invest in lobbying, unite interests, and how to engage in political institutions. |

*Table 3 A tool with 14 topics to address to have a holistic conversation on IPM.*



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# 8. Results 2: Constructing community and meaning through peer learning interactions in IPMWORKS hubs

## 8.1. Introduction

In this second part of the results, the learning process that farmers in a IPMWORKS hub sustain by interacting with each other and with the farm environment demonstrated is described. The focus lays on the interaction patterns that enables others and oneself to learn and to collectively argument and negotiate the meaning of what is shown and discussed during the hub meetings.

Conversation is a social experience that enables learners to 'learn experientially' with and from each other. Within the experiential learning theory proposed by Malinen (2000), each mode of thinking (retrospective, critical, analytical, rational, and personal thinking) is marked by different interactional rules and conversational elements that can enable or prevent them to learn from each other. In this, it is not about what they talk, but how they talk. The purpose is to expand the insights in how interaction patterns between farmers enables them to learn and negotiate meaning with each other. Therefore, it is questioned which interaction patterns in IPMWORKS hubs facilitate discussions on the practice and meaning of the demonstrated IPM practices and strategies? The results indicate that:

- **Retrospect** happens by sharing observation and making references to other experiences, thereby liaising with each other. Sometimes, the group fails to retrospect because they assume commonality between the participants.
- **Critical** questioning happens when someone explicates problems, and by questioning each other's knowledge, which can be stimulated by comparing similar experiences. Often critique is brought with humour to soften it and sometimes it is covered, depriving the others of a learning opportunity.
- **Analytical** testing requires a first conception of the situation at hand and continues by posing analytical questions and by detailing the decision-making process, which can also be facilitated by visualising the situation as a model in which things could be hypothetically changed.
- **Rational** justification starts with scouting for new information and with farmers suggesting and demonstrating each other new practices. The validity of new knowledge is assessed by comparing and prioritising it to similar experiences and legitimised by mentioning the source of the knowledge.
- **Personal** believing is discussed by sharing opinions and motivations of why or why not to try a new practice or consider new knowledge and is often met with peer support from the group.

These results are presented in more detail below, starting with a short definition of the experiential mode of thinking and its basic interaction, stemming from the book of Malinen (2000). Subsequently, per section a general description is given of how this was interpreted in the hubs, followed by bullet points showing the more specific interaction patterns that come from the analysis of the observational data.



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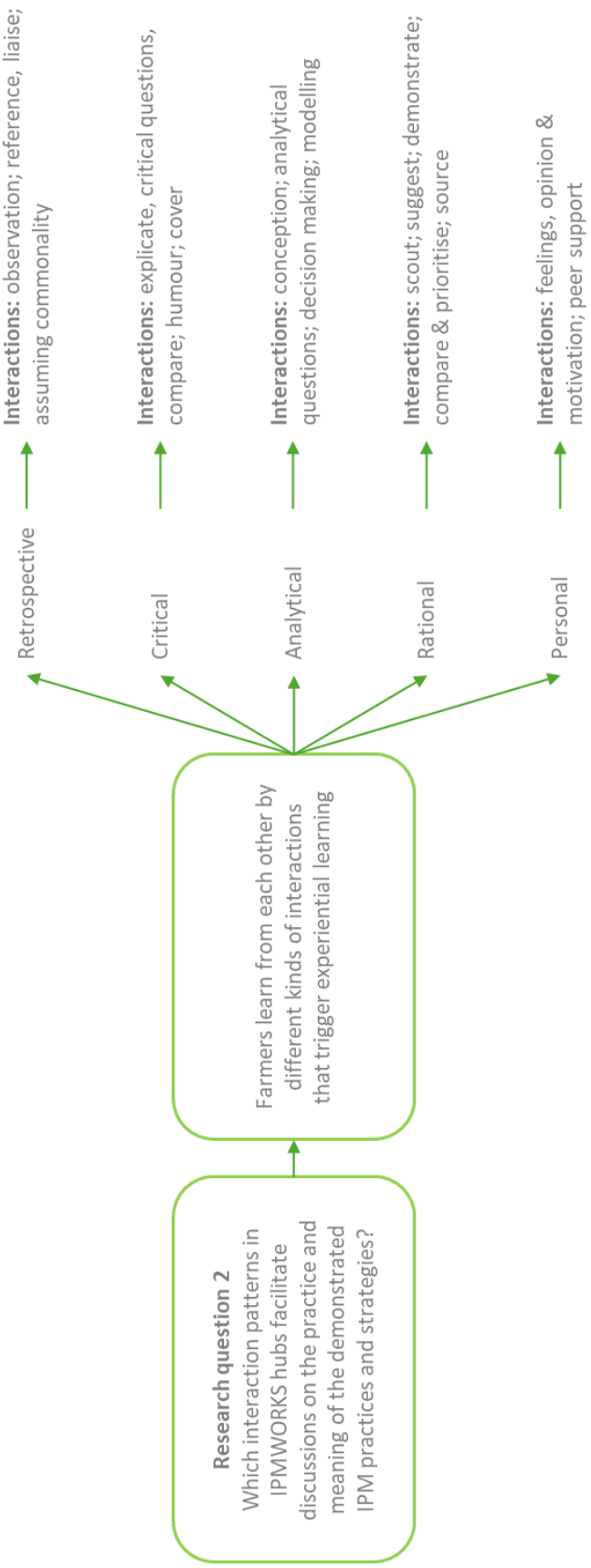


