EU CAP NETWORK

EU CAP NETWORK REPORT

EU CAP Network Focus Group ‘Production of protein crops under climate change’

Final report

Funded by the European Union

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1. Introduction

This report presents the outcomes of the EU CAP Network Focus Group (FG) on the *Production of Protein Crops (PCs) under Climate Change (CC)*. The FG examined how farmers can increase PC production and marketing in the EU, considering the impacts of CC. An introduction to the topic is provided in the Starting Paper of the FG. Key challenges and success factors identified by the FG experts were summarised in five Mini Papers. The final report aims to support farmers and stakeholders across the EU in exploring opportunities for PC cultivation in diverse regions and value chains.

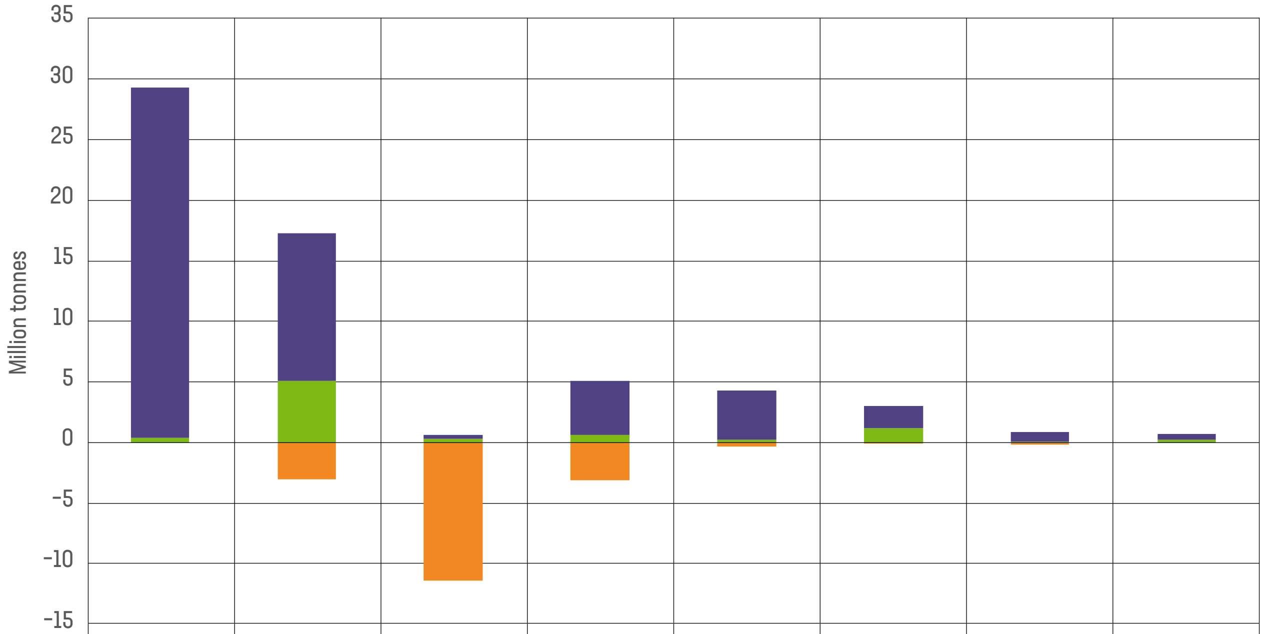
Table 1. Topics and contents of the Mini Papers

Topic	Content
Guide for climate-resilient PC farming	Guidance on cultivar selection and regional cultivation strategies
Characterisation and genetic improvement of protein crops	Target traits for sustainable PC production and breeding targets in the context of CC
Strengthening regional value chains	Collaboration and regional branding to support PCs
On-farm processing of protein crops	Local PC processing and circular bioeconomy practices
Exchange and creation of knowledge for PCs under CC	Cooperation between research, applied research and farmers

a) EU's protein crop production gap

The EU's PC production gap—where demand exceeds domestic production—has been driven by several long-term developments. Rising livestock numbers and the associated demand for feed have increased the need for PCs, while the cultivation area of PCs has declined. One reason for this decline is the increasing use of synthetic nitrogen fertilisers, which reduces the incentive to grow legumes for nitrogen fixation. This substitution is visible when comparing conventional and organic systems: organic farming relies on legumes for nitrogen fixation, whereas conventional farming largely depends on synthetic nitrogen. This is reflected in production data: in 2022, 24% of the grain legumes produced in the EU were organic, although only 9.1% of total EU farmland was managed organically. When compared internationally, the share of agricultural land dedicated to PCs in the EU remains very low. The expansion of livestock farming has gone hand in hand with dietary preference shifts towards greater consumption of animal-based, and a decline in plant-based, protein-rich foods.

Figure 1. Origin of protein used for feeding EU livestock and exports of those products (in million tonnes of protein). Soya is the main PC imported



	Roughage	Cereals	Soya bean meals	Other oilseed meals	Other co-products	Non-plant sources	Pulses	Oilseeds
Non-EU Origin	0	-3	-11.4	-3.1	-0.3	-0.1	-0.2	0
EU Origin	28.9	12.2	0.3	4.5	4.1	1.8	0.8	0.5
EU Exports	0.4	5.1	0.3	0.6	0.2	1.2	0.1	0.2

Source: DG AGRI – EU Feed Balance Sheet – 2022/23

Compared with other crops and PC imports, the EU's production of PCs is limited by weak economic competitiveness; as a result, cropped areas of PCs remain small. Closing the gap requires measures to increase competitiveness, applied research on processing, variety improvement, and better use of underutilised PCs. In addition, dietary shifts toward plant-based foods, together with strategic efforts to enhance profitability and marketability, are needed for wider PC adoption in the EU.

Figure 2. Sources of plant-based proteins

Cereals

are grasses with a high grain yield and starch content. Despite their comparatively low protein content, cereals are one of the most important sources of protein in the EU owing to well-established variety development, cultivation systems and value chains.

Grain legumes

include various types of PCs for food and animal feed, which have a high protein content and varying levels of starch and oil.

The plants are capable of biological nitrogen fixation in symbiosis with soil bacteria.

Sources of plant-based proteins

Oilseeds

are various species that are mainly cultivated for oil. The by-products of the oil pressing have a high protein content (press cakes) and are a popular protein feed for animals.

