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CropBooster-P

Deliverable No. D2.1

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EXECUTIVE SUMMARY

The interlinked challenges of population growth, climate change and shifting diets have put the future of food and farming firmly in the spotlight. CropBooster-P aims to develop a roadmap to future-proof European crops for these challenges – to do so, it is employing a stakeholder-focused approach to determine the impacts of various strategies for crop improvement.

In Work Package 2 we held 10 online workshop focus groups with 35 participants from across the European agri-food sector to understand the potential impacts of these crop improvement strategies. Farmers and farmer organisation representatives, non-governmental organisations, policy makers, plant breeders, agri-business association representatives and consumer experts were all invited to scrutinise 15 crop improvement options developed by Workpackage 1 of the Project.

These workshops allowed us to understand a wide range of potential social, economic and environmental impacts from different CropBooster options. Important themes for the development of the CropBooster roadmap were also identified, such as consideration for:

- **The trade-offs and knock-on effects for particular crop improvement strategies**; such as the potential for decreasing negative and toxic compounds in the plant to weaken resistance to pests and diseases
- **How the impacts of certain crop improvement strategies vary geographically**; including the likelihood of certain options, such as salt stress, being relevant to only a few European regions
- **Whether non-plant breeding mechanisms could better meet specific societal, economic or environmental aims**; for example, the potential for improving dietary choices among European consumers to improve nutritional outcomes rather than breeding for these aims

Alongside the workshop focus groups an online survey assessed how key stakeholders prioritised the broader goals of CropBooster-P – increasing crop yield, maintaining crop nutrition and improving crop sustainability – as well as the 15 discrete options for crop improvement. The survey demonstrated a preference for sustainability options, such as improving plant water use and improving heat stress tolerance (see **Figure 1**).

Option	Farm-level	Agri-business	Consumer	Plant scientists
Improving plant water use	■	■	■	■
Improving heat stress tolerance	■			■
Improving Nitrogen uptake and use	■		■	■
Improving Phosphorous uptake and use	■		■	
Increasing antioxidant content				■

FIGURE 1: OPTIONS SELECTED AS 'VERY IMPORTANT' BY EACH STAKEHOLDER GROUP, AS DETERMINED BY OPTION PREFERENCE MEDIANS*

*** DARK BLUE INDICATES THAT THE MEDIAN PREFERENCE FOR THIS STAKEHOLDER GROUP FOR THIS OPTION IS 1 (EQUIVALENT TO 'VERY IMPORTANT')**

This report has been divided by specific Workpackage 2 tasks, which focus on different levels of the agri-food sector: Task 2.1 focusses on farm-level impacts, Task 2.2 on agri-business

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impacts and Task 2.3 on consumer-level impacts. The Introduction and Methods sections are shared across all three deliverables.

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1 INTRODUCTION

1.1 *Aims*

In working papers D2.1 D2.2 and D2.3 we share initial findings from Work Package 2 (WP2), which aims to assess the the potential economic, social and environmental impact of the CropBooster options for improving yield, sustainability and nutrition arising from Work Package 1 (WP1) of CropBooster-P. This document serves as a shared introduction and explanation of methods for the three deliverable working papers D2.1-3.

1.2 *Introduction to CropBooster-P*

Food security, population growth and improving crop yields in the face of climate change are some of the greatest challenges facing humankind. We will need to feed 9.7 billion people in a sustainable way by 2050, whilst transitioning from a fossil fuel-based economy towards a bioeconomy in order to mitigate the effects of global climate change. This will require a doubling of global crop productivity to produce enough plant biomass to achieve both food and nutrition security, as well as to meet the demands of a future bioeconomy. Projections from the current rates of crop yield increases suggest we will fall 40-70% short of future demand. Increasing crop production must be achieved whilst maintaining crop nutritional quality and will require crops that combine sustainability, efficient use of scarce resources (e.g. water and minerals) and cultivation schemes and practices that preserve Earth's biodiversity. The crops must also have good yield stability with a high resilience to adverse climate and volatile weather conditions.

To meet these aspirations, our current crop plants need to be re-designed and thus mapping out how they can be "future proofed" is urgently needed. Progress could be mired by the complexity of a multitude of possible crops and genetic changes, combined with multiple environmental changes, policy and societal challenges. CropBooster-P is a Coordination and Support Action within the EU H2020 research programme that aims to address this by identifying opportunities to adapt and boost productivity in a background of environmental and societal changes. The Cropbooster-P objective is the development of a roadmap for future proofing our food system and the European bioeconomy, with a specific focus on making crop production more sustainable, resilient, and responsible, while at the same time guaranteeing nutritional food quality. Taking a Responsible Research and Innovation (RRI) approach, CropBooster-P involves key stakeholders, such as scientists, business, farmers, consumers/citizens, and policy makers, to align the process and its outcomes with the values, needs and expectations of society, such as the demand for adequate and sustainable supply of affordable and nutritious food that has been produced with acceptable environmental impact, taking into account that agricultural activity must be commensurate with the demand for food. The roadmap will minimize environmental impacts and provide routes to adapting to environmental change whilst strengthening the bioeconomy.

1.3 *Overview of Work Package 2*

Work Package 2 (WP2), as illustrated in Figure 1, takes a mixed-method, stakeholder-focused approach to understanding the potential economic, social, and environmental impacts of options for future-proofing crops in Europe, identified in WP1 (see Figure 2).

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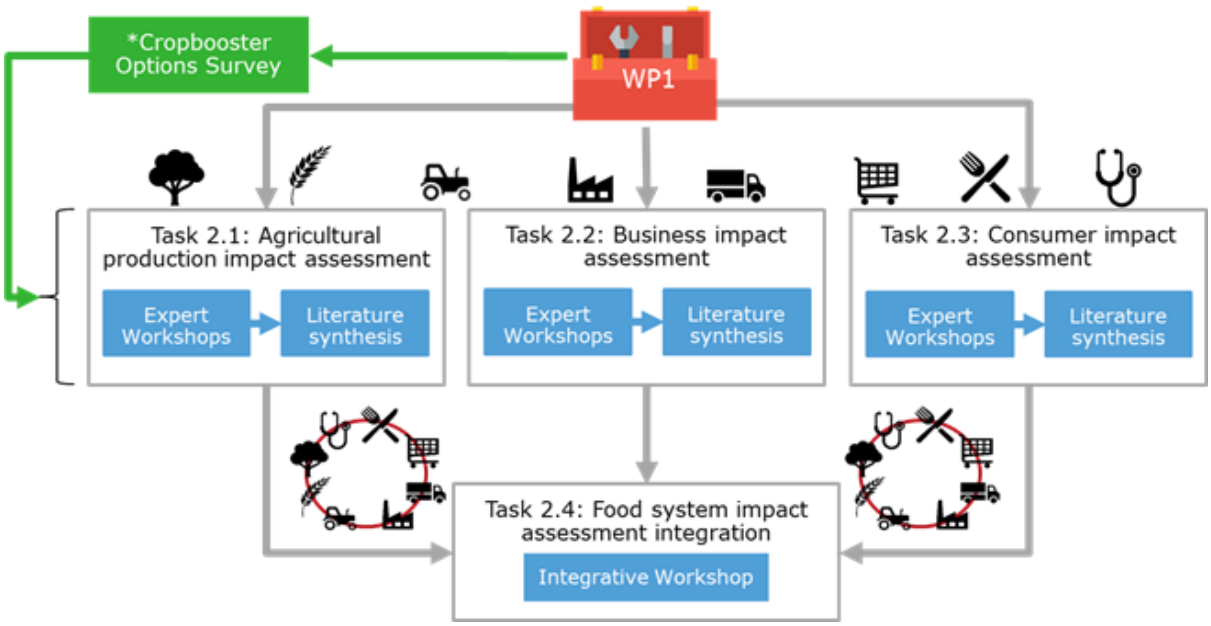

FIGURE 2: TASKS AND APPROACH IN WP2. *THE SURVEY, SHOWN IN GREEN, WAS ADDED TO THE ORIGINAL PLAN TO INCREASE THE ROBUSTNESS AND RESILIENCE OF THE DATA COLLECTION AND INFORMS THE LITERATURE SYNTHESIS ELEMENTS.

In Tasks 2.1 to 2.3, respectively, we hosted a number of workshop focus groups centred on three key points in the food system/bioeconomy: at farm-level, in agri-businesses and the food and feed supply chain, and at the consumer level. We gathered expert stakeholders from these three areas in a series of online mini-focus groups to discuss: which crop improvement goals and options arising from WP1 they felt were a priority for the future of Europe, and what would be the social, economic and environmental impacts of adopting these options. This produced deep qualitative insights. We complemented these insights with the addition of an online survey, that provides quantitiative data on crop priorities from a wider range of participants. The outcomes of these actitivities inform the scope of later literature syntheses on environmental, social and economic impacts. These expert and literature insights will then be integrated via a multi-actor workshop to provide a food-system impact assessment (in Task 2.4).