*Figure 4 Peer interactions for experiential learning in hubs.*



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## 8.2. Retrospect - Sharing

**Definition:** When one retrospects, (s)he tries to recognise a current experience as something that has been experienced before, giving it a certain meaning by referencing it to previous experiences and to a personal conception of the world. In group, retrospect happens by sharing how one perceives a certain experience. The others are invited to try to see through the eyes of the one describing an experience. (Malinen, 2000)

**Retrospective mode of thinking in the hubs:** The farm visit, demonstration, meeting, or other activity in the IPMWORKS HUB is introduced by naming who will provide a testimony, what will be seen, what the topic is, making explicit the objectives and purpose of the meeting. By introducing the meeting, the following conversations are framed within the initial description of the context and purpose, as also the others are invited to think together, establishing the social learning space. The visited farm shares what happened on the farm and in the fields in terms of practices and strategies against pests, diseases, and weeds, and how they think this led to the actual situation being observed during the demonstration. They tell a factual story of all their experiences with the field, crop or practice being demonstrated, a testimony of all practical steps that have been taken over a season from preparation to planting, growing, and harvesting, showing what and how things have been done. Other farmers share if they have been in similar situations, encountered similar problems or applied the same practices. By conversating they try to fully understand how the visited farmer experienced the situation. The conversation is not on creating new knowledge on the situation, but understanding with which knowledge the visited farmer looks to her/his situation and decisions. By sharing, the individual experience becomes a common experience on which the group can learn together.

- **Observation:** Explicating what one has observed to put this information and initial interpretation in the conversation. As for example one farmer who shared during a demonstration on different substrates that he observed that the substrate shrinks during the season, causing the plants to stand a bit too deep in the tray. To which the hub coach asked, “Have others also experienced this?”, opening the space for others to share similar or different experiences and to connect to the experience shared. It is important when sharing observations to give credibility to observations with all senses, as one farmer shared that she had planted strawberries with DCM in the substrate, to which another farmer reacted that this product “stinks like a cat”, which was confirmed by the other farmer, opening a conversation between them.
- **Reference:** Situations and observations are explained by referencing to past seasons and previous meetings. The farmers referred for example to previous lectures or exercises done in the hub to make clear what they observe or what they think, and often refer to the previous season to make comparisons with what happened then, for example “last year I was harvesting in October and it was 20°C”. By referencing, the context and conversation get framed within previous knowledge, as also recognition and mutuality is created by pointing to similarities, or differentiation by pointing to the dissimilarities. Advisors can play an important role in this because they come on many different farms and can reference to what they experienced in these different farms. This happened often during the demonstrations in the zucchini hub that is cooperating with an external advisor, who constantly referred to what was seen during the demonstrations and what he has seen on other farms. Referencing also builds a certain continuation in the learning process. The hub coach of the arable farm had a habit of repeating what happened the previous meeting, to frame the current meeting in what had been seen before, and on which topics they would continue the discussion.
- **Liaise:** By sharing observations and referencing to similar situations and experiences, the farmers created equality between each other. By overcoming individual confidentiality of information, the farmers created a mutuality between them and involve each other in a common learning process. This was exemplified by two farmers of the arable hub who had experimented with weeding robots. In a previous meeting one of the two farmers gave a demonstration of this robot. In the following meeting the other farmer started to share his experiences and ideas with the robot to the farmer



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that demonstrated. The openness of the one farmer to demonstrate this innovation and let others learn from it, created the mutuality that made the other farmer do the same thing. In the strawberry and zucchini hubs, this mutuality was often established by having the same crop variety. Again, the hub coach often asked, “who has the same variety?” or “who also has tried this before?”, opening the possibility to liaise.

- **Assuming commonality:** When things are not shown or shared, because one assumes a shared experience and does not imagine the possibility of diversity within similar experiences, it is assumed that the other participants will already know what can be known from an experience and so that it is not worth repetition. This could also be rooted in fear of stating the obvious, showing that one is not fully assimilated within the common identity of the group, endangering one’s membership. Assuming commonality was observed once explicitly, when before a farm visit the host farmer said that he was mainly interested in the preservation techniques of the others, because for the rest he could predict how they worked and that for growing raspberries there are not as many options as with strawberries. During the farm visit, conversations went on pruning, cutting, timing, etc. to which one farmer concluded that “there are so many systems of growing raspberries” and the host farmer added “yes, as many as there are growers”, showing that he came back on his assumption that all raspberry growers have roughly the same way of working.



