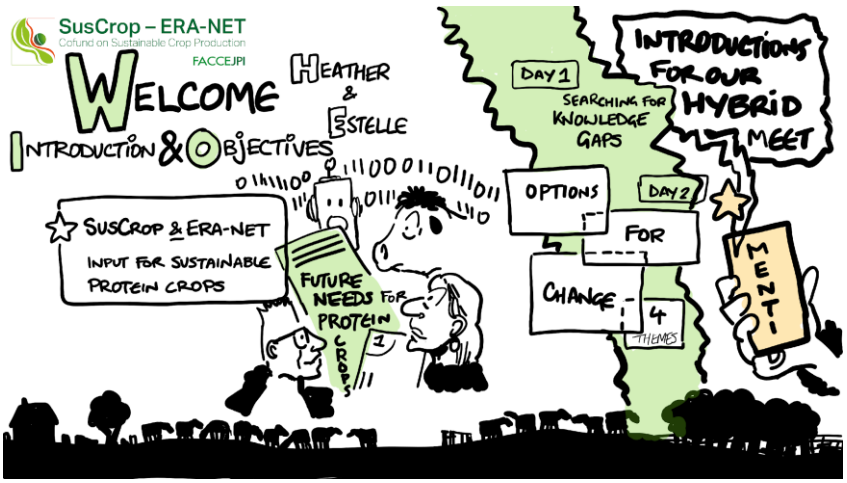
EXPERT WORSHOP ON PROTEIN CROPS
What are key research needs to support protein crop production and value chain?

November 14 & 15 2022, Brussels

REPORT



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INTRODUCTION

This expert workshop aimed to scope **future research needs** concerning **protein crops**, primarily for food but also including feed. Here we use the term protein crops in a large sense, referring to proteins coming from plants (but not algae) and therefore including e.g. grasses. The focus was on production (crop improvement and cultivation), but taking into account the value chain.

The workshop was convened by the SUSCROP ERA-Net to first gather views and recommendations from the scientific experts. An additional workshop will open up the consultation to stakeholders in 2023. In addition, the European Technology Platform "Plants for the Future" also held a workshop in November, 2022 that focused on protein crop value chains and is thus complementary to the present workshop.

The outcomes of the workshop are expected to give rise to a white paper and will also feed into, among others, the FACCE-JPI Strategic Research Agenda (SRA) and be available as advice to Member States (SCAR) and to the European Commission (DGs RTD and AGRI).

WORKSHOP METHODOLOGY

The workshop was organised in two sessions (Annex 2- Workshop agenda): the morning was dedicated to short presentations from panellists. Panel 1 was focusing on policy perspectives and Panel 2 on stakeholder perspectives. Some technical issues with zoom panellists resulted in presentations delivered in a different order. These presentations allowed for some discussions in Q&A sessions and fed into the final brainstorming to identify main areas of work in small groups.

The following session was dedicated to small group work in a "world café" style with 4 topics identified from the previous discussions tackled in 4 break-out groups. Two rounds of discussion could take place and for each round, participants could change group/topic. A facilitator and a "volunteer" expert were assigned to each group to capture the discussions and summarise them to newcomers.

After these 2 rounds, a reporting on the results of discussions for each topic was done for each group the following day. Participants were then invited to think of which research needs should be prioritised in terms of policy relevance, feasibility, and innovation potential. The discussion led to the identification of 3 topics to further discuss and tackle in more detail.

The discussions were captured by a "drawnalist", Matthew Buck, who summarised visually the key outputs of presentations and discussions.

WORKSHOP RESULTS

Participants were asked to use Mentimeter for a quick icebreaker:

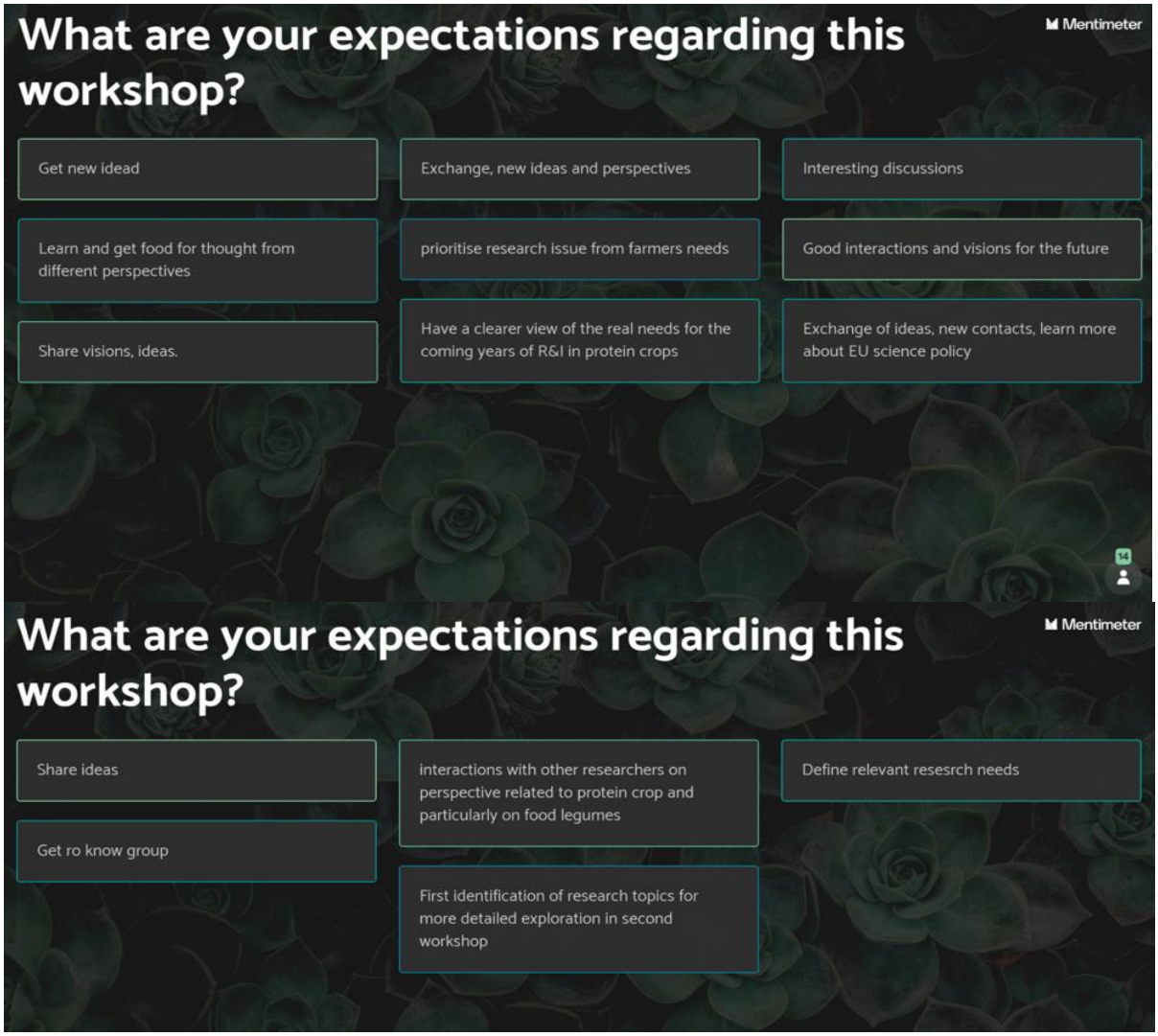
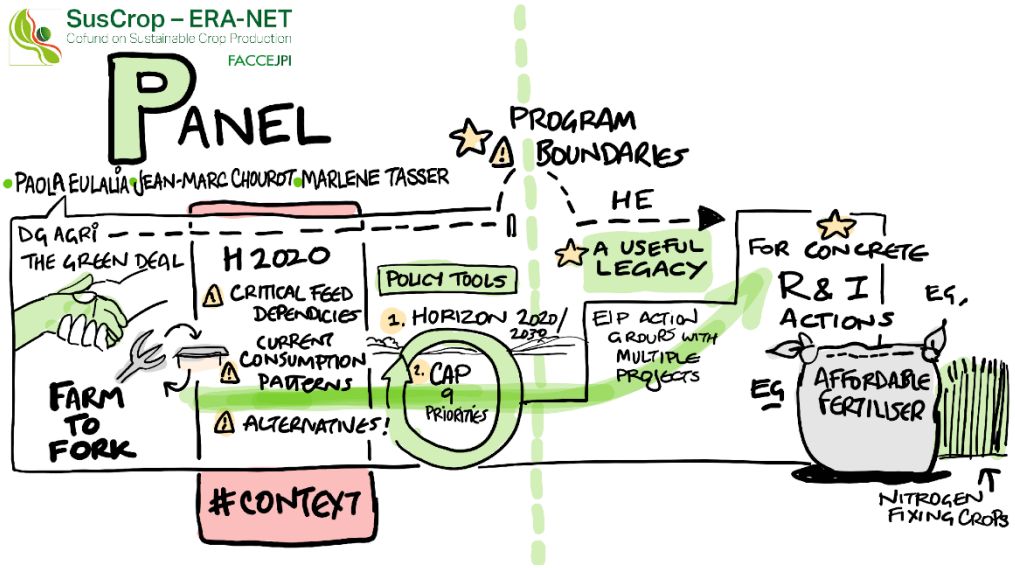