1.4 *Cropboosting goals and options*

Work Package 1 identified a toolbox of "cropboosting" crop improvement options and technologies, drawing on the state of the art from the plant science community (as shown in **Figure 3**). These options were grouped under the three overarching CropBoosting "goals" of the project: increasing yield, nutritional quality and sustainability. We acknowledge that some options are interconnected and may deliver across two or more goals. However, the option primarily corresponds to the goal under which it has been categorised. This alignment to the goals allows us to tie the outputs to the overarching aims of CropBooster-P and helps to structure our communication and the resulting priorities of various stakeholders.

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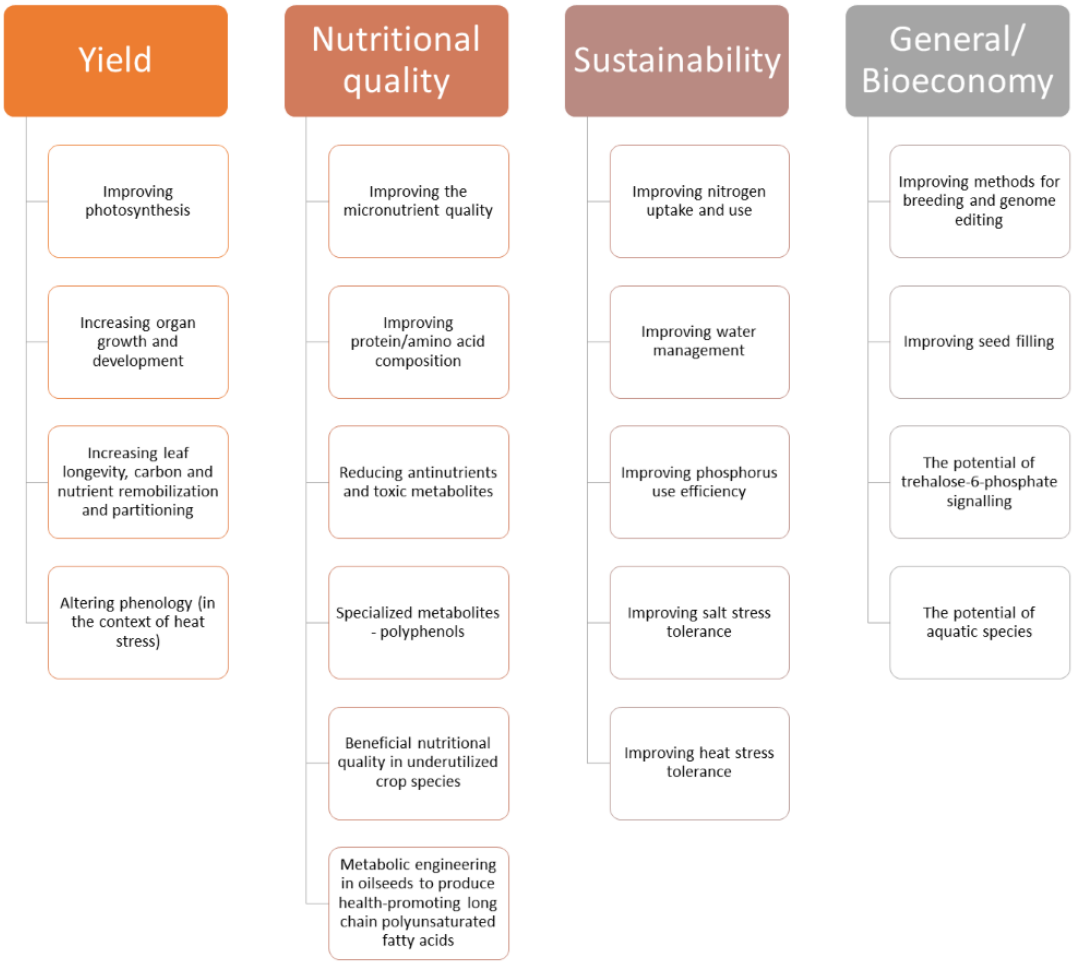

FIGURE 3: INITIAL CLASSIFICATION OF CROPBOOSTER AIMS AND OBJECTIVES

We also had to ensure that the CropBooster crop improvement options could be understood and assessed by specialist (i.e. plant breeder) and non-specialist stakeholders. This began a process of refinement of WP1 outputs. Through consultation with WP1 and WP2 researchers, the CropBooster options were simplified and harmonised as outlined in **Figure 4**.

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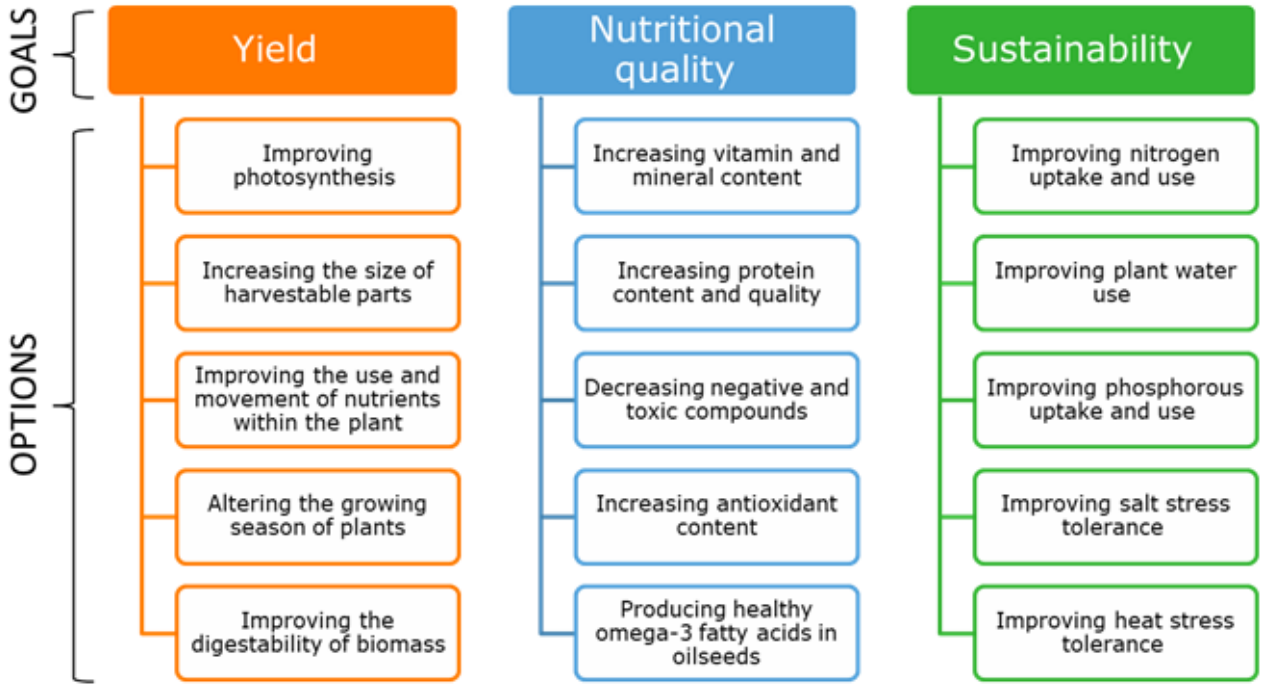

FIGURE 4: ***CROPBOOSTING GOALS AND OPTIONS USED IN WP2, AS SUMMARISED FROM THE KEY POINTS IN WP1, TASK 1.5.***

These options were presented to stakeholders through a series of workshops and through an online survey, the methodology of which is described below.

2 METHODS

The methodology of the study can be described as mixed-methods, combining qualitative data derived from focus groups to identify topics and quantitative data – in the form of a survey – and narrative analysis through a systematic literature review to consolidate the findings (see **Figure 5**). Described here are the methods employed in the first two components of the study.

2.1 *Workshop focus groups*

In order to understand the potential impacts of different future-proofing strategies for European agriculture, a series of virtual focus groups were held with relevant agri-food stakeholders from across Europe. Ethical approval by Lancaster University Faculty of Science and Technology Research Ethics Committee was granted (reference: FST19070), which outlined the overall protocols of the study, what types of data would be collected and how it would be managed.