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## 8.3. Critical - Questioning

**Definition:** Thinking critical means testing one's knowledge, ideas, viewpoints, and understandings of experiences. A group can stimulate and guide critical thinking by questioning each other and recognising contradictions, assumptions or false information in one's perception of previous and current experiences. "This retrospective critique only reveals the limits of the learner's understanding, but nothing beyond those limits." (Malinen, 2000, p. 79)

**Critical mode of thinking in the hubs:** Gaps in knowledge on what is happening on the field and in the crop can be explained by the farmers themselves or can be revealed by other farmers who question what they see and hear. Explaining problems shows that something went wrong and we do not know yet what. In this stage problems are defined as problems to which new knowledge is needed to better understand them. The farmers compare thoughts and situations to get to know if there are other understandings of similar experiences. Critical thinking is not only focused on problems encountered, but also on showing that there exist many different practices and strategies to grow a healthy crop and that there are many different perspectives of looking at farming and so that there might be a broader knowledge on how things could be done. Or that the knowledge held by the farmers is only valid in a specific situation. It defines the problem situation and about what aspects of the farm visit things could be learnt.

- **Explicate:** By admitting problems or by explicating gaps in one's knowledge, one shows that (s)he has sensed something unfamiliar, something unknown, thereby putting oneself in the position of the learner, in the position of the one with less knowledge and experience in the situation at hand. This gesture is showing to the others that one is open for critique, which is an invitation to learn together or to be taught. Farmers open up to each other by for example stating that a particular crop variety has a lot of troubles with phytophthora, to which another farmer puts himself in the position of the unknown, responding "is that because of the cuttings or because of the substrate?", "yeah, what could be the cause? The weather? It could be because of so many things?". Or "I have this black fly hovering around during blossoming, what is it, do you also have flies?". In these examples, they explicate problems and by questioning show that they lack a certain knowledge.
- **Critical questions:** By questioning, one shows that there is not enough information shared to fully understand what is shared, potentially revealing that also the one who shares has gaps in their understanding. By questioning, one also commits to think together, showing the will to understand what is shared. Critical questioning can be questioning the terms and concepts that are used to describe an observation or a situation, such as during a demonstration on Trianum in the soft fruit hub, two farmers asked each other "what is a resilient plant?", to which one of them states that a resilient plant is a plant with good rooting, which was questioned by an invited seller "with all due respect, but what is that based on that makes the plant more resilient?", to which a conversation started about all researches they have heard about to prove this argument.
- **Compare:** Seeing differences shows that one's experience and knowledge is limited. Comparing similar situations, makes it possible to see differences, which could lead to questioning why similar situations could have different outcomes, revealing unknown factors. In the zucchini hub, many trials are done at the experimental station to compare different varieties. One farmer commented that "the variety trials should be done at a producer. Here it is in a greenhouse and not in open soil. This way the potential of the varieties can't be shown.", in which he was asking for more comparability between the trials and his own context. Both in the soft fruit as in the zucchini hub the farmers often compared varieties, questioning if "they notice a difference in taste?" or "which is the easiest to harvest?". During the variety trials the hub coach prepared booklets for the farmers, in which the data of the trials are written down, making it possible to compare based on data. There are also crates with the different harvests of zucchinis or strawberries for the farmers to taste, touch and evaluate, to enable a complete comparison. Subsequently, a control trial makes a new practice or strategy comparable and so makes differences visible that can clue problems or opportunities with



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the tested practice or strategy. When evaluating the past year in the arable hub, the farmers stated that the comparison between the trials with IPM and 'conventional' farming in the experimental station is "super valuable", because you can compare them, hear the story behand it and ask questions.

- **Humour:** A way of sharing examples, conceptions, critiques and comments that makes them less personal, shows the relativity of situations, or softens the critique.
- **Cover:** Covering happens by not (publicly) sharing information, not explicating criticism, or over nuancing statements, because of fear of offending and damaging personal relationships, or of inability to pronounce it, or of concurrence and competition, or of role conflict. Covering means to take away the possibility to learn from each other through conversation. This can be observed when walking through a field and all farmers are vividly discussing one-on-one, but when they stand in group, almost nobody shares their thoughts or reacts on questions. Or sometimes the hub coach decides not to go into specific topics. Or sometimes questions are posed, and others refuse to answer or avoid giving real information. The most telling example observed was at a farm visit when one farmer explained his IPM strategy and mentioned that he chemically disinfects the soil sometimes. Later on, during the farm visit, another farmer told me informally that chemical soil disinfection is not really a good IPM practice. When I confronted the hub coach with this after the visit, (s)he responded that (s)he did not want to get into that, because she was afraid to offend the farmer and to discourage other farmers to also open their farm for a visit.



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## 8.4. Analytical - Testing

**Definition:** Analytical thinking means to search where contradictions, assumptions, or false information in one's knowledge and thinking came from, making these mistakes explicit. After critically questioning revealed that there are knowledge gaps, analysing makes the knowledge gaps more concise and defines what exactly is not known yet. In group others can test each other's knowledge to get this depth. "During this analytic phase an adult begins to realise not only that he is looking at the world in an inadequate way, but what kind of inadequacies they are." (Malinen, 2000, p. 81)

**Analytical mode of thinking in the hubs:** To analyse what caused pest, disease and weed problems and why IPM strategies succeeded or failed to prevent or cure them, it is necessary to have the right data of a field situation, and to understand the argumentations, reasonings, ideas and conceptions behind certain actions. To identify factors of failure or success, the farmers share their conceptions, question each other to have all relevant information clear and propose hypotheses that can be tested by bringing in different experiences of other farmers. It is about understanding how this interaction between problem origins and practices works. Everyone shares their perception of the problem and formulates hypothesises of what happened in the situation at hand. They search for different perspectives of what happened on the field.