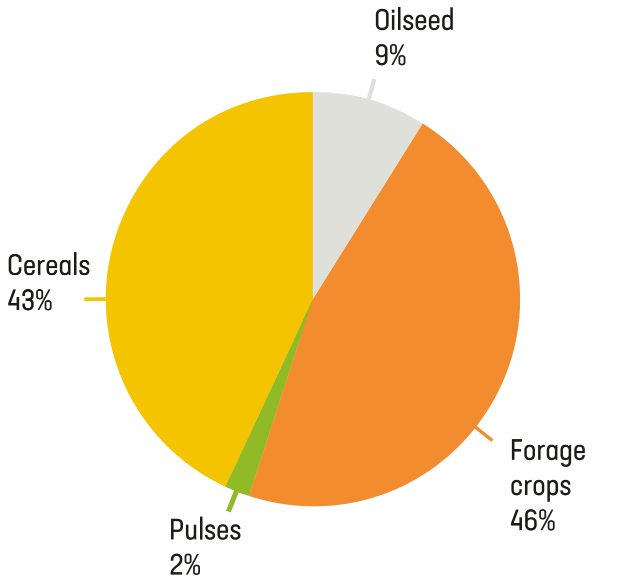
Forage crops

are crops which are harvested as whole plant for fodder. In forage cultivation, leguminous and non-leguminous species are often cultivated in mixture, combining the advantages of grasses and legumes.

b) Sources of plant-based proteins

All plants contain sources of protein (Figure 2). Currently, plant protein production in the EU relies primarily on cereals and oilseeds (Figure 3). However, due to their high-quality protein content and the ability to fix nitrogen, legumes are often considered the preferred source of plant protein. In line with the Common Agricultural Policy (CAP) of the EU and the political aim of reducing the use of synthetic nitrogen fertiliser through biological nitrogen fixation, from hereon in, the report will only consider legumes as PCs.

Figure 3. EU plant protein production in the years 2023/24 (share of crude protein). The European Commission only considers pulses, certain oilseeds, and roughage containing legumes as PCs



Source: European Commission based on DG AGRI/EUROSTAT/MS

c) Approaches and motives for closing the plant protein gap

To enhance self-sufficiency in plant protein supply and reduce dependence on imports within the EU, two approaches can be considered: increasing PC production, and lowering the need for imports. Increasing local production aims to replace imported PCs with domestically-produced ones, and can involve:

- **Increasing productivity**: improving the yield and efficiency of PC production through improved cultivation techniques, variety development and new crop species.
- **Increasing the overall share of PCs** in crop rotations, also to reduce synthetic nitrogen fertiliser use.
- **Strengthening value chains**: developing robust EU-based PC supply chains for food and feed.
- **Creating new markets**: establishing opportunities for high-value PC products that contribute to diversified farm incomes.

However, replacing imported protein crops has limitations. Substituting the current import volume is unrealistic, given feed demands as well as land, climatic, economic, and infrastructural constraints. Reducing import dependency therefore also requires lowering demand for plant protein by aligning production and consumption with EU resources.

- **On-farm or regional self-sufficiency:** matching livestock numbers with locally produced feed, thereby reducing the dependency on global feed markets.
- **Extensification:** reducing production intensity and external inputs can lead to lower yield outputs, but at the same time improve ecosystem services and the social working environment on the farm. It requires strategically well-considered adjustments at several levels of the farm system, including the introduction of alternative cultivation methods and crop selection, adjustments to nutrient cycles and, possibly, new marketing strategies.
- **Improved resource efficiency:** promoting the consumption of protein-rich plant-based foods, which bypasses animal feed conversion and thus reduces the required amount of land for plant protein.

These approaches require farm-level adaptations and changes along value chains. Increasing EU PC production requires technical and market innovations, whereas reducing PC demand calls for structural shifts in farming systems, as well as in social and dietary patterns. A combined and integrated approach may offer the most resilient path toward closing the EU PC gap. At farm level, extensification and intensification can occur simultaneously.

Figure 4. Selected motivations to increase PC production

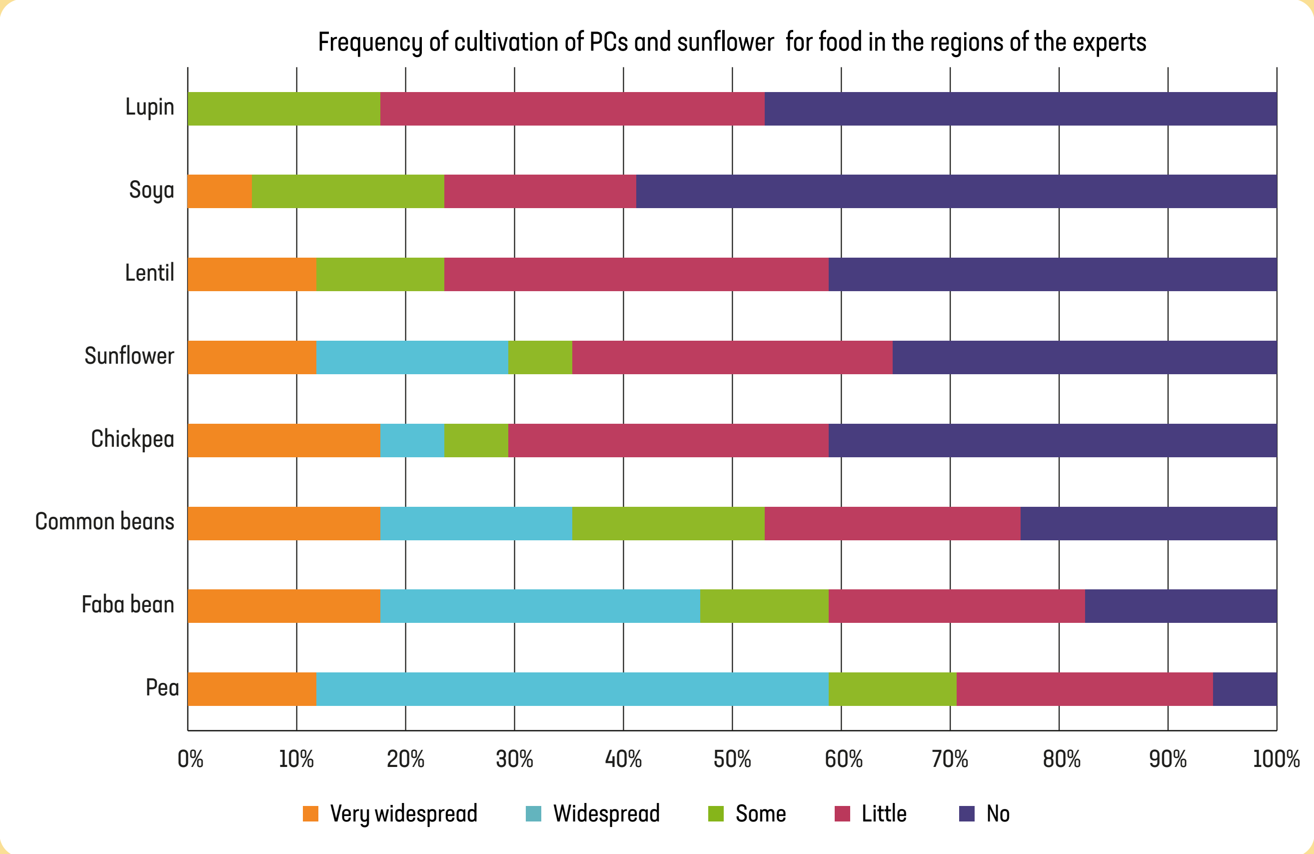
Food security Reducing reliance on imported soya-based animal feed by increasing the use of EU-grown protein sources.	**Strengthening local value chains** Strengthening regional feed and food systems through locally used PCs.
Human nutrition Promoting healthy PC-based diets while simultaneously reducing the need for PC imports and the environmental impact of livestock farming.	**Soil and ecosystem health** Integrating legumes into crop rotations to enhance soil fertility and ecosystem services.