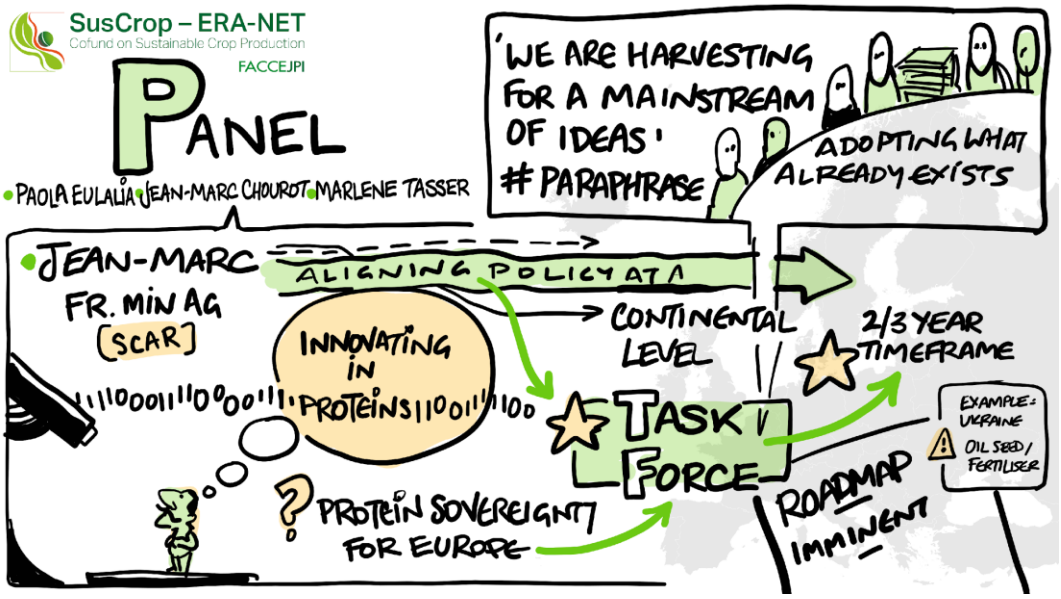
Figure 1: Participants' expectations

Participants highlighted as main expectations: sharing ideas and interacting with other experts, defining together research priorities and needs, having some opportunities to hear different perspectives.