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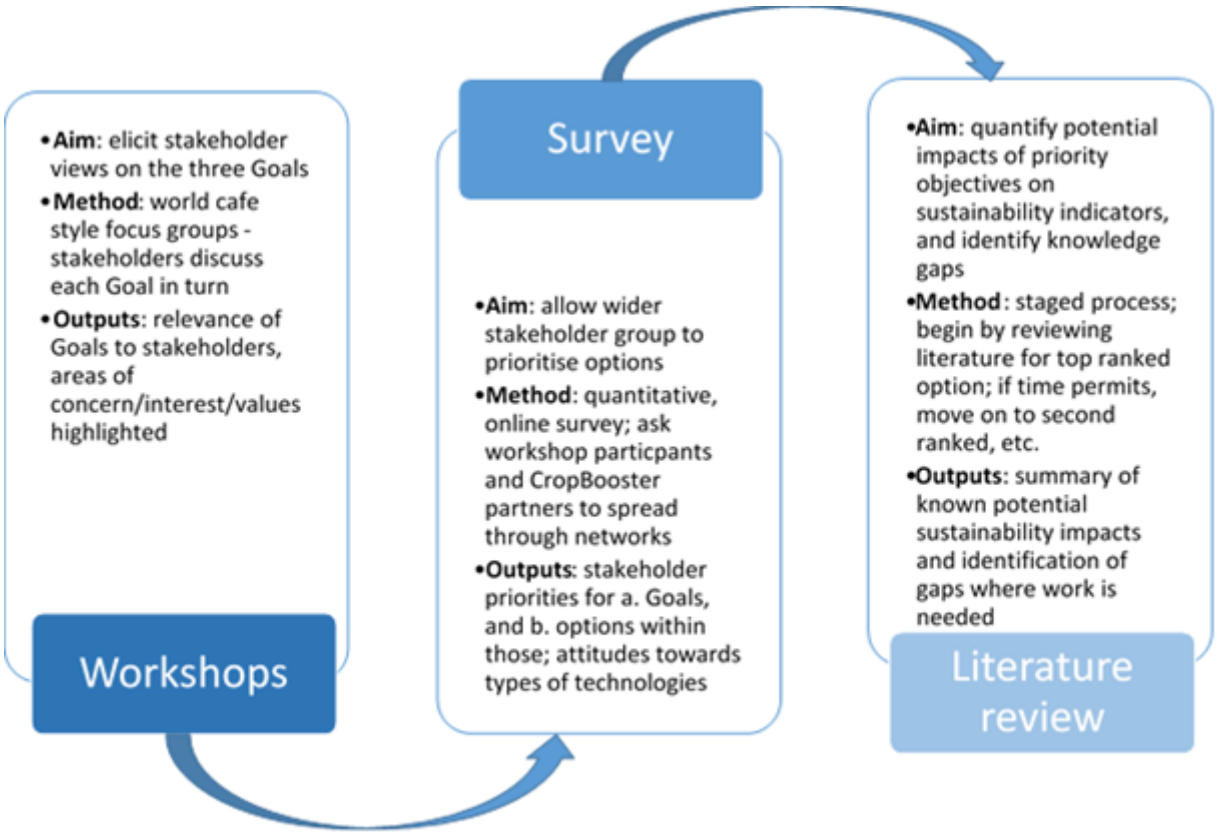

FIGURE 5: OUTLINE OF METHODOLOGICAL APPROACH TAKEN IN WORK PACKAGE 2

A topic-specialised researcher (farm-level SS, business JM, consumer AN) was assigned to coordinate workshops. To ensure alignment of methods and data collection researchers mutually assisted each other.

2.1.1 OPTIONS PRESENTED IN THE FOCUS GROUPS

To facilitate discussion and to present all the options to participants, the 15 CropBooster-P "options" for crop improvement were introduced on double-sided option cards, an example of which is given in **Figure 6**. These cards featured an indication of the broader aim in which they sat, an explanation of the option itself and a science-based example of this option applied to a real-world crop (primarily drawn from examples in the WP1 toolbox).

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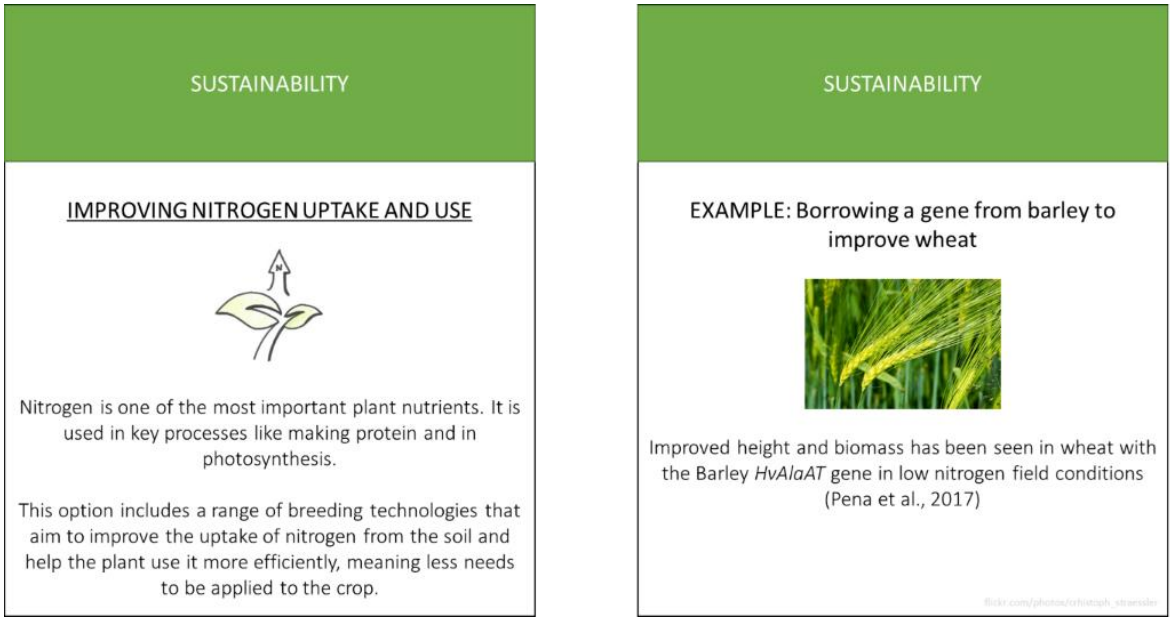

FIGURE 6: EXAMPLE OPTION CARD. FRONT (LEFT) AND BACK (RIGHT)

In addition to the 15 option cards, a blank card – "Option Card #16" – was created in order to foster discussion about what potential crop improvement strategies could be added to the list developed by WP1 (see **Figure 7**).

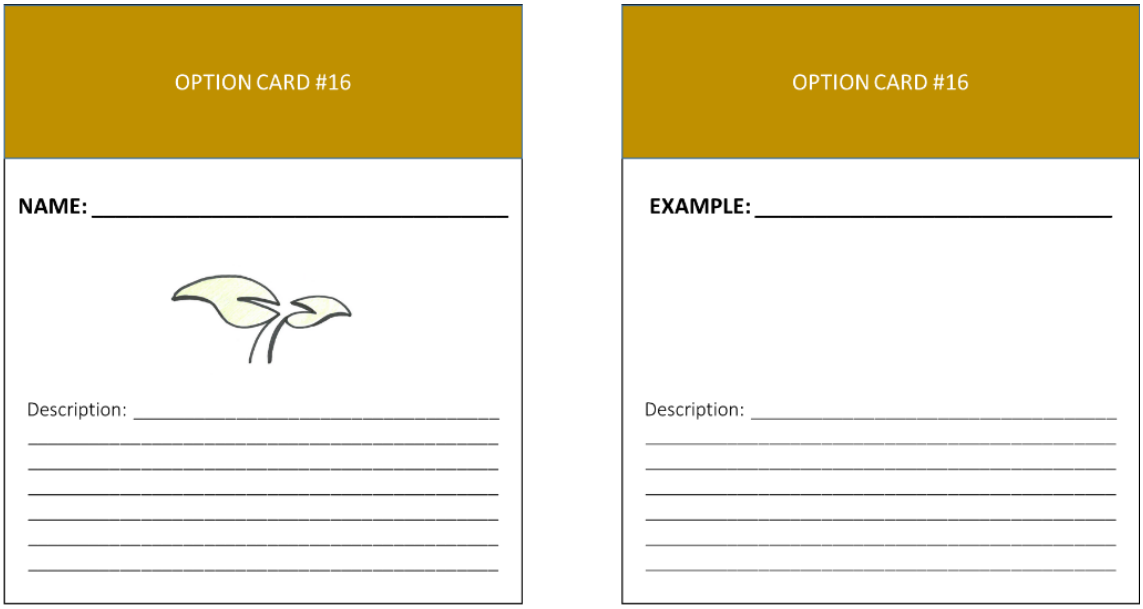

FIGURE 7: OPTION CARD #16 ACTIVITY CARD

2.1.2 FOCUS GROUP PROTOCOL

Focus groups provide a mechanism for both the generation of new ideas and the assessment of potential ideas – they offer insights into the differences of opinion that exist among selected groups of people and generate a large amount of data in a relatively short period of time

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(Breen, 2006; Rabiee, 2004). Focus groups were thus considered an appropriate tool to investigate a broad range of opinions on the various crop improvement strategies summarised for this purpose.