Approaches to increasing PC production are diverse, ranging from local value chains with direct marketing to large-scale industrial processing. Decisions on the cultivation, processing, and marketing of PCs depend on underlying objectives and motivations, such as enhancing feed and food security, improving farm profitability, or promoting environmental sustainability (Figure 4). Achieving these objectives requires the strategic selection of PCs and value chain models.

PC for food

The European Commission has acknowledged the environmental, agricultural, societal, and health benefits of producing and consuming plant-based foods. While the consumption of plant-based protein foods is still small compared with animal-based protein products, direct human consumption represents an environmentally and economically viable alternative to producing PC feed. Halving the consumption of animal foods would reduce the EU's protein deficit by 75%, agricultural nitrogen emissions by about 40%, and land demand for food production by 23%. By contrast, the effect of increasing PC cultivation on the food system is minor compared with changes in the consumption and production of animal-sourced foods. This highlights the role of PCs in supporting dietary shifts by providing high-protein plant-based foods. Figure 5 shows the frequency of PC and sunflower cultivation in the EU regions as represented by the FG experts.

Figure 5. The extent of various crops grown for protein-rich foods in the EU regions as represented by the FG experts. It reflects the experts' perceptions and is not based on representative data collection



d) Climate change and protein crop production

CC increasingly affects agricultural production through changing weather patterns and growing conditions, leading to reduced crop yields and quality. These changes are largely unpredictable, making it difficult to plan production and select the appropriate PC species. PCs are vulnerable to climate change impacts such as rising temperatures, prolonged droughts, and shifting precipitation patterns. At the same time, their strategic use can contribute to mitigation by reducing greenhouse gas emissions from nitrogen fertilisation and by replacing animal-based proteins in human diets with plant-based alternatives. Current and projected climate impacts on PC cultivation underline the need for targeted adaptation strategies at the farm level. These may involve adjustments within existing systems, such as adopting irrigation technologies or drought-tolerant varieties, or broader changes such as shifting towards more extensive production models with lower water demands and reduced livestock numbers.

Figure 6. Several CC-related challenges for PC cultivation (left) and opportunities for adaptation (right) identified by the FG experts. The statements highlight that while CC poses challenges, it also offers opportunities for development through adaptation measures

Challenges

- Lack of water, early spring drought, heat
- No irrigation available
- Increased pest and disease pressures
- Increased weather extremes (heavy rains)
- Higher temperatures in summer impact pod fill and therefore crop yield

Opportunities

- Exploitation of new protein crops for feed and food
- Shifting to the cultivation of protein crops from other non-profitable crops that are affected more by climate change
- Climate change will cause a shift of areas typical for some crops towards the north
- Climate change will open new opportunities for crops with fewer soil and water requirements

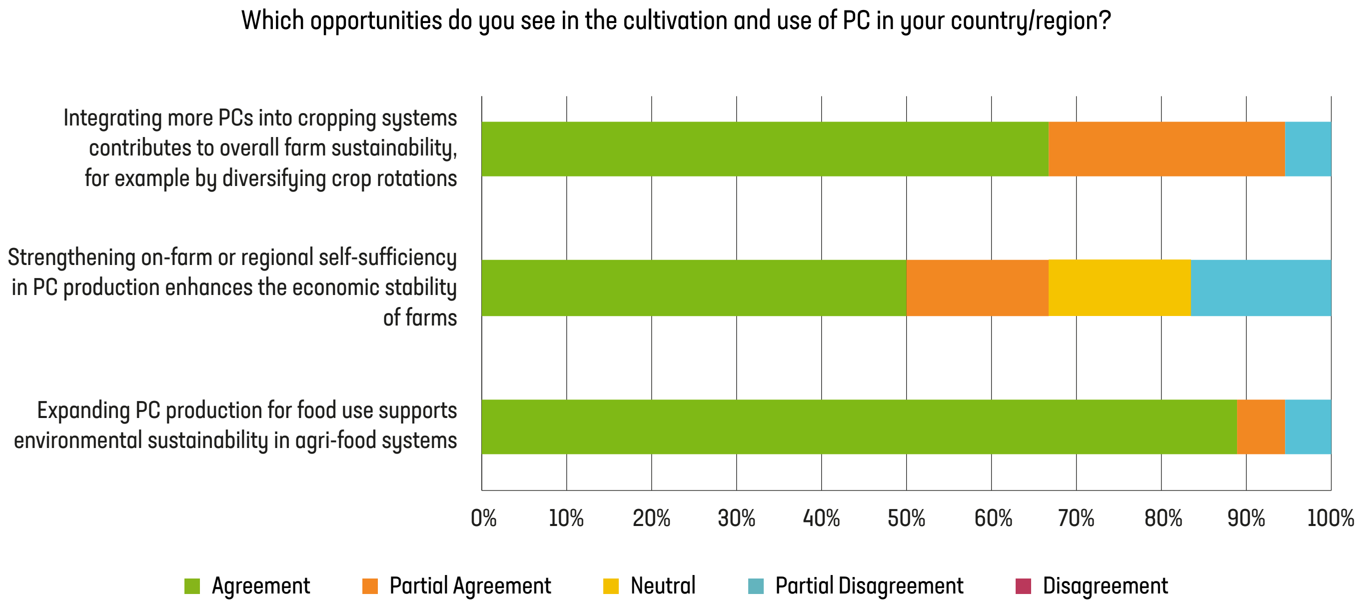
FG experts emphasised the high unpredictability of CC effects. While certain changes, such as rising temperatures, are relatively predictable at the global scale, their impacts on local climatic conditions are more difficult to forecast. Farmers therefore need flexible, locally-adapted strategies to cope with these shifts.

Successful adaptation and mitigation will depend on innovative approaches that integrate new production techniques, alternative crops, and diversified economic models. These may include shifts in market orientation, product development, or value chain integration, all tailored to farm-specific conditions and opportunities.

2. Challenges and opportunities

Most experts anticipated positive effects on agriculture and on the food system from expanding PC production (Figure 7). Achieving these benefits will require coordinated action across value chains. Socio-cultural factors, particularly food habits, play a crucial role in enabling this transition.