PANEL SESSION

PANEL 1





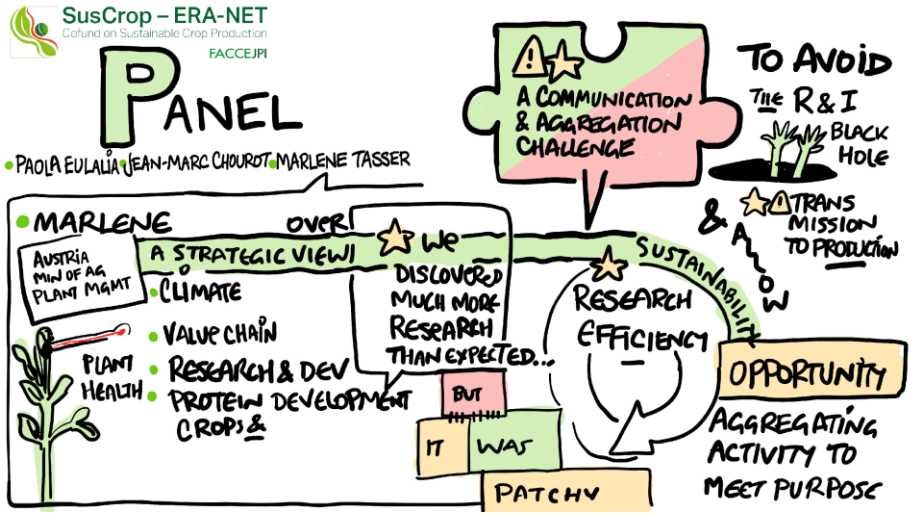
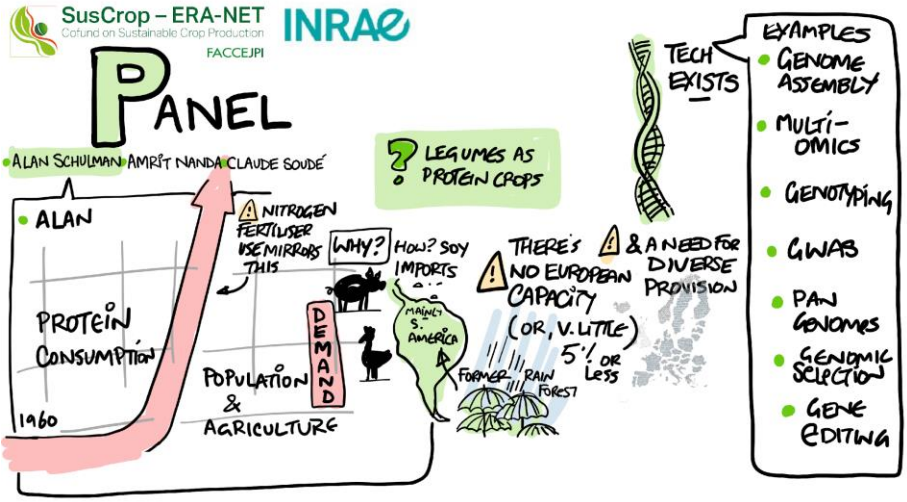
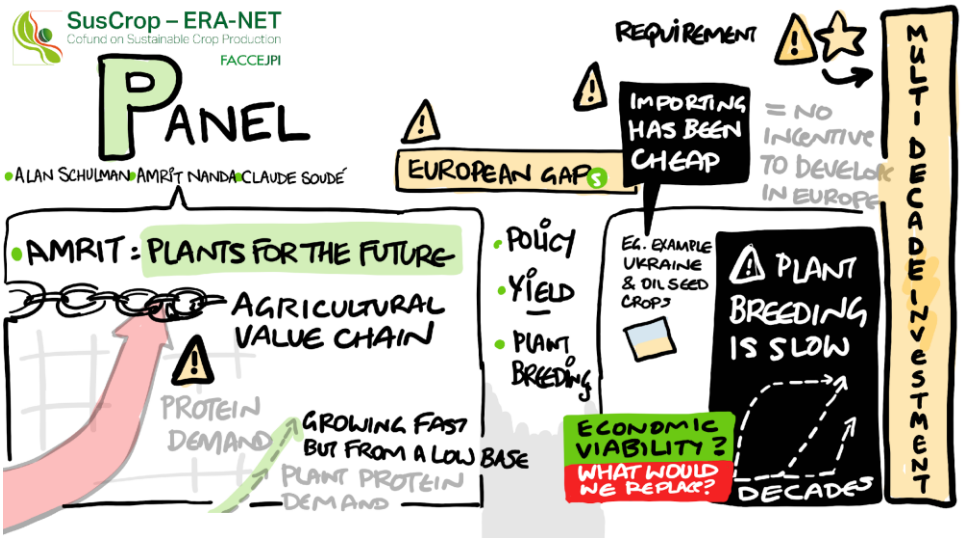


Figure 2: Summary of presentations from Panel 1 on Policy perspectives

PANEL 2





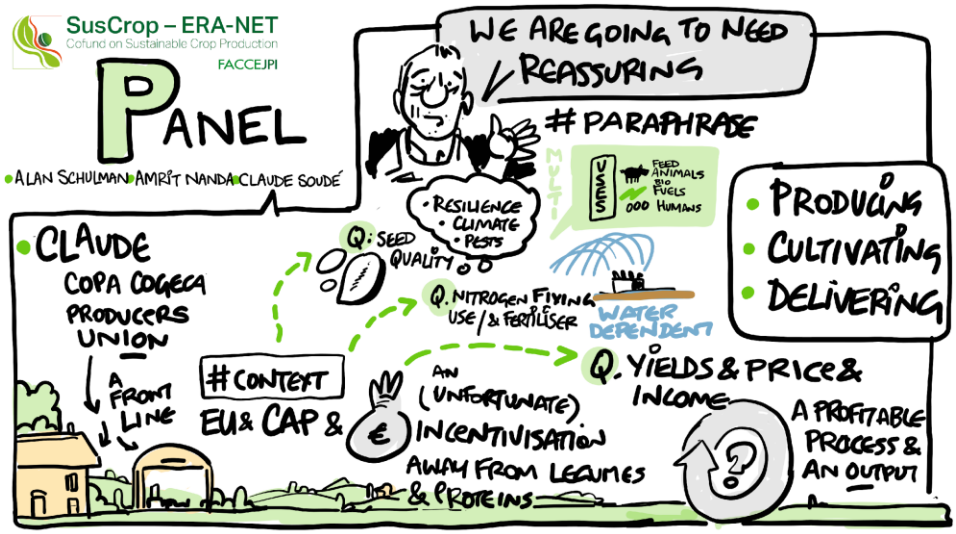


Figure 3 : Presentations of Panel 2 on Stakeholder perspectives

BRAINSTORMING DISCUSSION ON RESEARCH MAIN AREAS TO TACKLE IN GROUPS

Due to technical issues, some delay resulted in a shorter plenary discussion to identify areas to be tackled in small groups to answer the following questions:

- What are research needs on protein crop production for food?
- What are research needs on protein crop production for feed and other parts of the value chain for food and feed?