- **Conception:** To dig deeper in one's knowledge gaps and misconceptions, it is necessary to have insights in what that a person is actually thinking about a certain experience. The initial thoughts and ideas have to be exposed to the group, showing with which concepts one understands the situation at hand. For example, the hub coach of the zucchini hub shared his idea of how mildew develops on the plant and took leaves with him to show where the mildew developed the first on the plant. By doing this, others could react on this, share what they think is wrong in his reasoning, why they think it is dependent on certain conditions, and shared their own conceptions of how mildew develops. Or during the planning meeting of the arable hub, where the farmers discussed which experiments they would do on their farm that year, one farmer explained that he conceives soil pores as "chimneys and if the wind blows over it, it sucks up all the groundwater out of the pore". To maximally keep moisture in the ground he would do a fieldwork that crumbled the top layer of the soil and so closed the pores and at the same time create a stale seedbed. By opening up his conception to the others, some shared that they actually already work this way, but that they remain having difficulties with grasses, and others questioned if seasonal effects and soil type would not be the main factor in soil-water regulation?
- **Analytical questions** are questions that try to get more detailed information from experiences and that often entails a hypothesis about the situation at hand. For example, when the hub coach explained an experiment with different varieties of strawberries and she shared what the effect was of the heat of that summer, the farmers asked if the heat would have the same effect if they limed the greenhouse? Subsequently, analytical questions often also question the cause of observed anomalies or differences, searching for the origin of problems or successes and revealing the factors of importance. It shows that one is willing to 'dig deeper' and opens an analytical conversation. It allows to go beyond what was experienced directly. For example, when the hub coach explained that they measured low bumblebee activity, the farmers questioned "what is the reason of that low activity? Could it be because of the cold?" or when a farmer shared that during the season he saw that different varieties of sugar beets in his field had different colours of leaves and asks an invited expert if that was because different varieties needed different amounts of nitrogen or if it was just a difference in plant characteristics? In the hubs it is often questioned where pests, diseases or weeds come from, shown by following example: "we have plants next to the road from which the stems become yellow. Is that because of the humidity?".
- **Decision making:** Dividing crop cultivation into a process of continuous decision making, explaining when, how, why and based on what decisions were made, thereby enabling the others to analyse where and when right or wrong decisions were made. For example, a strawberry farmer opened up



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her line of thinking on why she does not choose for the 'sonata' variety anymore, enabling the others to understand her thinking and decision-making process. She also explained which experiences she based her decision on, as she explained "I had sonata for four years, but now not anymore. I thought it was a tasteful strawberry, and it becomes red very fast in the season, ideal to sell on the farm, but I had 10% loss. The first year it went well, but then bad for two years. […] I know sonsation (a strawberry variety) is sensitive for root rotting. I think it is a difficult decision because I think sonata is the most tasteful". In the arable hub, the farmers questioned the best moment to spray phytosanitary products, critiquing the decision-making app for not being exact enough and that it is unclear on which calculations the app makes decisions. They questioned where one can find thresholds and how to interpret drone and satellite images and field observations to make the right decision on where and when to spray. Questions that show that they are in need for more data and interpretative skills for the analytical thinking necessary to make decisions on spraying.

- **Modelling:** Modelling is imagining the farm as a system or farming as a process that can be schematised and for which different hypotheses can be tested. Also, it can be considered which different factors to take into account in the model. For example, in the zucchini hub, the group was asked to draw a timeline of a hypothetical zucchini farmer, and to discuss when and why in the cultivation of the crop which IPM practices had to be implemented. Or during another farm visit an invited expert had a poster with him schematising the 'success cycle of leaf fungi management' depicting the elements they considered in their IPM strategy, on which it was also stated that farmers should wait before they see the first spots on the leaves. Farmers could react on the different practices, as they said "if you see spots, you're too late. You have to spray preventive. I don't know the effect on resistance if you wait for the first spots.". With these comments they question if the right factors were taken into consideration in this model.



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## 8.5. Rational - Justifying

**Definition:** Rational thinking means to actively search for new insights, knowledges and experiences that could complement or reconceptualise previous experiences and to accept these reconceptualization's as true. To be acceptable as truth, new conceptions are defined and justified towards others in dialogue and have to "conform to standards of objectivity beyond itself and beyond the person who makes the statement". (Malinen, 2000, p. 108) Truth, what is rational to think, is collectively constructed, conformed and agreed upon. Meaning is ultimately the responsibility of each individual, but knowledge is created in collaboration with others. (Malinen, 2000, p. 110)

**Rational mode of thinking in the hubs:** When problems have been explained, different viewpoints have been laid out, possible causes of problems have been hypothesised and analysed, comes the rational thinking where options for alternative practices and strategies are collected and new knowledge is created by giving each other advice and assessing these possibilities. Different options are considered and weighed by criterions of IPM and standards of what good farming is. The group arguments over why certain options and ideas are in general terms a good option or idea and are worthwhile to explore further and try out. They give arguments for why a way of thinking is legitimate and a certain practice is rational to implement.