Figure 7. Responses from the FG experts on the opportunities associated with the production of PCs in their region

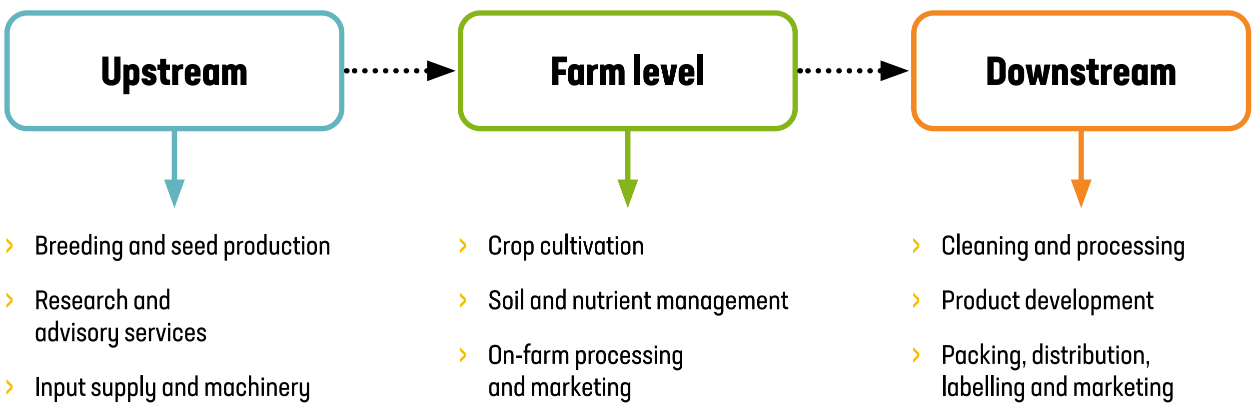


Note: Please note that no respondents were in disagreement.

Source: European Commission

Challenges identified in the FG were grouped into three stages: upstream, farm level, and downstream (Figure 8). The upstream stage covers inputs and services that support pre-production; the farm level encompasses core on-farm activities; and the downstream stage includes all processes after harvest.

Figure 8. Upstream, farm-level and downstream challenges of PC production



Source: European Commission

a) Upstream challenges

Crop choice and availability of locally-adapted PC varieties are the basis for PC production. Plant breeding contributes to the development of varieties with the required agronomic and processing traits. Commercial plant breeding provides farmers with high-yielding, locally-adapted cultivars of major PCs, such as pea and soya. Public and private variety performance testing generates information about varietal performance. The changing needs of producers are detected by breeders through their interaction with the value chain. Minor and underutilised PC species are grown only locally and on a small scale, partly due to limited access to information and seeds. The lack of commercial incentives leads to underinvestment in the development of underutilised PC species. Very few countries have PC breeding strategies, and even then, they do not always focus on developing varieties according to the needs of producers and the market.

In regions with little or no PC cultivation, farmers have limited access to information on species and varieties suitable for their area. This makes the decision to cultivate PCs risky from both agronomic and economic perspectives, particularly for crops that require well-informed variety selection based on cultivation and marketing-related traits (Figure 9).

Figure 9. Lupin (yellow lupin on the right) is an underutilised PC. The usability of the harvest depends on the alkaloid content of the seeds, which is influenced by the variety and growing conditions. Lupin seeds can be used for animal feed, food, and specialities such as lupin coffee (on the left)

Source: https://www.gzpk.ch/

In some protein crop value chains and cultivation areas, exchange between variety developers and value chain actors remains limited. As a result, key agronomic and processing traits, such as lodging resistance, dehulling ability, and cooking time, are not sufficiently considered in varietal development.

> ***"Throughout the winter, I tested the cooking time of green peas in my home kitchen to find a variety for production that was quick and easy to cook. Although it was possible to order seeds of different varieties, information about cooking times was not available."***
>
> ANNA VAN DER BIJL
>
> Dutch legume expert and producer

Figure 10. Legume Hub is a positive example of a European online platform for sharing information on legumes. Other platforms have been created as part of EU projects

Source: https://www.legumehub.eu/

Information systems for commercial PC varieties and accessions in germplasm collections exist but remain incomplete. Farmers often lack information on the specific traits and agronomic performance of commercial varieties. Data generated from trials involving germplasm collection accessions is often not fed back into the information system. Although information systems such as EURISCO provide an important foundation, they currently contain mainly accession information. Trait and performance data from field trials is sparse and inconsistent, which limits its practical use for breeders and other stakeholders in the supply chain who require accessible, trait-specific data.

b) Farm-level challenges

At the farm level, low productivity and limited resource-use efficiency in many PCs are significant production barriers. PC cultivation is often economically uncompetitive compared with other crops. In addition, cultivation and postharvest processing require machinery that is often unavailable at either the farm or the regional level, and cooperation through shared equipment, coordinated production, and joint marketing is rare. Missing information makes PC cultivation difficult. Although many applied research projects on PCs have produced valuable results, practitioners often find the information difficult and time-consuming to access. Effective tools for crop rotation planning, soil and disease management, and knowledge exchange are lacking, and extension services and best-practice examples remain insufficient (Figure 10).

CC adaptation adds further complexity, requiring techniques that improve soil health and water retention, as well as crop associations that stabilise yields. Input substitution through PC cultivation can support both sustainability and farm self-sufficiency, but these shifts demand reliable support structures and regular monitoring of crop performance and system functions. Farmers' motivation and experimentation play a crucial role, as many advances are driven by pioneers who test PCs using their own time and resources. However, in many regions, networks and exchange opportunities are missing, leaving farmers isolated with their cultivation challenges.

c) Downstream challenges

Downstream, value creation and market access remain key challenges for PC producers. Farmers often receive only a small share of the value created, as most processing and marketing take place after harvest. Close collaboration across the value chain or on-farm processing enables producers to capture more of the added value. Networks and exchange platforms are lacking in many regions. The demand for plant-based protein products is growing, particularly in the context of sustainable and regional food systems. Farmers need access to information about quality standards and the selection of varieties suitable for processing. Processing on-farm requires infrastructure and machinery. This is often too expensive for individual farms to purchase, which results in such products not being widely available at a regional level.