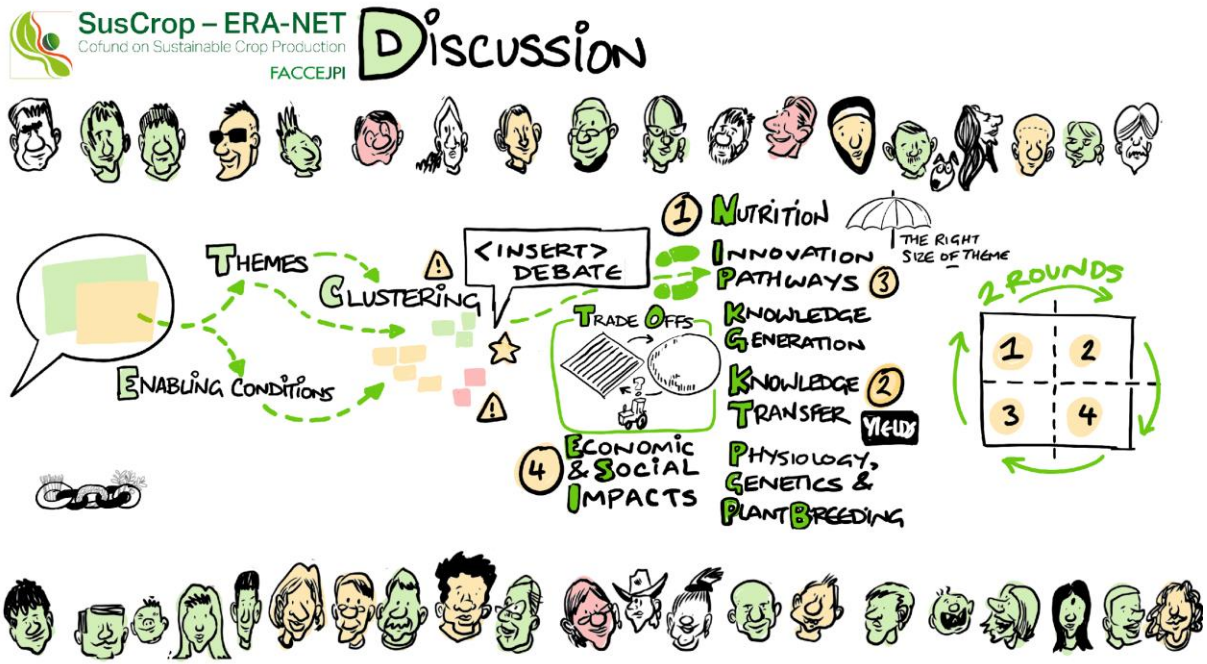


Figure 4: Summary of plenary discussion on topics to explore in break-out groups

Based on the discussions four topics were proposed for the afternoon break-out groups:

- Topic 1: knowledge generation on crop species regarding nutritional aspects
- Topic 2: knowledge generation and transfer on crop species regarding yield stability and efficiency
- Topic 3: Better understanding of innovation pipelines and value chains
- Topic 4: Better understanding of impact assessment and trade-offs

All topics are interconnected but each group was asked to explore more in detail the specific research needs that could support further protein crop production and value chains.

BREAK-OUT GROUP SESSION

Participants could choose which topic they wanted to discuss in a first round of about 30' and could then move to another topic for round 2 for 20'.

Round 1: In this area/topic, building on the panels' key messages, what are the current specific knowledge gaps and research needs?

Round 2: Reflection on the identified research needs by newcomers

Reporting took place in the morning of day 2.

BREAK-OUT GROUP SESSION DAY 1

TOPIC 1: KNOWLEDGE GENERATION ON PROTEIN CROP SPECIES IN RELATION TO NUTRITIONAL ASPECTS

The discussions highlighted the interest of exploring a set of traits for a chosen species. This/these chosen species would be selected based on their potential in terms of protein content and a specific (climatic) region where it is traditionally cultivated / can be cultivated in the future.

Biological research combining plant biology, physiology, genetics and "-omics" would then be carried out for each of these species **on its *nutritional quality for human health,*** such as

- the amino acid composition,
- the micronutrients to maintain / enhance
- the anti-nutrients to reduce,
- the **bioavailability** of the beneficial compounds (amino acids, micronutrients) during human digestion and how this could be improved
- the ***variation/diversity in the species***
- interdisciplinary research consisting of plant science, human nutritional science and human health science.

This knowledge generation will then be used for crop improvement:

Further research will be needed on the links between genetics and genomics of the species. This will be taken further in plant breeding.

Some possible tools: Omics (genomics, metabolomics, proteomics, phenomics), New Breeding Technologies (NBTs), classical breeding.

Combine with crop management and crop processing:

Based on these traits, further research could investigate the plant breeding/crop management and processing through a systems approach: crop improvement, crop management, crop processing (e.g. combining compounds from different crops, preserving nutritional quality compounds, improving bioavailability of nutrients).

Finally, knowledge on this/these particular species could be used to ***understand other species*** (i.e. bridge species for trait-genetics gap with genomics across related protein crops) in the region and also to explore how this species develops and behaves in different regions.

For the small number of species chosen in a first step, future research needs to provide critical mass funding in order to have a systems approach on each one of them, including all components described above for that species so as to achieve the best impact and move that species from a niche to a main crop. In a second step, more species can be chosen to improve.

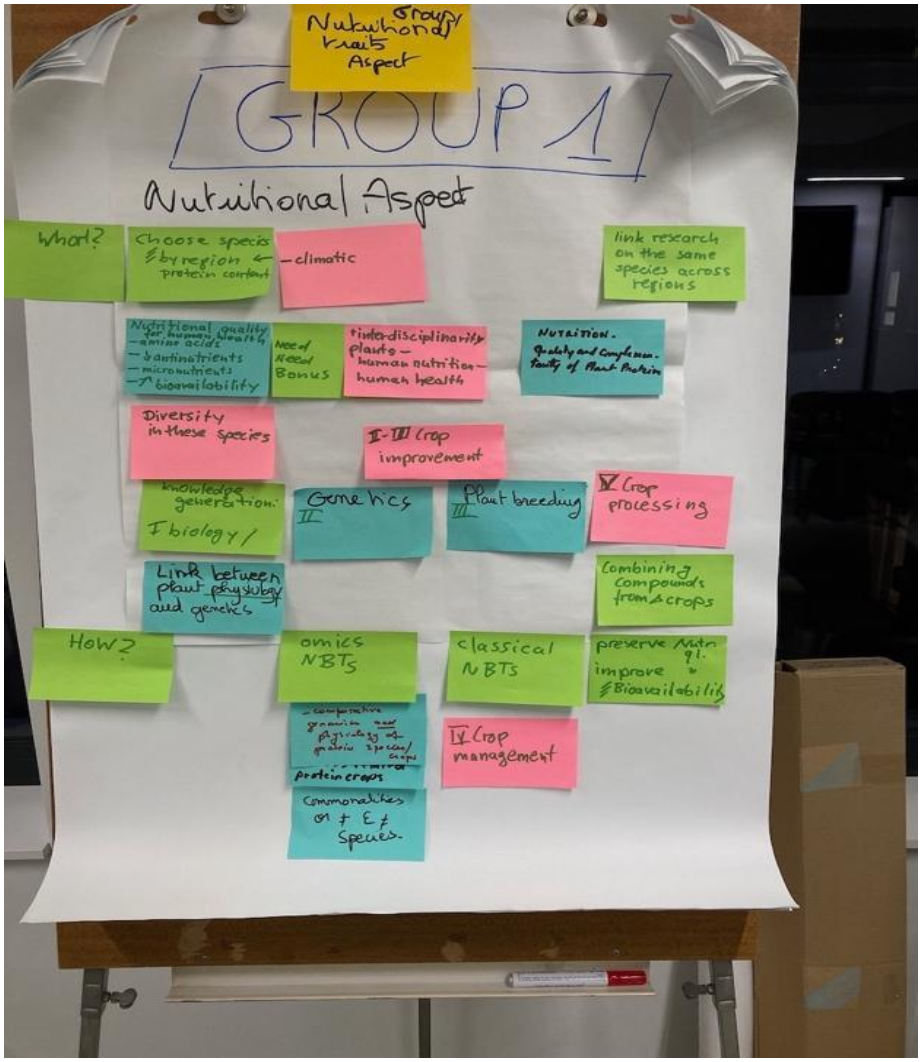


Figure 5: Group 1

TOPIC 2: KNOWLEDGE GENERATION AND TRANSFER ON PROTEIN CROP SPECIES IN RELATION TO YIELD STABILITY, EFFICIENCY, NUTRIENT QUALITY FOR BOTH FOOD AND FEED

Further research is needed on the links between yield and biotic (pests, diseases…) and abiotic stress (drought, salinity due to climate change, CO_2, temperature). An important priority research area concerns the investigation of multi-stresses.