- **Scout:** Scouting for new, searching for new practices to apply, looking where to find solutions for a particular problem, and asking if new explanations, practices and solutions fit in the unexplained experience. To scout is to search for new perspectives that are present by the other participants, engaging them to share their knowledge. For example, when the farmers are presented with a rather new pest like suzukii fly in soft fruits, they scout for new practices "do there already exist pheromones?" and search for new knowledge with the advisor asking whether "you don't attract suzukii to your greenhouse with those traps and can you catch them all with those traps?". Or when they have a new problem with bugs one of the farmers said that they could maybe "learn something from the farmers in Limburg". When the advisor takes leaflets and brochures of study days, fairs, research projects and conferences to the meetings, the farmers always show a lot of interest. The farmers show a great eagerness to learn new practices, as they often ask how things happen in other countries and when some of the farmers went on cross-visit it afterwards opened vivid debates. During the evaluation of the arable hub, the farmers said that one of their major motivations was to "follow developments in new techniques and regulations. To know what the future will bring. By following the trials we stay informed of the solutions for the products that are dropping out". The evaluation and planning meetings are crucial for scouting. At these meetings the farmers exchanged about the pest problems they have and which they expect next season and share possible solutions with each other and what the options are to experiment with these or go on a visit to get a demonstration.
- **Suggest:** Making suggestions on using a specific practice or strategy and on how to perform these. This often happens with a suggestive question, asking why a certain practice or strategy was or was not used. In the same conversation it mostly goes as follows: one raises a pest problem, someone gives a suggestion and the others evaluate this suggestion by sharing their experiences and thoughts on whether it might or might not work. Suggesting shows that one is thinking along, is empathic with the situation, and is willing to share information with the purpose to improve the situation of the other participants. An example of such suggestive conversations goes as follows: "I heard in the auction that aphids can survive deep in the ground and then suddenly can come up in big numbers. What do you do then?", to which others suggested different products, other spraying nozzles and spraying pressure, to which someone responded that these could potentially kill the beneficial insects and that the plants become sticky of these products. Another farmer says that the water hardness is also important when he sprays and suggests to don't use city water. Another example, took place during a demonstration at the experimental station where the hub coach showed



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different banker plants that were used in a trial. She had put up a poster with different suggestions of where in the greenhouse to place these banker plants. The farmers had stickers that they could stick at what seemed them the best option. This opened up conversations between the farmers on why they think this is a good option or not.

- **Demonstrate:** Suggestions are not always explicated verbally but can also be demonstrated by showing how an alternative practice or a suggestion works in a specific context. The group can also search for opportunities for demonstration of different IPM practices and strategies, which shows openness to get convinced by building up tacit argumentation. For example, one farmer tested different potato varieties in his field in combination with different gradients of fertiliser to see its effect on phytophthora infection. In the field he explained that we could see which variety was killed completely by phytophthora and for every different variety they dug up some potatoes together to inspect them and evaluated the number of potatoes, their shape and their structure. The other farmers compared what they saw with their own field experiences.
- **Compare & prioritise:** To evaluate the validity of new knowledge and justify which of the different practices might be the best option, these new knowledges and practices have to be compared with familiar knowledge and practices, to be able to weigh benefits and drawbacks in comparison to the familiar way of working. The farmers suggest different parameters based on which the comparison should be made, and they share experiences to add information on each parameter. When for example a weeding robot is demonstrated they compare the robot to field works done by tractor or by hand weeders and pose questions like “how does it function with different weather conditions?” and “How many hectares can it do autonomous?” and “how accurate is it?”, comparing the cost of a robot to that of a tractor. Or when onions that are planted in press pots are demonstrated the hub coach said that the final test is the fact that you have more hours of weeding, 150 onions less, but 0 chemicals in comparison to onions planted from seeds. Followingly, between different options a priority has to be set and the best choices have to be made. Now the parameters for comparison are weighed against each other, the relative importance of one parameter against another should be discussed. As for example when they discussed on the threshold for spraying fungicides against leaf fungi in sugar beets, discussing the difference between harvesting in October or November in harvest in comparison to the cost of an extra time spraying. An external advisor said that it depends on the tons of harvest that you gain by spraying, to which the farmers reacted “tons or in sugar content?”, by which he questioned the parameters based on which this choice has to be made.
- **Source:** The source refers to mentioning the information source from where new perspectives, insights and information originates, to give credibility and legitimacy to the argument. For example, a farmer experimented with intercropping seed mixtures referred to a lecture of Brendon Rocky (a famous American farmer), with whom he talked and copied his mixture. Also, he used green manure and stated that “without synthetic fertiliser you get more vigorous crops, but also more vigorous weeds, tell that to Marc”. Marc is the responsible for the experimental farm where the hub often meets and whom they respect. In another demonstration of sugar beets one farmer said that “Bert says that you can grow a beet with four healthy leaves. Maybe he can count only on one hand, but I think Bert is quite a connoisseur”.