Figure 11. Summary of the challenges mentioned by the FG experts for increasing the production of plant proteins in the EU. The left column describes relevant aspects before production (Upstream farm level), the middle column aspects during production on the farm (Farm-level) and the right column aspects after the harvest

Summary of barriers and opportunities for PC production in the EU

Upstream farm level

Lack of suitable PC species and cultivars

- Develop and provide a wider range of suitable species and cultivars, breed varieties with improved traits tailored to specific market demands
- Select and test species and varieties under local growing conditions, including less productive areas
- Strengthen participatory variety selection to ensure local adaptation and foster uptake by value chains
- Explore innovative breeding methods (e.g. genomic tools, organic heterogeneous material) within the framework of EU law
- Propagate and conserve local varieties and landraces, ensuring seed availability for farmers

Lack of local demand

- Promote local food consumption of protein crops to stimulate production
- Foster regional cooperation to build strong structures linking farmers, processors, and consumers

Farm level

Lack of agronomic knowledge and knowledge creation

- Develop practical recommendations for PC cultivation, including machinery use, intercropping, and mechanical weed control
- Demonstrate best practices for PC cultivation through on-farm trials
- Create user-friendly guidelines for integrating PCs into farm systems and crop rotations

Low profitability of grain legume production

- Enhance resource efficiency and productivity of PC production by optimising input use and cultivation techniques
- Highlight the economic and ecosystem benefits of PCs, such as cost savings from biological nitrogen fixation
- Demonstrate market opportunities for replacing imported PCs with EU-produced alternatives in feed and food chains

Downstream farm level

Lack of supply chains

- Develop infrastructure for local and on-farm PC processing, including protein extraction for food and feed
- Define and harmonise quality standards for PC processing

Lack of novel PC products

- Process PCs into innovative foods
- Identify new markets for PC-processing by-products
- Characterise PCs for feed use, highlighting their specific nutritional values for animals

Unutilised potential of collaboration

- Support cooperatives and producer groups to share machinery, aggregate volumes, and market PCs collectively
- Encourage farmer working groups to experiment with PCs and exchange experiences

Lack of consumer awareness

- Link PC production with healthy diets, promoting the nutritional benefits of plant-based eating

Climate change

Upstream farm level	Farm level	Downstream farm level
Develop varieties with improved traits that are relevant to climate change adaptation	Develop practices for growing PCs under temperature and water-stressed conditions	Increase resilience and adaptability of regional value chains to unpredicted climatic changes

Source: European Commission

3. Innovations and opportunities to improve uptake

The following sections summarise outcomes and proposed solutions from the FG experts. More detailed information on specific topics is provided in the Mini Papers.

a) Climate-resilient PC farming and crop options

Mini Papers one and two provide guidance on how to choose and further develop PCs. The experts emphasise the importance of varietal selection based on regional suitability, climatic risks, and intended end uses.

- **Adaptation to local growing conditions**: matching species and varietals to specific regional climates, soil types and cropping systems. It is often worth trying species from other regions to test their performance under changing cultivation conditions.
- **Climate Resilience**: choosing stress-tolerant species and varieties. Consider adapting cultivation methods to mitigate increasing climate variability and extreme weather events (earlier spring sowing, moving to autumn sowing or mixed cropping).
- **Market-Readiness**: choosing varietals specifically for food or feed markets based on processing quality or nutritional traits. Depending on the PC, varietals differ in quality traits.
- **Biodiversity and Soil Health**: selecting species that contribute to diverse crop rotations and support soil fertility. Different PCs and cultivation methods can enhance soil properties, such as increasing soil organic matter, which in turn improves water retention and strengthens resilience to climatic extremes.

Figure 12. Protein pea is a common crop in various European climates (left, pea grown in mixture with barley). However, it is not drought resistant. Chickpea (right) is more drought-tolerant; however, the crop does not tolerate humidity in summer. Therefore, it is an alternative to pea, but cultivation in many regions is associated with risks

Source: https://www.gzpk.ch/

b) Breeding and access to seeds

In varietal development, breeding efforts should prioritise traits that enhance the economic competitiveness of PCs.

- **Improving yield, climate resilience, pest resistance, and seed quality**: the impacts of CC on annual crops cannot be predicted with certainty. Breeding should therefore prioritise general adaptive traits such as early maturity, deep rooting, and winter hardiness.
- **Traits required by developing markets**: stronger alignment of breeding goals with market and processing needs is essential to increase PC production, particularly for protein foods.

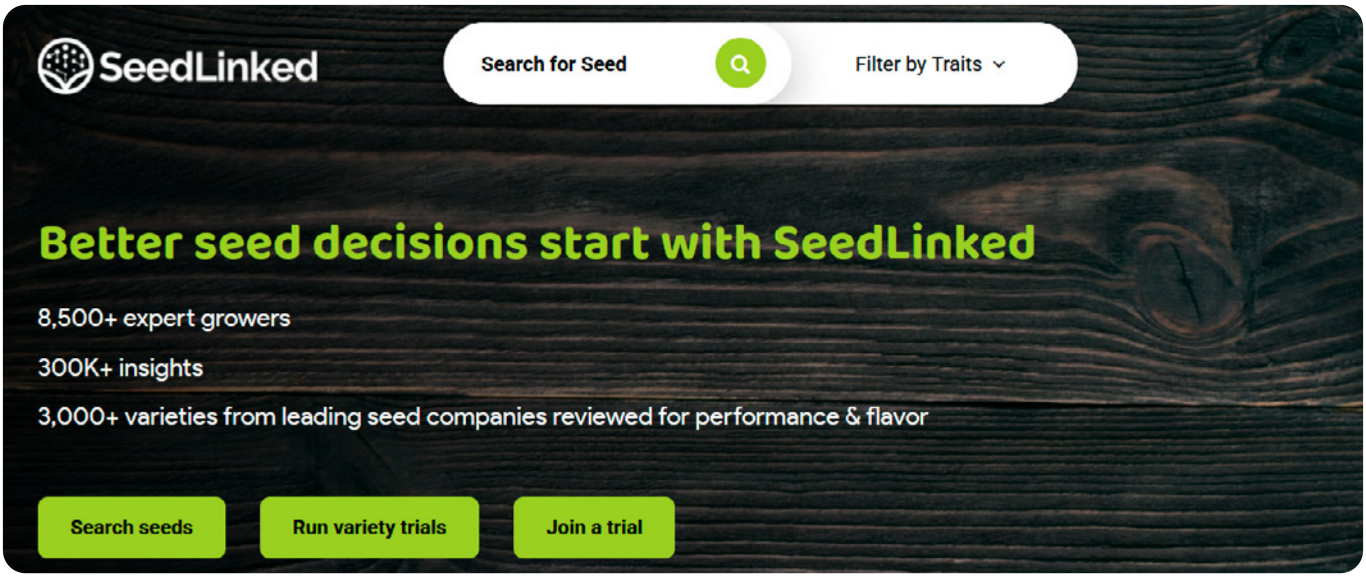
Figure 13. Different types of chickpea seeds. While dark-seeded types often have superior agronomic traits, yellow seeds are preferred by consumers

Source: https://www.gzpk.ch/

Large seed companies mainly supply major PCs, while minor PCs, such as grass pea, are maintained and provided by local seed companies, local initiatives, and farmers. With changing climatic conditions, regionally cultivated PCs may gain prominence due to their ability to perform better under harsh environmental conditions.