Another important research need would be to further explore the root/microbe/soil interaction (rhizobiome, microbiome, rhizosphere) ***and the consequences on yield efficiency***: soil borne diseases, water uptake, nutrient uptake.

Finally, research should also focus on consistency between cropping systems and agronomic practices: exploring e.g. possible species mixes and optimising practices over growing seasons (for example, 2 growing seasons in 1 year),

A final point was raised concerning the need to investigate storage of products/crop protection and conservation.

Important enabling conditions would be to develop adequate research infrastructures, including seed banks: testing locally adapted varieties and genotypes. This could be inspired

by the phenotype network. A network focussing on genetic diversity would allow for comparative genetics and further exploration of links between phenotypes and genotypes.

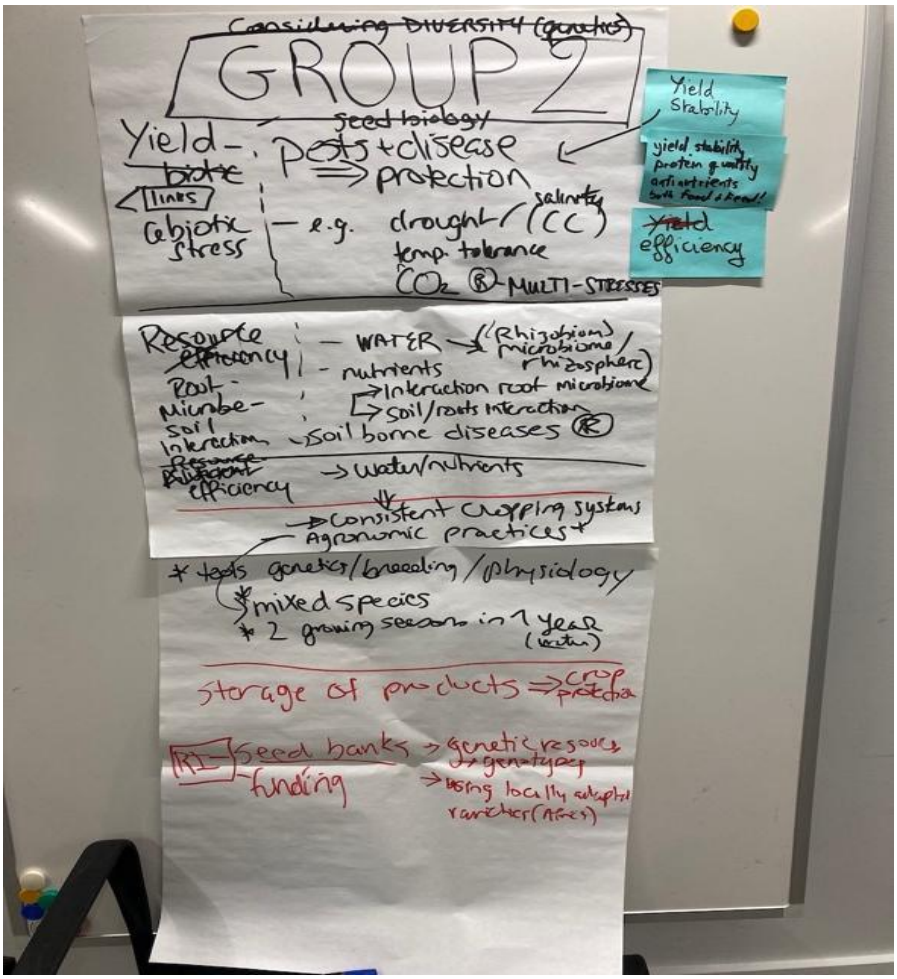


Figure 6: Group 2

TOPIC 3: INNOVATION PIPELINE/ PROTEIN CROP FOR FOOD AND FEED VALUE CHAINS: HOW TO BUILD UP A VALUE CHAIN FOR UNCULTIVATED PROTEIN CROPS

Research is needed to support the development of the protein crop food value chain as efforts so far have supported mainly the feed value chain.

In particular, research should focus on better understanding the needs, barriers and incentives:

- making use of several innovative approaches such as big data analysis
- developing multi-stakeholder participatory approaches for identifying needs and incentives for both producers and consumers
- promoting interdisciplinary studies involving socio-economics and health sciences.

These efforts should support the development of networks integrating consumers and producers and helping the understanding of the "biology of food". The use of citizen science could be explored for generating a better understanding on protein crops and involvement in value chain development

Enabling conditions would require the strengthening of research infrastructures (e.g. big data/databases) and a support and catalysing effect from policy for example by developing public procurement opportunities for plant protein use.