A detailed semi-structured focus group protocol was created aimed at face-to-face focus groups. The protocols were pre-tested to guide the researchers through the workshop focus groups and ensure consistency and comparability between the data from each stakeholder group (for the full protocol, see **Annex 1**). The primary questions were:

- What are the biggest challenges for the European agri-food sector over the next 30 years?
- Which CropBooster option is most important?
- Which CropBooster option is least important?
- What might the social, environmental or economic impacts of a particular option be?
- How do these options meet the challenges facing the European agri-food sector?
- What other things should be included in the CropBooster options?

This protocol was piloted by each of the three researchers and by the work package lead; 16 people took part in the in-person pilots, recruited from Lancaster Environment Centre and Wageningen University.

Although conceived and planned as more conventional in-person workshops, the COVID19 lockdown measures in Europe required the protocols to be redesigned for online application. It was determined that virtual focus groups offer comparable data to in-person groups of the same kind (Woodyatt, Finneran, & Stephenson, 2016), although the specific steps to transfer an existing protocol to fully online were not specified in a single source.

To transfer our protocols, while retaining relevance, we adopted the following steps:

1. Identifying a suitable hosting platform and means of recording the focus groups.
2. Determining the best way to adjust the protocol and present Option cards and similar materials in an online enviroment.
3. Scrutinising to what extent the adjustments in materials amid platform changes the extent to which our main research questions could still be answered.

We detail these steps further below.

To idenfity a suitable hosting platform: Many potential options were considered; it was decided that *Microsoft Teams* would serve as a suitable hosting platform for the virtual discussions as:

- Meetings can be audio and video recorded
- The research team had experience with the software, and the software is fairly easy to use.
- Screensharing made it possible to guide participants through the options cards easily
- Participants can join meetings from an internet browser and are not required to create an account in order to attend the meeting
- It is a widely available platform with fair stability and security options

To facilitate working with different option cards Microsoft Teams was combined with the website *Mural (*www.mural.co*)*, which provides a platform for multi-person, interactive whiteboarding. The option cards and the content-free Option Card #16 activity were incorporated into a Mural whiteboard (see **Annex 2**). Multiple versions were created with different card orders to avoid ordering bias.

This allowed us to transfer the existing protocol to an online version with relatively few changes. To do so, some demands for the online tools had to be met, particularly around ease of use; for example, the research team selected a whiteboard and videoconfering tool that did

not require workshop participants to create an account before using the whiteboard (as this may slow down the workshop and some participants may not have felt comfortable creating an account). In addition, specifically for the whiteboard; the research team also selected Mural as it offers participants the choice of navigating the Mural whiteboard themselves or following along via screensharing – similar to handling offline option cards or sticky notes. To capture the full interaction online, where in contrast to offline focus groups, no physical products or lasting geographic ordering of notes could be created; it was necessary to record both video footage next to the originally planned audio recordings. This adjustment was granted with a revised ethical approval. In addition, specific for the online environment; safe collection and storage of video images (which contain personal data in terms of recognisable faces) became a demand for the platform. Microsoft Teams met these demands as it saves recorded meetings to a secure, encrypted platform called *Stream*.

After addressing these issues, the protocol was re-piloted and produced similar outcomes as the offline protocol. Subsequently, recruitment of potential participants began. As our research population was specifed as experts, primarily purposive sampling was applied – targeting people identifed by the research team as being expert in the field and belonging to one of the three stakeholder groups outlined earlier.

Some participants provided additional suggestions as co-nomination ("snowball sampling"). Potential participants were approached using an email based on a standardised template (see **Annex 3**) by either the researcher responsible for recruitment of that stakeholder group or by one of our partner organisation representatives. These emails were first targeted at those people who had shown interest in attending the in-person workshops, but later expanded to include a larger pool of potential participants.

2.1.3 WORKSHOPS

In total 10 workshops took place between late April and early June 2020 with a total of 35 participants. These involved:

- **16** farm-level participants in five workshops
  - The total number of farmer and farmer organisation representatives approached for these workshops is unable to be determined, as the invitation was sent out through a large agricultural umbrella organisation newsletter.
  - In total 11 farmer/farmer organisation representatives took part in workshops, with 12 initially responding to invitation and one non-attending.
  - In the case of farm-level NGO and policy representatives, 5 took part in the focus groups with 39 approached, 9 responding and 4 were non-attending
- **11** agri-business-level participants in two workshops
  - 30 potential participants were approached, 14 responded, one non-attending
  - 6 plant breeding company representatives
  - 5 agri-business consortium representatives
- **8** consumer experts in three workshops
  - 120 approached, 12 confirmed, four non-attending
  - Experts on consumer issues in agri-food

The workshops were convened by three researchers (SS, JM and AN). All have experience with qualitative data collection. None had any pre-existing relationships with the participants. In the agribusiness workshops, the project was first introduced by a representative of Euroseeds (PJ), who has a professional relationship with several of the participants – after which the representative left before the actual focus group commenced.

The focus groups lasted between seventy and one-hundred twenty minutes, with the average time being one hundred minutes.

A standardized form was used by the researchers to keep notes as they progressed through the focus group protocol.

2.1.4 ANALYSIS APPROACH

The video recordings of each focus group were sent to a private GDPR-compliant company for transcription – non-disclosure agreements had been signed in advance. Once the transcripts had been returned, these were checked for errors and anonymised by removing identifying information.

Adopting a *Framework Analysis* approach (Ritchie & Lewis, 2010; Srivastava & Thomson, 2009), an initial coding framework was developed by open coding the transcripts associated with each WP2 task. After these were agreed through consultation with at least one other member of the research group, the transcripts were fully coded and analysed using *NVivo* qualitative data analysis software for Windows and Mac. An overview of the emergent themes was shared within the wider WP2 consortium for comments. A number of overlapping themes – that is, themes shared by more than one stakeholder group – were identified, as well as others that appear to be more closely aligned with one group rather than others. These are outlined in the results section (section 3).

2.2 *Survey*

2.2.1 SURVEY DESIGN, DEVELOPMENT, AND DISTRIBUTION

A survey was designed as an extension to the original WP2 workplan in order to identify which of the options arising from WP1's report were felt to be priorities for the broader constituency of key stakeholders sampled for the workshop, and thereby help to consolidate the findings of the workshops. The survey was primarily quantitative, with some open-ended qualitative questions included to elicit more complex responses to key questions, and focused on understanding which of the fifteen options taken forward from WP1 (following the methods described above in 2.1.1) were felt to be most important. In addition, the survey aimed to identify key crops which participants felt were of importance to the future of European agriculture, to further target the literature synthesis and highlight any important research gaps in relation to these crops.

In line with the workshop, participants were classified to represent three stakeholder groups – farm-level stakeholders; agribusiness level stakeholers; and consumer level stakeholders. In addition, the category of plant scientists was added (a stakeholder group who will be driving Cropboosting technologies). Specific demographic information was gathered from participants relevant to the stakeholder group - for example, farmers were asked questions regarding their farm size and level of agricultural education – in order to allow for comparisons with the target population. The survey was implemented on the Qualtric online survey software (Qualtrics.com). A summary of the questions asked and their method type is shown below, in **Table 1** (See **Annex 4** for a copy of the full survey in English for further detail regarding the precise demographic questions included for each stakeholder stream). Only one question in the survey forced response before the participant could continue (age, as those under 18 were not allowed to complete the survey). The survey took a median of 10.9 minutes to complete.