- **Dedicated structures are needed to maintain and further develop minor PCs**. Participatory varietal testing and regional breeding initiatives, involving value chains and genetic resources, offer pathways for tailored variety development and maintaining local varieties.
- **Improving access to seeds and information.** Farmers outside the regions where PCs are cultivated often lack access to both seeds and information. However, such varieties are becoming relevant for cultivation in other areas as well. Participatory variety testing, together with digital information tools, can help facilitate the exchange of knowledge and seed sources between farmers and regions.

Figure 14. SeedLinked is a digital platform for collecting and sharing data from participatory variety testing, as well as for exchanging information on seed sources. It currently focuses mainly on vegetables in the US. A similar tool for protein crops could support EU farmers in selecting and accessing suitable varieties



Source: https://seedlinked.com/why-seedlinked/

c) Opportunities for on-farm processing of protein crops

The opportunities for on-farm processing of PCs to enhance profitability and self-sufficiency at farm level were discussed. Several techniques farmers can adopt to improve the nutritional quality and marketability of their produce were identified, including dehulling, roasting, and seed cleaning. On-farm processing can enable farmers to capture a larger share of the value chain to increase self-sufficiency and profits. However, practical challenges remain, creating the need for:

- **Affordable and accessible equipment:** low-cost or locally accessible machines for processing are needed for on-farm and regional processing.
- **Flexible processing**: adjustments in processing and storage practices are needed to address quality fluctuations caused by climate stress. The ability to use and process different qualities of harvested PCs guarantees incomes for farmers and reliable product availability.
- **Need for inspiration and guidance**: extension services and successful PC production and marketing cases are needed for a broader uptake of on-farm and regional processing across diverse farm types. The context-specific benefits of PC production and processing are often not well communicated.

On-farm processing can begin with low-level changes, such as increasing the feed value of grain legumes by roasting them with a mobile machine directly on the farm. Such measures can improve the utilisation of locally-produced PCs. Examples from farms in different EU regions demonstrate that integrating on-farm processing can significantly contribute to protein self-sufficiency and aligns with circular farming approaches. Widespread adoption, however, depends on access to appropriate equipment. Local businesses, joint investments in shared infrastructure, and low-tech machinery can help overcome cost barriers.

Figure 15. Scotston Farm in Scotland produces nearly all its PC feed on-farm, which is then converted into animal products and sold locally. This self-sufficiency in protein feed contributes to both the farm's economic resilience and its environmental sustainability

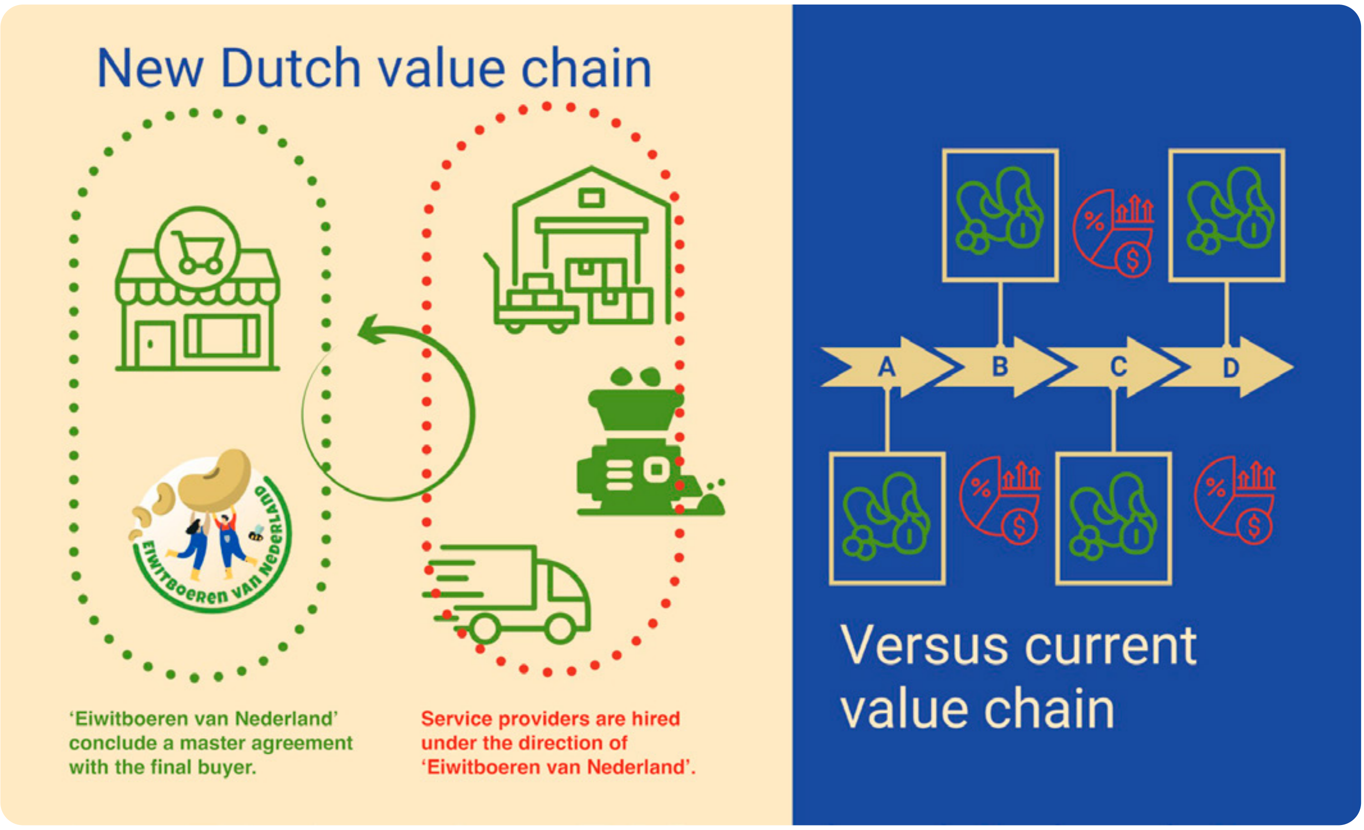
Source: Piete Iannetta

d) Strengthening regional value chains

The experts working on value chains stressed the importance of shared identities among farmers. Farmer-led organisations, regional branding, and shared values can create strong identities and improve market access for PCs. Empowering and connecting farmers is crucial to unlocking the full potential of PCs for both feed and food.

- **Stronger collaboration**: building trust and cooperation among farmers and with other value chain actors (processors, retailers) is essential for establishing PC value chains. New markets can only emerge if production, processing, and marketing are organised jointly with the participation of all stakeholders.
- **Farmer organisations matter**: collective action through cooperatives or producer groups strengthens farmers' bargaining power and visibility, particularly for niche or underutilised crops.
- **Regional identity & branding**: promoting region-specific crops and linking production to local traditions and values can create unique market opportunities and strengthen collaboration around shared goals. Motivating consumers to buy locally-produced foods further supports regional production and value chains.