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## 8.6. Personal - Believing

**Definition:** Personal thinking means searching for personal meaning with respect to one's totality of experiences and knowledge, holding a belief in the new truth even though that truth is never absolute and universally proven. It is about finding a purpose in accepting new knowledge, seeing the relevance of it for one's own life, and giving value to new interpretations, with the prospect of engaging to this new perspective and acting upon it. (Malinen, 2000)

**Personal mode of thinking in the hubs:** Personal interactions are not as factual and scientific as critical, analytical or rational interactions, but share or cover a personal opinion and motivation on why to do or not do something, which can or cannot be supported by the other farmers. The impact of an opinion on one's personal beliefs is dependent on the social relationship between the people who interact.

- **Feelings:** Giving an opinion on a demonstrated or explained practice or strategy, revealing a personal judgment based on what a participant feels. The farmers share in their testimonies what they like or dislike with statements like "I don't like it when I have to go through the tunnel in my white suit with my back sprayer" or "that is one of my favourite varieties (showing enthusiastically videos of a harvest of that variety on his phone)" or when a farmer asks the hub coach about a certain fungi that he saw in his field, saying that "that is a frightening image when you see that in the field, it is stressful". These examples share something of the farmers' feelings, which are important in their decision making.
- **Opinion & motivation:** Giving an opinion on a demonstrated or explained practice or strategy, revealing a personal judgment based on what a participant believes. By giving an opinion, the participant goes beyond the facts and reveals personal beliefs, motivations, and visions. For example, at the demonstration on the farm where the farmer had invested in a weeding robot, one of the farmers sceptically stated that he would not get rid of those weeds anymore. The host farmer stated that "he should not panic too fast. It maybe does not look good now, but we learn something from that. […] That development will continue, you can't stop it.". With this statement the host farmer shared his personal belief and vision for the future. Later on, for the larger group he stated that "this hurts to see and we pay our dues. It sounds weird, but the robot has to learn to work with the farmer and vice-versa. We have to learn what the strengths and weaknesses are of the robot and how we can deal with this.", continuing that the robot will never be perfect and that one will always have to adjust it, referring that it is "we" who has to learn to work with the technology just as we learned to work with tractors at the time. With this statement he shared his motivation to learn and why they are investing that much in this experiment, as also his opinion on new technologies in agriculture. The hub coach picked in on this statement, asking the group "if we look at this, what do you think are good aspects? The search is to use less input and remain an acceptable result.", engaging them to think for themselves and form their own opinion.
- **Peer support:** Participants support each other's opinions by confirming that they experience and think the same way. They thereby identify each other as peers on the same level, building the trust that an argument will be understood by the other and be treated the way they would treat it. This could also lead to peer pressure and defensive reactions. For example, at the planning meeting the hub coach asked one of the farmers what he will do in his sugar beets? The farmer reacted that he sprays everything possible. He stated: "IPM? Then my whole field looks brown by August", to which another farmer supported him saying that the disease pressure in the area of the one farmer is very high. Later on, we went to visit his farm and while the farmer expressed big concerns, the group members motivated him that it is already a nice harvest. This example shows how the farmers in the hub confirm and support each other. Sometimes the farmers even ask for peer support, asking "Am I the only one that thinks that way?" or "I'm afraid that the plants are too short, but I better not panic I guess?".



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## 8.7. Conclusion & discussion

In this second results section, the five modes of thinking in the experiential learning theory as defined by Malinen (2000) are elaborated with twenty-one interaction patterns observed between the participants of IPMWORKS hubs, that enable them to learn from their individual and shared experiences. In line with CoP theory, our hypothesis is that farmers of a IPMWORKS hub build a community by engaging in these interaction patterns that provide learning opportunities for other farmers and enables them to discuss meaning and to create a normative structure.

We argue that learning experientially, i.e. starting the learning process from concrete experiences is a leverage to overcome the **contestable** challenge of IPM by bringing back abstract concepts and universal principles to concrete experiences and local practices, thereby integrating these in the lifeworld of the farmers. Followingly, by introducing changes as real experiences in familiar contexts, passing them through different modes of thinking, the meaning and personal relevance of these changes can be argued within their own lifeworld. This way changes that might feel like **revolutionary** changes to the farmers are contextualised and given meaning. Finally, our observations show that the interactions between the participants of IPMWORKS hubs enable them in the first place to learn from each other by extracting new knowledge from each other and from their mutual experience during farm visits and demonstrations. In the second place, these learning interactions creates mutuality between them. Because these interactions create learning opportunities and support, thereby offering something to each other, trading knowledge and motivation, creating mutuality and dependencies. These interactions therefore bind them into a community that creates a platform to discuss new norms, overcoming the **normative** challenge of IPM. As they together argue whether some IPM practice is the most meaningful thing to do, they lay a rational foundation for a new norm. The impact of IPMWORKS hubs like these hubs is their potential to overcome the challenges of the contestabile, revolutionary and normative nature of IPM, by facilitating learning processes that creates meaningful knowledge and binds farmers together in a supportive community. I argue that the more diverse the interaction patterns are within hubs, the more learning potential is created, the more meaningful the shared experiences become, and the stronger the community to support changes towards a deepened IPM implementation.



Based on the results above, we developed a tool (table 4) to help advisors who facilitate hubs, to encourage interactions and deepen discussions in the group to create learnfull experiences. as well as to deepen discussions during these activities. It could also give guidance to policymakers and other stakeholders who are involved in advisory projects and services, in understanding what it takes to set-up peer learning groups and create an effective learning environment, and so in righteously valuing this role.