TABLE 1: SURVEY QUESTION SUMMARY

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Question category	Question	Question aim	Question type
Introduction	What is your current age?	Only those 18 years or older were eligible to take part in the survey	Quantitative – fixed choice selection
	Which of the following [stakeholder categories] best describes you?	Separating stakeholders into the relevant stream for demographic questions	Quantitative – fixed choice selection
Ranking	Please rank the following goals [Yield, Nutrition, or Sustainability] in terms of importance to future-proofing European crops	Identifying individual's overarching priority goals	Quantitative - ranking
	Please briefly describe why you have prioritized your chosen goal	Understanding individual's overarching goals	Qualitative – free text
	Please indicate how important you feel [option shown] is for future-proofing European crops	Understanding the importance of WP1 options	Quantitative – Likert style scale Question repeated for all 15 options; shown in a randomized order to reduce bias
	Are there any other goals which were not included in the above list, but which you feel are important for future-proofing crops?	Identifying priority areas not included in the 15 option cards produced from WP1	Qualitative – free text
Shared demographic questions	Are you contributing to a CropBooster-P focus group in spring 2020?	Identifying individuals giving data in both the survey and workshops	Quantitative – fixed choice selection
	Capacity in which you are filling in this survey	Filling any gaps in stakeholder information which might influence	Qualitative – free text

		data interpretation	
	What is your sex?	Calculating the gender balance of the surveyed population	Quantitative – fixed choice selection
	What is your home postcode?	Identifying the NUTS region relevant to each participant	Qualitative – free text
	Formal education level	Understanding the educational attainment of the surveyed population	Quantitative – fixed choice selection
	Which country do you live in?	Identifying the country in which participants lived (as a back-up for geographical analysis should participants refuse to give postcode data)	Quantitative – fixed choice selection
	Which crops do you feel are most important for the future of European agriculture?	Identifying key crops	Quantitative – fixed choice selection
Farm-level demographic questions	See **Annex 4**		
Agribusiness-level demographic questions	See **Annex 4**		
Consumer-level demographic questions	See **Annex 4**		
Plant scientist-level demographic questions	See **Annex 4**		
Final section	Any other comments?	Providing a space for further information of relevance to be collected	Qualitative – free text

	If you would like to receive information about the results of the project directly, please leave your email address below	Allowing follow-up contact to be maintained and key results to be disseminated to a wide audience	Qualitative – free text A total of 208 respondents completed this question

2.2.1.1 TRANSLATION PROCESS

In order to enable broad participation, and to reduce English-language only bias, the survey was translated into both German and French, and was therefore made available in all three of the EC's procedural languages. An adapted version of the TRAPD Team Translation method (Harkness & Schoua-Glusberg, 1998; Survey Research Center Institute for Social Research, 2016) was used (see **Figure 8**) to ensure consistency across languages. This method is particularly well-suited to projects such as this, where a number of researchers in the team are bilingual and can provide discipline and context-specific details to refine the generic translation provided by a professional. Survey responses obtained in German and French were translated into English by a professional specialist translator, and proofread by a professional bilingual specialist proofreader, so that results from all three languages could be merged for analysis.

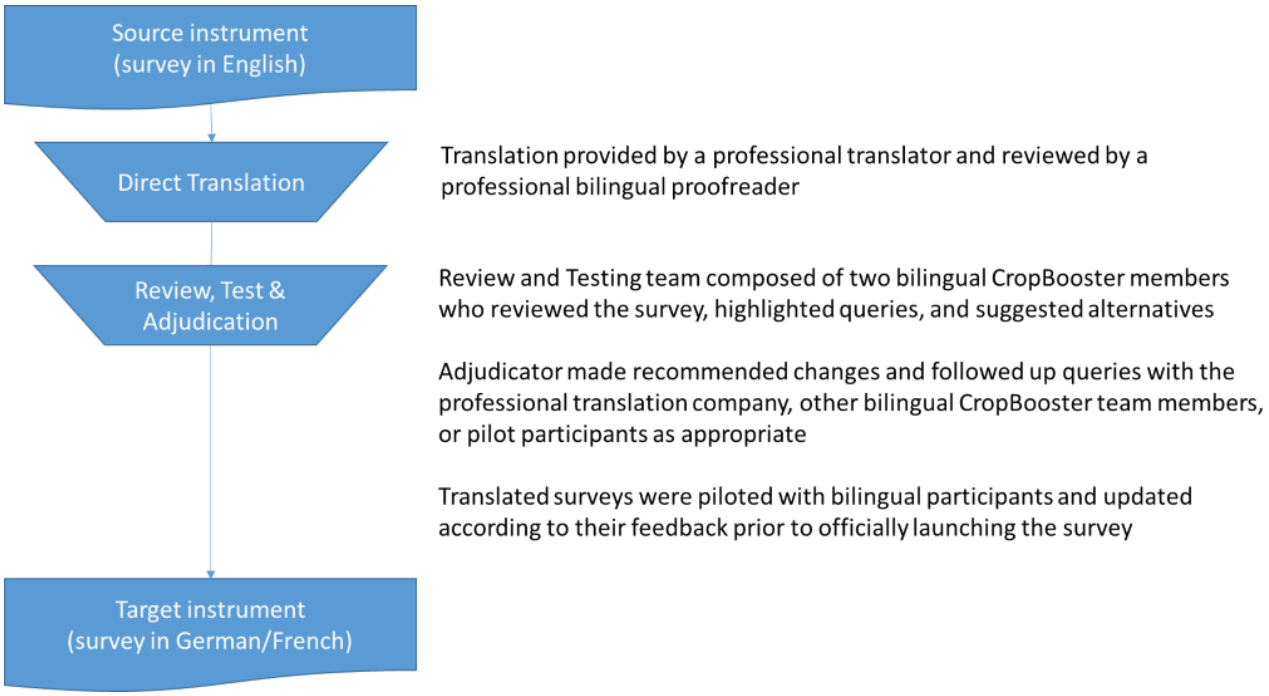

FIGURE 8: SUMMARY OF THE TEAM TRANSLATION METHOD

2.2.1.2 PILOT SURVEY

The survey was piloted in English prior to translation and piloted in German and French prior to the launch of the survey. A total of 17 participants piloted the English survey, with at least three for each survey stream. Six participants piloted the German and four the French versions, with at least one participant per language per survey stream. The pilot was designed

to identify potential areas of bias, check that the language used was comprehensible, that question instructions were clear, check the survey timing, and flag up any problems with the survey flow. Additional pilot questions at the end of the survey ensured data was collected to further these aims, and the feedback was incorporated into the final draft of the survey. Changes made to the survey following pilot feedback included improved signposting, minor corrections to grammar, and the updating of some terminology.

2.2.1.3 SAMPLING AND ETHICAL APPROVAL

Ethical permission was sought and granted through the University of Lancaster in the same application which approved the focus group workshop. As data was not collected from minors or vulnerable individuals, was not of a sensitive nature, was unlikely to cause psychological stress or harm, and was fully anonymized, the survey was deemed low risk.

A snowball sampling strategy approach was used to disseminate the survey in order to maximise the number of participants reached with minimal resource input, with WP2 partners sharing the survey links widely within their professional networks, on social media, and through direct contact with external organizations of relevance (such as the Food Climate Research Network, EAT forum, and IFPRI).

A total of 325 participants took part in the online survey (288 English responses, 23 French responses, and 14 German responses). Seventy-two of these responses were removed from analysis, as the respondents had not completed any data collection question blocks. A further 120 survey results were incomplete but were retained for analysis as the respondents had completed the initial data collection segment regarding goal prioritization – these 120 responses were not used for any analysis apart from the goal prioritization. Five survey responses were deleted as duplicate responses. A total of 204 responses were therefore recorded for participants who had completed all core data collection segments (goal prioritization and option card rankings): 39 for farm-level stakeholders, 27 for agribusiness level stakeholders, 38 for consumer level stakeholders, and 100 for plant scientists. The majorityof these participants came from the UK (83), with additional participation from: Belgium (8), Croatia (1), Cyprus (2), Czech Republic (1), Denmark (2), France (15), Germany (11), Greece (1), Italy (31), Luxembourg (1), Netherlands (7), Portugal (2), Romania (1), Spain (10), and a further 12 responses from individuals currently living outside Europe.

2.2.2 SURVEY ANALYSIS APPROACH

An agreed analysis framework was used to analyse all survey results across the four stakeholder streams – in these working papers in-depth results are reported for each of the stakeholder groups aligned with a specific task (see **2.1 for farm-level results; 2.2 for agribusiness level results; and 2.3 for consumer level results**).

2.2.2.1 OVERVIEW STATISTICS

For each stakeholder group overview statistics were calculated for the total number of responses, responses removed from the analysis due to incompletion or duplication, and the total number of responses used to analyse: (1) the goal prioritization questions, and (2) the option ranking questions. Basic demographic information, such as the number of respondents from each country represented, spread of age profiles, gender balance, and educational level are also reported, along with stakeholder-group specific demographic characteristics (e.g. farm size for farm-level stakeholders).

2.2.2.2 GOAL PRIORITIZATION

The percentage of each stakeholder group ranking a given goal (Yield, Nutrition, or Sustainability) as one (top priority), two (medium priority), and three (lowest priority) was calculated, and the most commonly selected top priority goal highlighted. Data from the free text question asking participants to briefly describe why they had prioritized their selected goal was separated into three categories: data from participants choosing Yield as their top priority; data from participants choosing Sustainability as their top priority; and data from participants choosing Nutrition as their top priority. This data was then exported to NVivo 12, and thematically analysed to identify the key issues being raised as explanations for a given goal's priority.