Figure 16. Visualisation of the value chain proposed by the "Eiwitboeren van Nederland" from the Netherlands in comparison to dominant value chains. The direct connection enables farmers to market new products and exercise greater control over prices



Source: Eiwitboeren.nl

Regional producer associations organised around a shared branding have emerged as a promising solution, enabling shared resources, knowledge exchange, and coordinated marketing efforts. Such networks can support public awareness around sustainable diets and local food systems. Strengthening these regional food networks can diversify income sources for farmers and improve resilience. Supporting these structures, alongside clear labelling, public procurement initiatives, and consumer education, can enhance the visibility and value of PCs and help scale up production across the EU.

e) Knowledge exchange and creation

Increasing PC production requires collaboration across sectors and farm-level advice supported by research and actors of PC value chains.

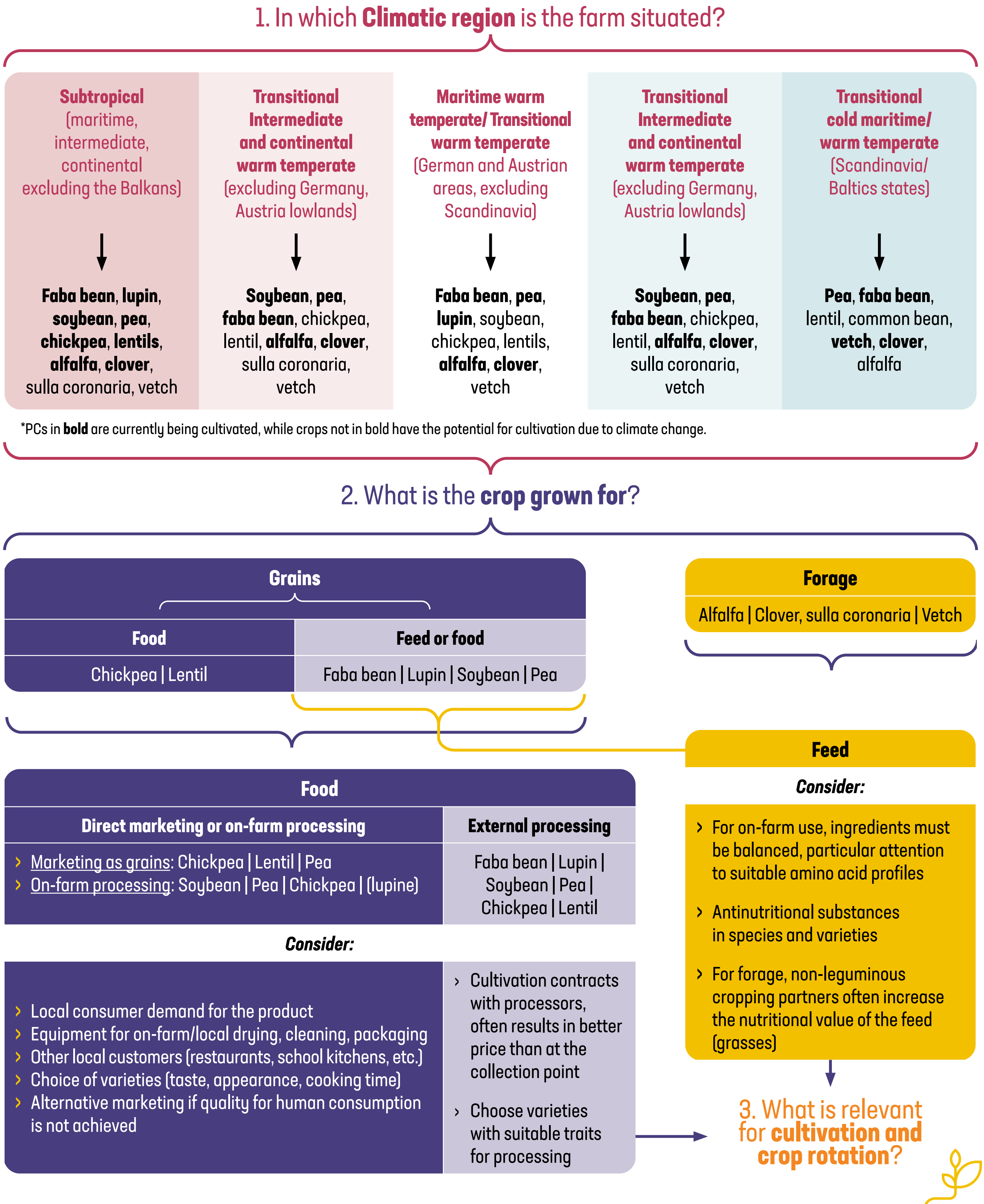
- **Strategic knowledge sharing**: effective PC cultivation requires targeted collaboration between researchers, entrepreneurs, producers, interbranch organisations, and farmers. Long-term knowledge exchange programs and access to information are needed.
- **Best practices and case studies**: discussion groups, pilot farms, and farmer-to-farmer exchanges help transfer hands-on knowledge. In addition to the content-related work, cultural activities help to strengthen team spirit within the groups. Pilot farms can act as local knowledge hubs and training centres. These activities would help build a shared identity around the common objective of developing PCs at the local level.
- **Industrial research and innovation**: farmers need to work with the value chain - from crop selection to consumer-ready products such as plant-based meat and milk alternatives. This approach supports the cultivation of PCs required by the markets.
- **Individual support**: advice must be available and tailored to individual farms, covering planning of all production steps.

PC cultivation requires knowledge of cultivation methods and processing, as well as positive collaboration between farmers and other stakeholders in the supply chain to share and develop this knowledge. In view of the challenging market situation for PCs in the EU, the commitment and motivation of everyone involved is crucial.

4. Decision support for PC choices

The selection of appropriate PCs depends on many factors and cannot be generalised. The matrix below offers guidance for identifying suitable PCs for a specific farm, and is designed to support farmers in asking the relevant questions when making their choice. The questions focus on climatic conditions and marketing considerations. Further details are provided in the Mini Papers *A Grower's Guide to Protein Crops under Climate Change* and *Characterisation and Genetic Improvement of Protein Crops*.