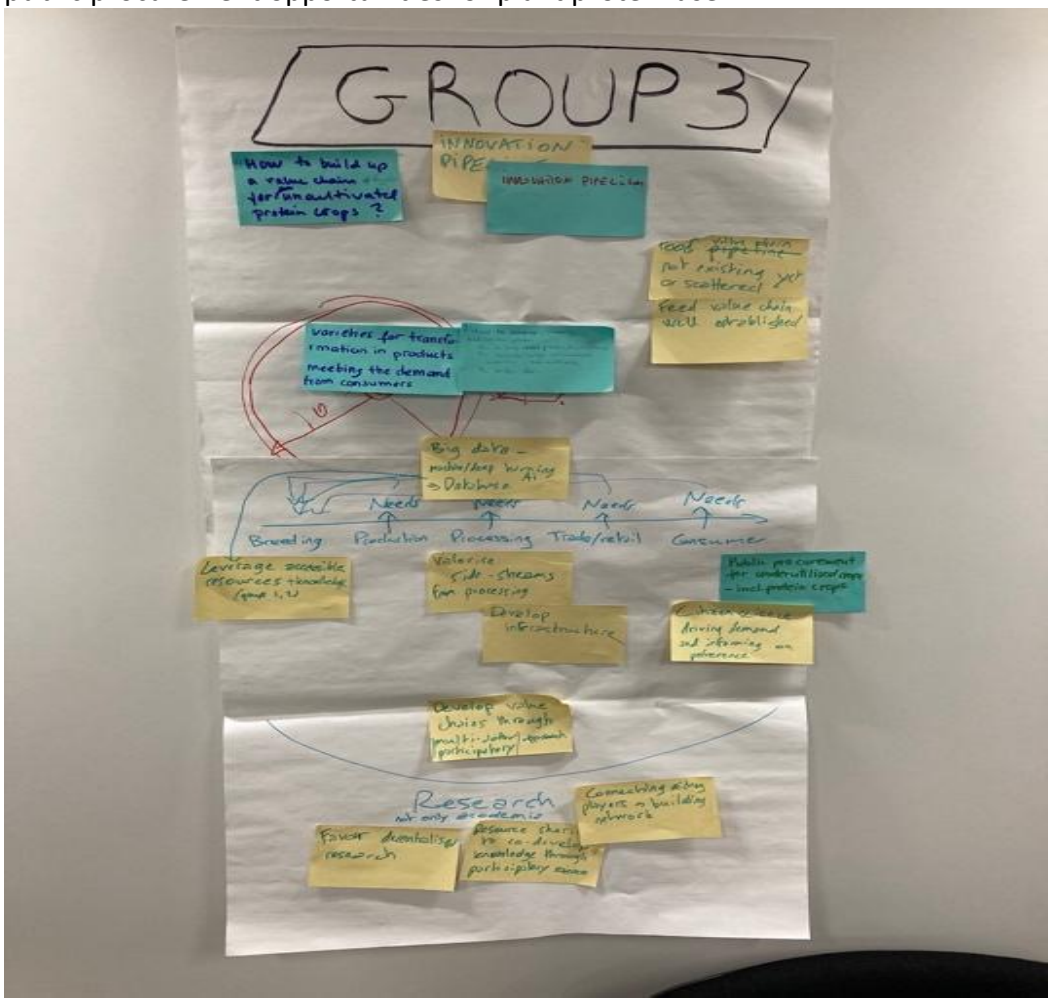


Figure 7: Group 3

TOPIC 4: IMPACT ASSESSMENT AND TRADE-OFFS

Group 4 discussions focused on research needs regarding the impacts of switching our current land use and production to protein crops with emphasis on the shift to systemic approaches and on resulting consequences with regard to climate change. ***There is a need to strengthen the understanding of both socio-economic impacts and the environmental impacts at local, national and international levels***. In addition, further research is needed to understand barriers and enabling conditions to support this potential shift including the incentives for producers and consumers.

In terms of environmental impact, further research would be needed on the interactions between species traits, ecosystem resilience and agronomic cultivation practices (for example with regards to climate change).

The socio-economic impacts have to be investigated at farm level to support farmers in their decision-making to switch to protein crops with a better understanding of trade-offs and risks. In addition, ***macro-level scenarios should also be explored on how to consider a global***

evolution of our food systems with a potential shift of protein consumption from meat-based to plant-based, in particular in terms of imports/exports balance and impacts and consequences on the global market. Scenarios need to be developed making use of modelling for ensuring informed policy decisions.

Figure 8: Group 4

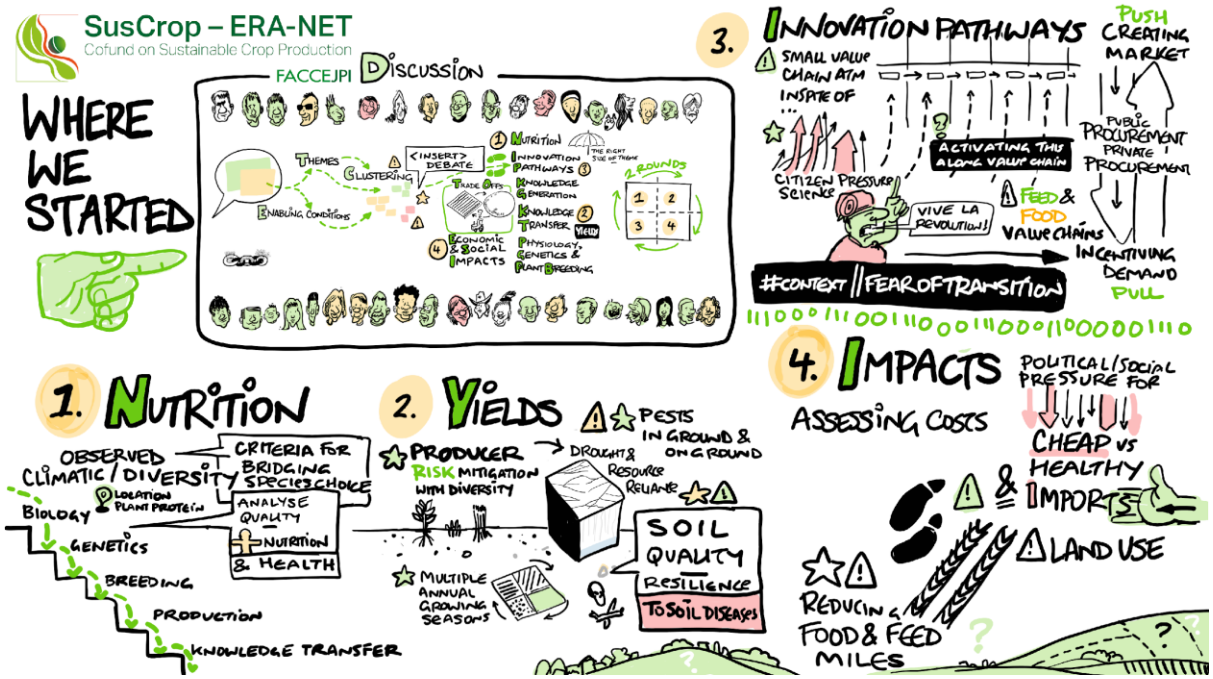


Figure 9: Summary of group discussions Day 1

BREAK-OUT GROUP SESSION DAY 2

After reporting on results from day 1 break-out groups, participants agreed to explore more in detail some specific research needs and enabling conditions:

- The species knowledge generation in relation to practitioners/farmers needs
- The macro level socioeconomics

- The research infrastructures needed to capitalise on data collection (physiology, genetics and genomics).

GROUP LOOKING AT RESEARCH NEEDS IN RELATION TO SUPPORTING FARMERS NEEDS

For farmers, concrete information on a particular species is required to make decisions on cultivation practices. As a consequence, they would like to see further research as described below on the example of pea.

- better understanding of pea growth and biology/genetics:
    - Looking at genotype/breeding/ crop improvement
    - Growth conditions: above/below soil behaviour and consequences for rotation times and soil pathogens
    - Adaptation through agronomic practices (e.g. spring-winter cycles in relation to day light) and how to manage land use.
    - Development of synchronised cycles for harvesting
- Better understanding of crop management for pea
    - Associated cropping/mixed livestock cropping and cutting
    - Effect of microbiome on plant protection: factors affecting microbiome composition

In addition, further research is needed on:

- Multi-stress tolerance/sensitivity though an integrated approach
- Nutritional quality of protein crop species for human health including stress tolerance (increasing micronutrients, decreasing anti-nutrients, bioavailability, amino acids) and the associated processing techniques to maintain the crop qualities.