2.2.2.3 OPTION PREFERENCES

For the 15 Likert-style questions relating to the options identified in the WP1 report, responses were tallied for each of the choices available, and the percentage of participants choosing each statement calculated. The median value for each option was calculated by assigning a value to each Likert-style statement as follows: 'Very important' – 1; 'Important' – 2; 'Neither important nor unimportant' – 3; 'Unimportant' – 4; 'Very unimportant' – 5 (Don't know and blank responses were excluded from the median analysis). The use of a median value here is particularly useful as it allows a way of quantitatively comparing across a number of Likert-style questions which are not designed to be intrinsically linked (Boone & Boone, 2012) (e.g. the options are not presented as necessarily being mutually exclusive, due to their potential importance both individually and in combination), but which have a comparative relationship due to their intrinsic nature. In this instance, calculating median values for each option is particularly valuable, as it allows identification of priority options for each stakeholder group. Differences between option median results were then reviewed based on: top goal priority, gender, and other stakeholder group-specific demographic questions as appropriate, in order to identify patterns and trends.

2.2.2.4 MOST IMPORTANT CROPS

Survey respondents were asked to choose up to five crops which they felt were most important for the future of European agriculture. The most frequently selected crops were identified for each stakeholder category, and differences in option preference based on crop preference were reviewed for the most frequently selected crops in each stakeholder group.

2.2.2.5 OPTION CARD 16

After reviewing the 15 pre-defined options identified in WP1, survey respondents were asked "Are there any other goals which were not included in the above list, but which you feel are important for future-proofing crops?" This question was included in order to compare with the Option Card 16 activity which focus groups took part in, described above. The free text data collected for this question was thematically analysed for each stakeholder group to identify recurring themes and key options which respondents felt were missing from the survey.

2.2.2.6 ADDITIONAL STAKEHOLDER-SPECIFIC ANALYSIS AND SYNTHESIS

Additional analysis of relevance to each stakeholder group was carried out as needed, based on the group-specific demographic questions used, and is described in the relevant chapters of this report. A synthesis of the overarching themes and results arising provides key conclusions for each stakeholder group, identifies the priority options to be taken forward in the next stages of the project, and links results from the survey with those from the stakeholder workshops.

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3 INTRODUCTION TO DELIVERABLE 2.1

3.1 *Aims*

In this working paper, we share initial findings from Work Package 2 (WP2), which aims to assess the the potential economic, social and environmental impacts of the cropboosting options for improving yields, sustainability and nutrition arising from WP1 of CropBooster-P.

This paper specifically focuses on assessing the farm-level impacts associated with adopting the breeding options identified in WP1. We have taken a mixed-method stakeholder-focused approach to exploring the cropboosting priorities and potential impacts of adopting the cropboosting options in Europe. Here, we report on the findings from a series of online focus groups and an online survey focusing on contributions from farm-level stakeholders.

The expert stakeholders engaged with in the development of this working paper include: farmers representing key EU crop sectors and a range of EU countries from a variety of pedo-climatic conditions and organisational specificities, and non-farmer experts including regulators and policy makers, and scientific and NGO experts on resource use efficiency, the environmental impacts of agriculture and food systems, and similar topics.

Key impacts of interest in this task include farm-level issues such as yields and crop failure risks, resource-use efficiency, changing practices and labour, and farm income and costs; as well as the wider environmental impacts of production systems, including air and water quality, soil health, biodiversity, and climate change.

4 FARM-LEVEL FOCUS GROUP RESULTS

A total of five online focus groups were held with 16 participants representing ten EU countries (Belgium, France, Germany, Italy, the Netherlands, Portugal, Romania, Spain, Sweden, and the UK). Three workshops focused on farmer representatives, of which a total of eleven where recruited from the membership of COPA COGECA, representing six different European countries. Of these eleven participants, five were female and six were male. Two workshops brought together those working in food policy with representatives from NGO's with a focus on farm-level issues, such as the impact of agriculture on the environment; a total of five participants were involved in these workshops, two from policy and three from NGO's, representing five European countries. Of these five participants, three were female and two were male. Workshops contained between two and four participants, and lasted between 1 hour and 12 minutes and 2 hours. Many participants had lived and worked in multiple EU countries and brought insights from multiple country perspectives to bear in the discussions. Results from these focus groups are merged to present broad farm-level stakeholder input, except where important differences exist between the perspectives put forward in the farmer representative and NGO/Policy stakeholder discussions.

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4.1 *Key themes*

Five key themes, alongside a number of additional themes, were identified in the analysis of the focus group discussions, as shown in **Figure 9**. These are discussed in detail in the sub-sections that follow.

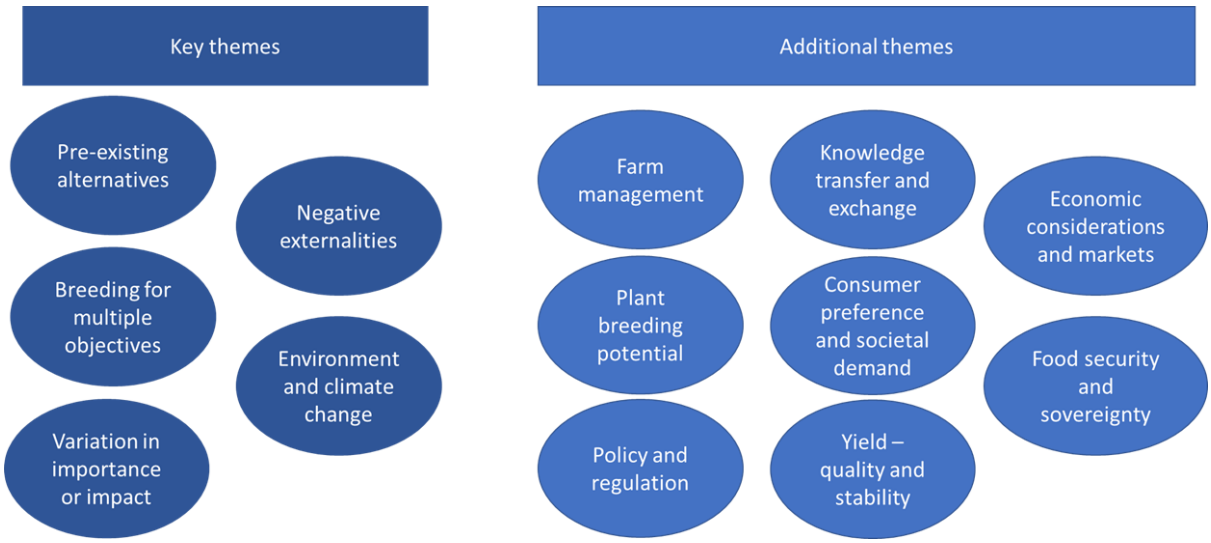

FIGURE 9: CORE THEMES ARISING FROM 2.1 STAKEHOLDER WORKSHOPS

4.1.1 PRE-EXISTING ALTERNATIVES

Both stakeholder groups frequently raised the availability of pre-existing alternatives – a range of solutions, strategies, or mechanisms which already exist and are available to actors to tackle a specific option's challenge – (or lack thereof) to contextualise why a given option was or was not important to them, with options that had pre-existing alternatives often being classed as less important priorities for breeding than options without such alternatives. Frequently raised pre-existing alternatives are summarized in **Table 2**. 'Improving plant water use' and 'Improving heat stress tolerance' were frequently raised as being important due to a lack of control.