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| **Constructing community and meaning through peer learning interactions in IPMWORKS hubs** | | |
|---|---|---|
| **Goal:** The assumption is that the more learning interactions there are between the farmers in Farm Demonstration Hub, the more profound their learning experience will be, and the more arguments they have as a group to adhere meaning to IPM practices and strategies. The goal is thus to facilitate as many different learning interactions as possible.<br>**Method:** Explain to the group that you will take up the role of facilitator to make them share knowledge. Prepare your facilitation methodologies in advance. Pose more questions than you give information. Prefer demonstration above explanation. Be empathic and have fun. | | |
| **Experiential learning** | **Peer interactions** | **Facilitation & learning questions** |
| Retrospect - Sharing | Observation | Go in the fields and around on the farm. Let growers use all their senses to observe. Name what you observe (explicate) (ie colour, weight, leaf growth, smell etc). Make sure that the phenomena or practices discussed are observable.<br>**Q:** What do we observe? |
| | Reference | Refer to previous seasons, to other farms, to previous meetings and farm visits, linking to what is observed and discussed before in the group.<br>**Q:** Did we observed or discussed before? |
| | Liase | Make sure everyone shares to create equality between the members.<br>**Q:** Who had similar experiences before? |
| | Commonality | Avoid conclusions that all situations are the same, search for nuance and differences, showing the learning potential.<br>**Q:** Does everyone have the same way of implementing this IPM practice or strategy? |
| Critical - Questioning | Explicate | Let farmers explicate problems. Make it less personal by broadening it to problems experienced with a specific crop, in a particular area, or with a certain IPM practice. Use concepts to describe a situation and question if this is the right concept to do so. Explicate what was unforeseen during the season and how practices were adapted.<br>**Q:** Which problems did you experienced this season? |
| | Critical question | Stimulate the group to pose critical questions.<br>**Q:** Do we have all information to understand what is happening? |
| | Compare | Provide comparability by organising comparative trials and by having data to compare different situations.<br>**Q:** What are similarities and differences in what we experience in similar situations? |
| | Cover | Be aware of personal relations in the group and of what could be sensitive information to share. Ensure one-on-one contact and informal discussion moments. Make it useful to explicate problems by coupling it to an analytical phase of what went wrong. For trust, when problems are addressed, they must be taken seriously and require constructive follow-up.<br>**Q:** Who has similar problems or has tried similar practices? |
| Analytical - Testing | Conception | Ask the host farmer to share the initial idea of implementing a practice. Ask the group to share their hypotheses on what happened right or wrong.<br>**Q:** What is the purpose of this practice? |



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| | | |
|---|---|---|
| | Analytical question | Stimulate the group to pose analytical questions. Draw, sketch, schematise a situation and ideas to create a visual platform for discussion. Bring in IPM principles.<br>**Q:** What are the causes of this problem or success? What would have happened if done differently? |
| | Decision making | List all the factors based on which a decision between practices is made. Discuss conditions of when to implement practices. Questions in which contexts and under which conditions a practice works best, a machine is applicable, a strategy is suited, a variety is viable, etc. questions the situatedness and context dependence of practices.<br>**Q:** When, how, why and based on what were decisions between practices made? |
| | Modelling | Draw a timeline of the crop cultivation or schematise different practices and resources needed in a certain IPM strategy. Integrate practices into a strategy. Bring data in the discussions.<br>**Q:** Which factors must be taken into account in this cultivation or strategy, that could hamper or stimulate the implementation? |
| Rational - Justifying | Scout | Search for what farmers in the hub can show, for what farmers external to the hub who can show something. Search for experts who can come share ideas and product developers who want to introduce their products. Consult research literature and professional journals.<br>**Q:** Where could we find other expertise to invite in the group? |
| | Suggest | Encourage the farmers to give suggestions. Compare how things are done in other regions and countries.<br>**Q:** What would you do in this situation? |
| | Demonstrate | Search for opportunities to get demonstrated on different practices and strategies. Organise cross-visits. Encourage the farmers to do field trials.<br>**Q:** Can you show what you mean? |
| | Compare & prioritise | Map different alternatives and discuss what would be the best option. Weigh benefits and drawbacks. Discuss based on which parameters are comparisons and priorities made? Evaluate suggestions on their applicability.<br>**Q:** What is the best option? What has to happen first? |
| | Source | Find out where suggestions come from.<br>**Q:** What are your sources? |
| Personal - Believing | Feelings | Ask to share what they feel about the experience.<br>**Q:** What do you (dis)like? |
| | Opinion & motivation | Aks to share opinions, beliefs, and motivations.<br>**Q:** Why do you do what you do? What are your objectives? |
| | Peer support | Confirm that the group is there to learn from each other.<br>**Q:** How can we help? |

*Table 4 A tool with 20 questions to ask to foster experiential learning in hubs.*



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# 9. Conclusion: IPMWORKS hubs facilitate the transition to a more profound implementation of IPM if…

… the concept of IPM is made meaningful and applied in farmers' lifeworld's. Our observations in IPMWORKS hubs show that such hubs do hold the potential to create this meaning by facilitating learning and community development, as described in the following conclusions:

1. Farmers share different types of knowledges in IPMWORKS hubs that help them to better understand pest, disease, and weed situations, and to understand the purpose, functioning, applicability, implementation, possibility, effects, and desirability of IPM practices and strategies.
2. IPM practices and strategies get meaning if it can be explained in relation to field ecology, if their implementation is clear, if they are feasible within a field management, if they fit in a farm system, and if they are supported by the farmer community.
3. IPM practices and strategies need to be retrospectively compared, critically questioned, analytically tested, and rationally justified to be personally believed, rendering the farmer the knowledge needed to autonomously consider these practices and strategies.
4. By engaging in different interaction patterns in the IPMWORKS HUB, farmers create learning opportunities for each other, enabling them to learn experientially from each other's and shared experiences, as also, binding them together in a supportive community.
5. IPMWORKS hubs have the potential to overcome the contestable, revolutionary and normative nature of IPM by co-defining IPM as a farming practice in a given context, sharing practitioners' knowledge and creating peer support in a community.
6. Advisors have an essential role in facilitating learning interactions and organising the IPMWORKS HUB so it can function as a platform for community development.

We assumed that processes of learning are embedded in everyday life and happen constantly, in chaotic directions, with a variety of motivations, and with contradictory outcomes. The causes of cognitive and behavioural change are therefore not retraceable to single moments within the IPMWORKS hubs. The observations are the moments where these constant, chaotic, varied, and contradictory processes become explicit, and so become observable. Therefore, the purpose is not to quantify the impact these IPMWORKS hubs have on learning, but to show how learning processes open-up in such specific contexts and how they create the possibility for others to become part of these individual and social processes. It must be noted that the results could be dependent on the culture of farming communities, so other findings could have been obtained in other regions of Europe.

In conclusion, to take the turn away from adoption rates (Bartlett, 2008), farmers should not be perceived as 'takers' that make decisions between a set of pre-defined choices, but as 'makers' of their own, complex and site-specific IPM strategy. In IPMWORKS hubs farmers learn to "think IPM" and so will be able to plan IPM strategies and solve problems "the IPM way", by searching for logics and meaning together with other farmers. It is about giving farmers the credibility and agency to think for themselves (Bartlett, 2008). Additionally, the farmer should not be seen as an individualised business actors (Emery, 2015; Gray & Lawrence, 2001; van der Ploeg, 2018), but as social actors who look to their peers, are communal and are subject to societal influences (Burton, 2004; Charatsari et al., 2018; J.-P. Deguine et al., 2021; Moss, 2019).



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# 10. Recommendation: 7 crucial elements of hubs to facilitate learning towards sustainability

These recommendations are written based on the scientific work in this report, as well as based on many contacts with farmers, advisors, policymakers, researchers, and other stakeholders during the project. The recommendations are rooted in a belief that it is both in the benefit of society and of the farmers to transition industrialised farming systems towards agroecological farming systems. But they are also rooted in a genuine empathy, respect and admiration for the work of the farmers and advisors that we met during the project time. We conclude that for learning to play a role in sustainability transitions, it should be an emancipatory learning that enables the farmers to fully participate in this transition and thereby also have the power to change the direction of this transition. Learning only has a small impact if systemic errors undermine farmers agency to do something with their new knowledge. Therefore, learning will have greater impact if it entails learning to change the system. It is this political dimension of learning that underlies the true power of learning communities. Knowledge brokering between inside and outside of the hubs is crucial to facilitate this function of a learning community. The following elements are seen as pivotal in this function:

1. **Schedule an evaluation & planning meeting:** Hub participants should take the time to discuss what sustainability transitions and practices mean to them, how this resonates with their personal objectives, and from thereon, define their knowledge needs and learning objectives together. They should make clear what they can learn from each other and from others outside of the network.
2. **Advisors as knowledge brokers:** Advisors should adhere to their role as knowledge broker, bringing together farmers in the first place and different disciplines and stakeholders in the second place, facilitating dialogue to enable learning. They should show the importance of different types of knowledges as discussed in chapter 7 and make the implicit explicit.
3. **Time & training for advisors**: Building a community and a learning process takes time and social skills. Foresee time and training for advisors and for the hubs to learn how to dialogue.
4. **Farm visits & demonstration are essential:** Farm visits and demonstrations are the essential platforms to share experiential knowledge. But therefore, the possibility is needed to engage actively with these environments and to create possibilities to observe for the phenomena that are difficult to experience.
5. **Involve experimental stations & innovators:** New experiences and comparability foster different modes of thinking in experiential learning. Experimental stations with systemic comparisons between trials and innovative farmers who experiment with new practices are pivotal in the network.
6. **Organise cross-visits:** Visits between networks brings in new knowledges, stresses the contextuality of practices and strategies, and fosters community development between the members of the network. Cross-visits to other hubs with comparable context are to be planned as soon as possible in the beginning of network formation.
7. **Take care of testimonies & communication:** Bringing out testimonies and communication materials that address topics defined within the network and target responsibilities for stakeholders, firstly fosters community development within the network, because it gives extra relevance to the network and shows commitment of the members, and secondly, is a reflexive moment for the network itself, on their goals, position, and narrative.



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