GROUP ON SOCIO-ECONOMIC ASPECTS AT MACRO LEVEL

Macro-level socio-economic research is needed to identify and demonstrate the value of protein crops and to develop better understanding of both global environmental impact assessment and of the potential for protein crop value chains for food.

Consequently, research should focus on providing evidence for protein crop value and benefits in terms of social, environmental, health and food and nutritional security dimensions.

Socio-economic research needs to address macro- but also micro-economic levels
Questions at macro-level

- How to develop protein crops in the EU?
- How to use EU resources to replace imports (costs and benefits)?
- What are policy impacts and policy incentives?

Economic modelling is required to give as realistic as possible answers to these questions, taking into account regional specificities and multiple interactions between environmental, genetic, agronomic, and socio-economic factors.

Questions at micro-farm level: “to grow or not to grow”

- How to convince farmers?
- What crops make sense in which conditions and with which trade-offs?

Research can help build a decision support system for farmers: Assessing risk and benefits for growing protein crops under various conditions, managing risk by properly managing value chains.

An important research priority is the development of scenarios to better inform policy decisions in particular concerning the need to diversify our food sources for more resilient food systems (looking both at food and feed production). These research efforts should include:

- Identifying the dimensions/criteria that scenarios should consider throughout the value chain: nitrogen cycle, fertilizer use, economic return for farm industry, creation or destruction of jobs, feeding more people/limiting denutrition etc.
- Estimating costs and benefits of growing protein crops considering transportation costs and externalities, land use trade-offs and local production costs…
- Exploring consumers' habits and diets: dietary shift incentives and barriers
- Investigating the functionality of food and nutritional quality: convenience versus quality versus sustainability

GROUP LOOKING AT RESEARCH INFRASTRUCTURES:

Research infrastructures exist[1] but there is a need to make them take up some more innovative paths in building up large collections, in generating mapping of populations and in linking up with phenotyping aspects physiology, metabolites, proteomes, genomics (traits)). Data repositories (e.g. Genotyping of single lines/Sequencing data), gene banks passports, cooperation of gene banks should be financially supported and coordinated.

CONCLUSIONS

The workshop identified the following gaps that need to be addressed in the coming years:

- Crop improvement (to balance crop management and processing)
- Niche crops – in this workshop protein crops - (to balance staple crops)

[1] There was a discussion about existing infrastructures in the EU and that these should be explored and "new infrastructure" be aligned with the existing ones;

There is also existing infrastructure e.g. of collections of pests harmful to plants (several) which cover more than European countries (more info can be prepared if needed)

https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures_en

https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures/esfri_en

https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures/eric_en

- Nutritional security (to complement yield)
- Resistance / tolerance to combined abiotic and biotic stresses (to balance in depth work on abiotic, biotic stress resistance)
- Research Infrastructure
- Policy: legislation (enable the use of NGTs in Europe), public procurement (for niche crops – in this workshop protein crops)

The workshop highlighted several research priorities from the perspective of the participating experts:

Protein crop improvement and farm level

- Further strengthen knowledge generation at species level, with an initial focus on specific species that are both of interest for protein content but also currently important for farmers e.g., pea, soy and bean.
- For chosen species, investigate and improve the crops in terms of:
    - nutritional quality for human health (amino acids, micronutrients, their bioavailability, anti-nutrients)
    - resistance to individual and combined stresses, better linking genetics and genomics, and making more use of bridge species. Increase knowledge on high potential species and mix of species in a specific region.
- Connect genetics and biology with yield stability and efficiency in relation to biotic and abiotic stresses, as well as in relation to crop management (agronomic practices) and improvement. Develop multidisciplinary approaches and a decision support system for farmers to make informed choices in terms of improved crops and cultivation practices (per climatic region).

Value chain level

- Develop a stronger connection between farmers and actors of the protein crop processing chain. Utilise participatory transdisciplinary approaches to ensure knowledge transfer and capacity building of all actors in the value chain.
- Apply socio-economic sciences to identify incentives and barriers for producers and consumers, to better understand how the value chain could be catalysed and further developed.

Policy level

- Develop s cenarios integrating social, environmental, agronomic, economic, health, food and nutritional security dimensions to support national, European and international policy decisions enabling an increase in European protein crop production. These scenarios would need to address macro-level aspects but also support better understanding of farm-level economics and trade-offs.
- Develop a better understanding of environmental impacts and develop standard impact assessments at local and international level, to support the value chain development and scenarios building.

Identify enabling policy options that support and integrate relevant sectors from plant to nutritional research, to agriculture, trade, food security and

health. This support is required to shift towards a plant-based protein diet (e.g. public procurement for protein crops to be included in school meals etc.); to provide incentives and risk mitigation for breeders , farmers and transformers (enable NGT use by a science based exemption from additional legislation), to engage in this new value chain; and to support an adequate research infrastructure to build knowledge generation and capacity building.