> *"For me this one is easy. It is [heat] stress…It is one thing that I cannot manage. I think for me it is the most important because it is the one that I control the least" – Farmer organisation representative #3*

> *"I don't think any of these are important for human nutrition, because I don't think it's the plant's fault that we have malnutrition as a problem in Europe, be it lack of or too much. It is how we eat and what we choose to eat." -NGO representative #1*

TABLE 2: OPTIONS WHICH WERE FELT TO HAVE PRE-EXISTING ALTERNATIVES

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Option	Pre-existing mechanism
Digestibility of biomass	Processing
Increasing protein content and quality	Diet
Increasing antioxidants	Diet
Increasing vitamin and mineral content	Diet, Processing
Producing healthy omega-3 fatty acids in oilseeds	Diet
Decreasing negative and toxic compounds	Diet, Processing
Improving phosphorous uptake and use	Farm management
Improving nitrogen uptake and use	Farm management

4.1.2 BREEDING FOR MULTIPLE OBJECTIVES

A common concern was that breeding programmes should aim to avoid trade-offs, and focus on breeding to achieve multiple important objectives at one time:

> *"I don't like this idea of prioritising. I tell you straight out I'm very much against so-called trade-offs when it comes to breeding progress. There shouldn't be. It is possible to have a plant that has improved nitrogen and phosphorous uptake." - Farmer organisation representative #9*

Often, the multiple objectives to be aimed for were not explicitly stated, or were discussed in terms of their variability depending on region or crop (this theme of variation in importance is described further, below). However, several recurring combinations centred on:

- Coping with hot summers and low precipitation brought on by climate change – through a focus on heat and water stress
- Becoming more resilient to climate change through increased efficiency regarding inputs (nitrogen, phosphorous, and water)
- Reducing inputs to meet EU goals by improving both nitrogen and phosphorous use

Multiple participants mentioned the importance of all (or nearly all) options within each goal category, highlighting the importance of focusing on the broader outcomes:

> *"All the cards you showed us are very important" – Policy stakeholder #3*

Also repeatedly raised was the need to consider the broad range of situations in which these crops will be grown and design a crop which: is resilient, balances sustainability tradeoffs, and which incorporates as many positives with as few negatives as possible, while considering the wider implications for agro-ecosystems and wild populations.

A number of specific trade-offs to avoid were mentioned:

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- Increasing yield but decreasing quality (flavour, nutritional content, etc.)
- Reducing toxic compounds but increasing pest/disease problems
- Increasing yields at the cost of sustainability and resilience
- Crop or region specific trade-offs (described in more detail, below)
- Land use change and considering implications for rural communities
- Farm management issues, including harvesting, storing, and difficulties for perennial crops and agroforestry of short-term thinking in crop breeding

> *"We all know that many of the genetic improvements or alterations we have done in crops, they came with a cost, like is it taste, or vitamins, or…more diseases or whatever? It always had a drawback on one side. – Policy stakeholder #1*

4.1.3 NEGATIVE EXTERNALITIES

A number of potentially negative impacts arising from the various plant breeding options being discussed were highlighted by participants. These were generally highly specific to the option being discussed, and ranged from issues relating to broader impacts on the agro-ecosystem; knock on negative consequences for the crop itself; problems for food harvest, storage, and processing; and other issues relating to sustainability more broadly.

This theme highlights the importance of assessing potential tradeoffs and negative consequences, and engaging with stakeholders to identify and understand these, prior to committing to specific breeding aims or objectives. Four options specifically discussed in relation to negative potential impacts are summarised below in **Table 3**. It is particularly interesting to note that three of the four options identified as having negative externalities belong to the Yield category, suggesting that particular care may need to be taken to consider the broader ramifications of a breeding focus on yield.

TABLE 3: OPTIONS PARTICIPANTS SPECIFICALLY RELATED TO PARTICULAR NEGATIVE EXTERNALITIES*

Potential negative impacts in relation to:	Options			
	Altering growing season of plants	Increasing the size of harvestable parts	Reducing negative and toxic compounds	Improving digestibility of biomass
Consumer expectations				
Ecosystem impacts and biodiversity				
Pests and disease				
Crop harvest, storage, or processing				

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4.1.4 VARIATION IN IMPORTANCE OR IMPACT

A strong theme arose in relation to variation in the importance or impact of particular options across geographical regions, temporal scales, and between different crops. Certain options were seen as being universally applicable, and therefore of higher overall importance to European agriculture:

> *"Heat stress and water use, I mean it's a characteristic that is always desirable in all situations." – Farmer organisation representative #9*

Five options were specifically discussed as being universally important, either in terms of their importance to all crops, all European regions, or both: 'Improving Nitrogen uptake and use', 'Improving Phosphorous uptake and use', 'Improving plant water use', 'Improving heat stress tolerance', and 'Improving photosynthesis'.

However, all fifteen options were also considered by at least one stakeholder to be of differing importance when considered at different region/crop/temporal scales. Certain options were thought to be of relevance to specific European regions, or local contexts (e.g. salt stress being of importance to parts of the Netherlands), while others were considered to vary in importance based on the crop (e.g. increasing the size of harvestable parts was thought to be more relevant for those crops where this would not present a bio-physical problem), or temporal scale (e.g. the increasing importance of plant-based protein produced within Europe in the coming decades). Those options which were frequently referred to as having variable importance are summarised in **Table 4**, below.

> *"There is one aspect I would like to stress, which is really important. We have to keep in mind that different regions have different needs and different characteristics. When we talk about sustainability we tend to use a general European concept that cannot be applied the same way in the northern, in the centre or in the southern parts." - Farmer organisation representative #1*

Participants also noted differences in needs for the global market, particularly referencing developing country contexts versus the European market, highlighting the fact that Europe exports both technology and food.

TABLE 4: SCALES AT WHICH IMPACT AND IMPORTANCE OF OPTIONS WERE THOUGHT TO VARY

Option	Regional (within Europe)	Crop	Temporal	Global vs European
Improving salt stress tolerance	■	■	■	■
Improving plant water use	■	■	■	
Altering growing season of plants		■		
Increasing the size of harvestable parts		■		

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Improving heat stress tolerance				
Improving nitrogen uptake and use				
Decreasing negative and toxic compounds				
Improving digestibility of biomass				
Improving photosynthesis				
Increasing vitamin and mineral content				
Increasing protein content and quality				

4.1.5 Environment and climate change

A number of issues around climate change impacts on farming and food systems were raised, including grave concerns around the impacts of more extreme weather events, in particular desertification, droughts, and heat waves on food production:

> *"So the probably upcoming effects of climate change and the desertification of many places in the European Union. That will be something important to consider, very, very important." - Farmer organisation representative #10*

Several participants shared their experiences of drought stress (often in combination with heat stress), and the widespread crop loss that followed – while management strategies, such as irrigation, insurance, and sharing risk through farmer co-operatives were raised as potential ways of mitigating the impacts of drought, it remained a key concern for participants. Other climate change impacts which stakeholders repeatedly raised included the emergence of new pests and diseases, and the general uncertainty surrounding the future and need for broad resilience.

Sustainable land management and the need to sustainably produce sufficient food was often cited alongside issues of efficiency and circular farm management. The need to reduce inputs (fertilizers, pesticides, and water) both in order to meet European goals and to reduce the carbon footprint and/or improve the sustainability of food production in general was highlighted. The use of land for food production was generally (though not universally) seen to be more important than for biofuel production, with calls from NGO and policy stakeholders in particular to avoid widespread biofuel production:

> *"…Biofuel use or biomass in general should be very, very limited, or is very limited, in sustainable future energy scenarios." – NGO representative #2*

The need to maintain environmental characteristics such as soil, water, and air quality in order to reduce input requirements and improve the final quality of the crop produced were also discussed. Breeding with intercropping, mixed variety mono-species cropping, and crop diversification in mind was raised in several instances as a way of furthering sustainable production.

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"It can support crop diversification. Crop diversification, it's actually quite a good way to find a balance between biodiversity and the need of production…" – Farmer organisation representative #6

4.2 *Additional themes*

4.2.1 CONSUMER PREFERENCE AND SOCIETAL DEMAND

Consumer preference was highlighted as an important factor for farmers to bear in mind when choosing plant breeding targets, although tensions between who the end market actually consisted of and the ability of consumers to make informed decisions were raised:

"But the fact is that the market for the plant breeders, well it may look as if it is the growers, but in fact…[i]t is the processors, the buyers from the growers that determine." – Farmer organisation representative #1

"I think there is a difference between what the consumer wants and what the food citizen wants, because, unfortunately, because of a lot of other structures, the decisions that someone makes before they go into a supermarket and the decisions they make when they're in the supermarket are very different..." - NGO representative #1

4.2.2 ECONOMIC CONSIDERATIONS AND MARKETS

The importance of end markets, and bearing in mind the intrinsic international markets involved in import and export to/from Europe were highlighted, with concerns raised around the competitiveness of European agriculture on the global stage, as well as the responsibility Europe had to produce foods or seeds for export which met global needs as well as local ones. NGO and policy representatives also highlighted the need to consider the true cost of food production and re-evaluate pricing practices to reflect these accurately.

"If we talk about Europe, it is also in the world food system and we sell product to Africa which is a problem on vitamin and mineral content. So we need to make a choice which crops and which market we want to work, to give priority to this question." – Farmer organisation representative #10

"With China, US, I mean we have such big and strong markets around us. We have several restrictions in Europe and less funding." – Farmer organisation representative #4

4.2.3 FARM MANAGEMENT

Both stakeholder groups highlighted the importance of good farm management practices to future-proof European agriculture, and the need to breed crops which work within the farm management frameworks where they will be taken up.