Figure 17. Visualisation for the decision support for PC



3. What is relevant for **cultivation and crop rotation**?

Resilience and resistance

Species level

Tolerance to drought, water excess, heat and other biotic and abiotic stresses

Variety level

Resistance to root, stem and canopy diseases, chill and frost (winter or spring type)

Seed availability

- Seed sources: seed distributors, local seed sources (farmers)
- Seed information: availability of information on specific ingredients and other relevant characteristics
- Availability of seeds from varieties suitable for cultivation in mixed crops

Equipment

- Technical equipment for cultivation and processing: machines for hoe crop with wide rows or cereal system with narrow rows?
- Sowing machines for crop-specific seed placement and sowing depths
- Facilities for seed/forage drying and cleaning
- Availability of approved herbicides and pesticides for cultivation in pure stand or cultivation in mixed monocotyledonous plants (cereals)

Ecosystem and crop rotation

- Influence of PC on soil fertility (nitrogen fixation) and texture
- Food source for insects/natural pollinators
- Frequency of cultivation in crop rotation to prevent soil-borne diseases

4. **Collaboration and information** for PC production and marketing

Collaboration

- Producer groups for PC: joint cultivation planning, shared use of machinery, joint sales
- Consumer groups: planned production for local consumer groups
- Contract farming: guaranteed purchase and price

Information

- Processors, buyers
- Agricultural advisory services
- Other farmers
- Wide range of information online

5. Ways to **adapt to climate change**

- **Alternative crops** e.g. drought-tolerant alfalfa instead of clover
- **Adjustments in cultivation** e.g. mixed cropping and avoidance of evaporation
- **New marketing** e.g. drought-tolerant grain legumes for human consumption (e.g. chickpeas) instead of animal feed, better prices
- **Knowledge exchange** – stay in contact with farmers and scientists, try out adaptation strategies together, and share experiences

Source: European Commission

5. Future opportunities and recommendations

a) Needs from practice and research

The experts identify critical research and knowledge gaps that hinder the adoption and development of PCs, e.g.:

- **Identifying success factors for local proteincrop processing and marketing**. Across the EU, numerous initiatives have (sustainably) pioneered both the processing and the marketing of PCs locally. Research can work with these real-world examples to identify the practical, social and economic factors that make such value chains successful. These factors can feed into clear, step-by-step guidelines that farmers in other regions can use for their orientation. The experts highlighted the need for low-cost processing equipment: agricultural engineers can readily test available machinery, and publish open-source use and modification plans for the machinery to support farmers to adapt affordable tools to proteincrop processing.
- **Guidelines for adaptations in livestock feeding through increased on-farm PC production**. Scotston Farm in Scotland shows how integrating animal husbandry with onfarm PC cultivation can increase selfsufficiency. However, many farmers lack the knowhow to match on-farmgrown PCs to their animals' nutritional needs. Research can bridge this gap by analysing the nutrient profiles of different PC species, recommending crop choices that fit specific livestock rations, and offering practical guidance on feed formulation and quality-improving steps such as roasting.
- **Estimating the economic impact of onfarm PC adaptation**. When adjusting PC production, economic considerations must be considered. Key questions include: Is it costeffective to replace purchased feed with on-farm production if that means reducing animal numbers? What blend of onfarm and boughtin feed is most profitable? Is there a local market for PCs for food? Targeted studies can map the most influential economic factors such as input costs, yield volatility, livestock numbers and market prices, and translate them into decisionsupport tools farmers can use before making changes.

b) Ideas for Operational Groups

The FG experts developed ideas for Operational Groups, ranging from crop diversification and seed systems to on-farm trials and processing models. The three top-rated ideas were:

Table 2. Ideas for Operational Groups

1	Local seed trial and propagation network
Problem	High seed costs and a lack of adapted chickpea varietals in Northern Europe, as well as a low level of interest among commercial breeders in chickpea breeding. A lack of information about varietal performance from official performance trials to allow farmers to make a varietal choice.
Idea	Create networks of farmers to test and propagate adapted chickpea cultivars regionally and use open-source seed information platforms to share the resulting information and sources of seeds.
Region	Northern Europe.
Stakeholders	Value chain actors, farmers and seed producers.

2	Pulse fractionation via brewing/distilling infrastructure
Problem	Grain legumes are mainly used for animal feed, meaning that their potential for producing high-value products for human consumption is not being exploited.
Idea	The project involves targeting farmers with on- or close-to-farm brewing and distilling capabilities. Use a short value chain to brew or distil pulses to produce beer or neutral spirits. Farmers produce pulses for brewing and/or distilling and process them. Intercropping can be exploited to optimise starch and protein yields. Use the co-products for animal feed.
Region	Ireland, Scotland.
Stakeholders	Brewers, distillers, farmers, food technologists for research components.

3	Integrated pest management for grain legumes
Problem	CC and limited effective pest control options are exacerbating severe pest infestations, mainly by bruchid beetles and other seed-borne insects in large parts of Romania.
Idea	Experiment with continued use of certain pesticides, including eco-friendly substances as new plant protection products.
Region	South-East Europe.
Stakeholders	Plant protection research, pollinator research, farmers, cooperatives.

Figure 18. Grass pea is an example of a drought-tolerant protein crop that can be grown in many regions of the EU but is not yet bred on a commercial basis

Source: Tamara Lebrecht (left), European Commission (right)

6. Conclusions

PC production can support the sustainable development of EU agriculture, but only if agronomic, economic, structural, and cultural challenges across the value chain are addressed. Producers and agri-food systems are under pressure from multiple sides: climate stress, global market disruptions, and shifting consumer demands. While such pressures bring uncertainty, they also create opportunities for farms. The following points highlight where targeted support and action can strengthen PC production at the farm level:

- **Promoting diverse value chains:** PC value chains range from direct marketing to industrial processing, all of which can contribute to higher PC production.
- **Supporting the PC choice:** as climatic conditions shift, protein crops cultivated in one region can be appraised for their suitability in other regions.
- **Generating environmental benefits:** PCs improve soil health and make farming more resilient to climate extremes. Practices such as mixed cropping and improved water retention methods can strengthen these effects. For these measures to gain wider implementation, their benefits must be recognised and thereby translated into advantages for farmers.
- **Developing value chains collaboratively:** producer groups, cooperatives, and regional branding can motivate and support innovative solutions for PC processing and marketing.
- **Improving access to infrastructure:** shared use of machinery for processing and storage, particularly at the local level, can help reduce costs.
- **Exchanging knowledge:** continuous exchange among farmer groups, demonstration farms, and extension services helps identify problems, reduce uncertainties, and co-develop solutions. Strong social ties within groups can provide support in challenging times.
- **Improving variety choice and development**: farmers need better access to seeds and information on PC species and varieties from multiple sources. Breeding efforts can strengthen PC production by targeting traits relevant for processing and adaptation to changing climatic conditions.

The transition to more widespread PC production is not just a technical or economic challenge; it represents a cultural and systemic shift. It requires coordinated action from farmers, researchers, industry actors, and consumers. By embracing this shift, farmers can reduce EU dependency on imported plant proteins, support environmental and climate goals, and create new opportunities for regional development across diverse regions of the EU.

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