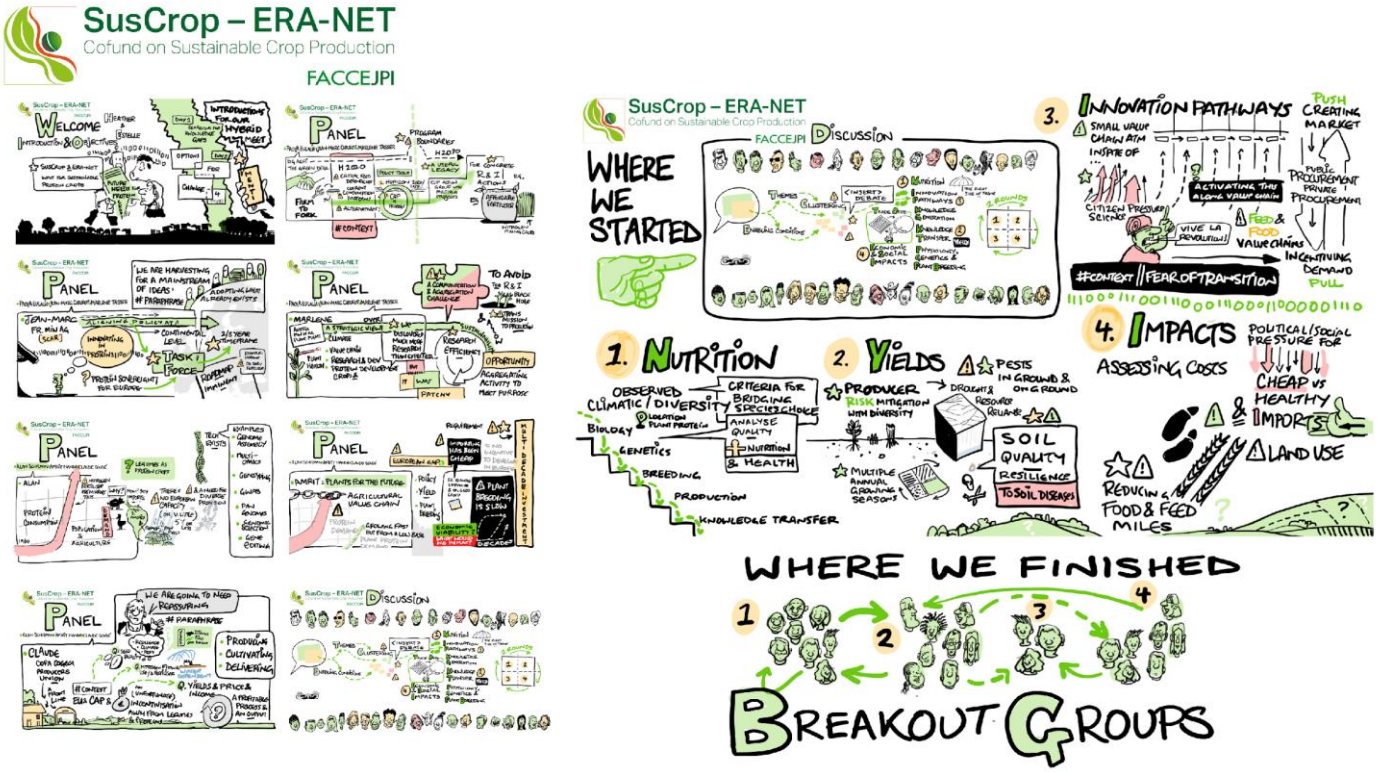


Figure 10: Summary of the workshop process and outputs

ANNEX 2 WORKSHOP AGENDA

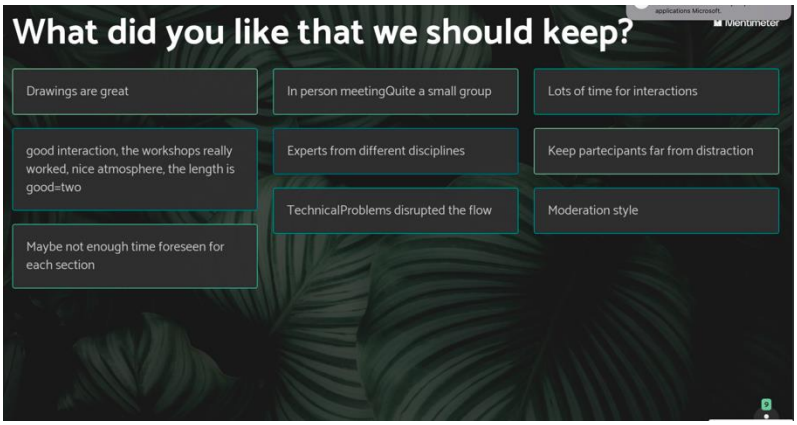
Day 1

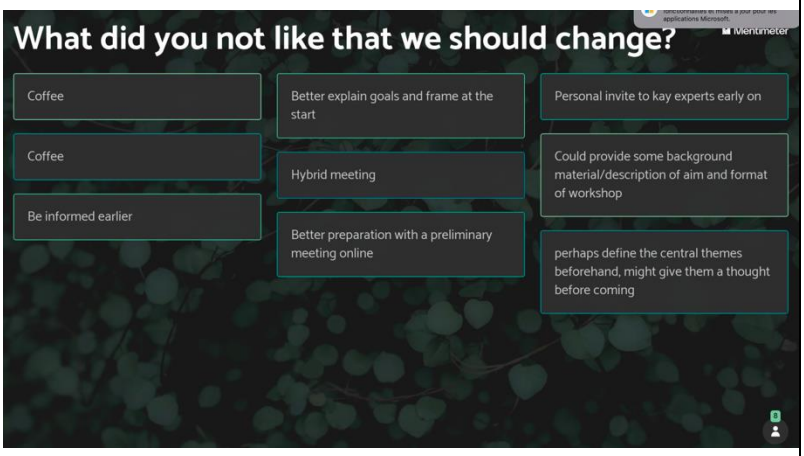
Time	Length	Title	Description
12:30	30m	**Welcome Lunch**	
13:00	25m	**Introduction Background and Objectives**	
13:25	40m	**Panel with perspectives of Policy makers**	**Perspective of European Commission** *Paola Eulalio (Agri)* **Perspective of SCAR** *Jean-Marc Chourot (FR)* **Perspective of a Member State** *Marlene Tasser (Austria)*
14:05	40m	**Panel 2 perspectives of Stakeholders**	**Perspective of the science** *Alan Schulman (EPSO)* **Perspective of Business** *Amrit Nanda – ETP Plants for the Future* **Perspective of farmers** *Claude Soudé (Copa-Cogeca)*
14:45	50m	**Discussion on the current knowledge on Protein crops and what would be future themes to further explore**	
15:30	*15m*	***Coffee break***	
15:45	10m	**Introduction to the afternoon Break-out group work**	
15:55	1h 00m	**Break-out groups session 1**	Question: Regarding the topic building on the previous discussion, what are the current specific research needs? 2 rounds of 30’
16:55	*15m*	***Short break***	
17:10	10m	**Evaluation of the day**	
17:20	**END OF DAY 1**		
19:00	***DINNER AT “LES FILLES” - RUE JEAN CHAPELIE 4, BRUXELLES***		

Day 2

Time	Length	Title	Description
09:00	10m	**Programme Day 2**	
09:10	30m	**Reporting of the breakout session 1**	
09:40	1h 00m	**Break out group Session 2**	Question: How would you prioritise the identified research needs in terms of - relevance for policy needs/ important outcome? - potential for innovation? - feasibility (medium term or long term)? *2 rounds of 30'*
10:40	*15m*	***Coffee break***	
10:55	40m	**Reporting of the breakout session 2**	
11:35	30m	**Conclusions**	
12:05	20m	**Evaluation & next steps**	
12:30	***LUNCH***		
13:30	***END OF DAY 2***		

Annex 3 Evaluation of the workshop





Participants appreciated having a face-to-face event and the interactive group discussions. The fact that the group was small and there was the opportunity to have a social event in the evening created a friendly atmosphere and a good interaction among experts.

Participants called for more information prior to the workshop and to have a better explanation of the goals of the workshop and to define some of the main themes before the meeting for better preparation.

The hybrid format created some issues and delays and should be avoided when possible.