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"Once more the examples that were presented, they were all about breeding and they were all about certain methodologies of breeding, but I think that for certain of the topics the agronomy plays actually an important role." - Farmer organisation representative #6

4.2.4 FOOD SECURITY AND SOVEREIGNTY

Issues around the need to ensure adequate production of key foodstuffs, particularly protein products, from within Europe, rather than relying on imports from other countries were highlighted both in terms of creating a food sovereign future and in mitigating the perceived issues around being able to import GM crops but not being able to grow them widely within Europe.

"A lot of young people now and in 30 years' time will probably be [vegan]... As long as we have a big import of soya for food and feed that is not a big problem I would say. But if you want to be self-sufficient on protein that is of course a big problem." – Farmer organisation representative #4

4.2.5 KNOWLEDGE TRANSFER AND EXCHANGE

The need for more integrated knowledge transfer, exchange, and education was raised in relation to several topics, including: engaging in an open and informed debate regarding GM and new plant breeding technologies (whether for or against); the need for plant breeding programmes to take into account the full supply chain; the need for discussion between all actors in the food system, including farmers, policymakers, the public, and scientists.

"I think the supply chain should be more involved in developing sustainable production systems. It should be a joint responsibility and you should not talk about resilient production systems. You should talk about resilient supply chains." – Farmer organisation representative #1

4.2.6 PLANT BREEDING POTENTIAL

The potential of plant breeding to accomplish the option aims, whether through traditional breeding methods, new plant breeding technologies, or GM was not always thought to be straightforward. Opinions were raised both for and against the mainstreaming of new plant breeding technologies and GM, with a frequently raised issue around practicality:

"The only issue I have with all these cards that you showed there is talk about breeding techniques and I think again to close the circle, how accessible will these breeding techniques become to European breeders and ultimately to the European farmer's toolbox?" - Farmer organisation representative #9

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4.2.7 POLICY AND REGULATION – INCLUDING INTELLECTUAL PROPERTY

Issues around agricultural and plant breeding policy were raised in relation to new plant breeding technologies and GM (both for and against), policy incentives for sustainable farming and food system practices, including a focus on sustainable nutrition, along with a number of concerns regarding issues of intellectual property rights and breeding, including avoiding linked treatments and ensuring seed saving remained legal:

> *"I think it is a good point also relating the whole question of accessibility of plant reproductive material for farmers. Now this is of course relevant with regards to patent protection. Also, plant variety rights maybe to a lesser extent, but also if we think about the farmer's privilege to save and reuse seeds for own purpose." - Farmer organisation representative #2*

4.2.8 YIELD – QUALITY AND STABILITY

While yield was considered an important trait, concerns were raised that certain options for increasing yield quantity (particularly 'Increasing the size of harvestable parts') might lead to reduced yield quality characteristics, thus having a net neutral or negative impact on output and profitability. In addition, farmer representatives felt strongly that the goal for yield should be to achieve yield stability, rather than an increase in tonnes per hectare, in order to future-proof production systems:

> *"In my perspective, the yield itself, it's not really the major issue. The major issue, in my vision, it's yield stability in the longer term. That's what farmers look for, and that's what the objective should be when we think to sustainable systems, in my opinion." - Farmer organisation representative #6*

4.2.9 COVID-19: A-PRIORI THEME

All comments referring specifically or obliquely to COVID-19 were coded to a pre-defined a-priori COVID-19 theme, to understand the concerns around this crisis and its impact on the food system. Concerns tended to focus on the uncertainties surrounding the long-term impact of COVID-19, impacts on purchasing and cooking, and problems with worker safety and worker availability for farm labour:

> *"I make a link with what is happening now, where farmers cannot harvest their production with no workers from Morocco or east side of Europe." – Farmer organisation representative #11*

4.3 *Option Card #16 results*

After participants discussed all fifteen option cards, they were given a chance to highlight possible options that they felt were important for future proofing Europe's crops through an activity called "Option Card 16". Participants during this activity mentioned several possible options, however they found it difficult to build consensus around one strategy as the most

important. Presented here is a summary of the key issues raised in these discussions – in the interest of brevity and clarity, only those issues which were raised multiple times and are not discussed in the general themes above are shown in **Figure 10**. It is worth noting that biotic stress and smart farming are outside of the CropBooster-P scope.

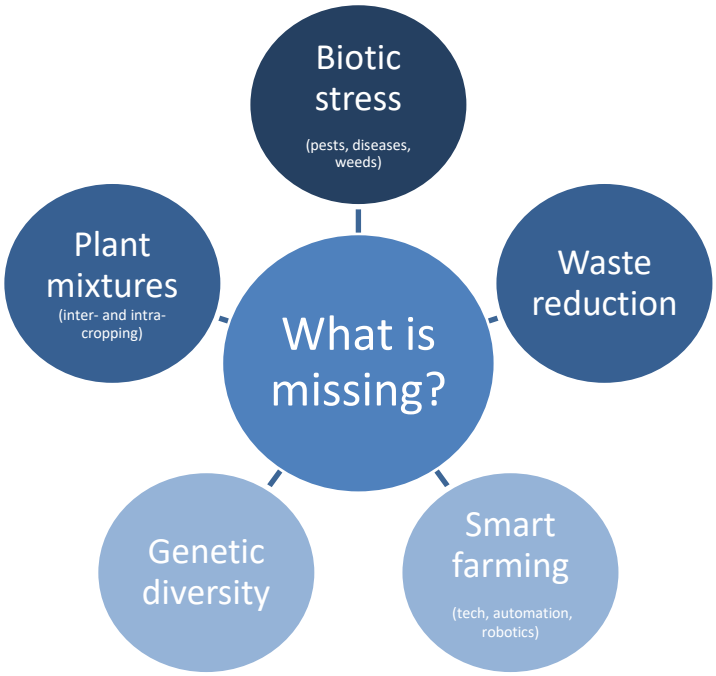

FIGURE 10: KEY THEMES ARISING FROM OPTION CARD 16 ACTIVITY (DARKER BLUE CORRESPONDS TO A THEME BEING MORE FREQUENTLY MENTIONED)

5 FARM-LEVEL SURVEY RESULTS

A total of 39 farm-level participants completed the survey; with an additional 4 who did not complete the survey, but did complete the first data-collection section relating to overarching goals for future-proofing European crops; to retain as much data as possible, these results are presented in the section of this report relating to goal prioritisation. Seven responses were removed from all analysis, as these were deemed 'very incomplete' – that is, the respondents had not completed a single section of the survey, and so their responses could not be compared. Most of the results refer to the 39 complete responses, though the exact number varies where participants opted not to complete a particular question. No farm-level responses were duplicates.

Nearly half of the respondents were between 25 and 49 years of age (18 individuals, 46.2%), with the rest falling between 50 – 64 (14 individuals, 35.9%), 18 – 24 (4 individuals,10.3%), and 65-79 (3 individuals, 7.7%). More than half of respondents (20 individuals, 54.1%) were from the UK, followed by 16.2% (6 individuals) from France, 8.1% (3 individuals each) from Belgium and Italy, 5.4% (2 individuals) currently living outside the EU, and 2.7% (1 individual each) from Greece, Luxembourg, and Portugal. Five of the participants in the survey indicated that they were also contributing to a CropBooster-P focus group. The sample was well gender-balanced, with 17 female (47.2%) and 19 male (52.7%) respondents. All participants had at least a bachelor's degree, with 21 individuals (54.1%) having a Master's or equivalent degree and 13 (35.1%) having a Doctoral or equivalent degree. Please note that the total number of

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responses for each of these questions may vary, as respondents had the option to leave questions blank.

Thirteen respondents were scientific experts in farm-level impacts, with only four respondents identifying themselves as farmers (see **Table 5**). Additional demographic information has therefore been pooled between farmers and non-farmer respondents, to ensure anonymity. In addition to the high levels of general education described above, stakeholders also had high levels of agricultural education, with fifteen having full agricultural training (two or more years of full-time higher education), and only five having only practical experience on-farm as agricultural training. Ten of the respondents worked on or with primarily mixed crop and animal farms, with six working on/with primarily crop specialist farms, and only one respondent who worked on/with animal specialist farm(s).

Farm size varied considerably within the sampled population, although large farms of 100ha or more were over-represented in comparison to EU farm statistics (see **Table 6**). Human food was the most frequently cited primary market (21 votes), followed by animal feed (14 votes), drinks industry (6 votes), and fuel (4 votes) – participants could select up to three markets.

TABLE 5: NUMBER OF RESPONDENTS BY STAKEHOLDER SUB-CATEGORY

Stakeholder sub-group categories	Number of respondents
Environmental regulator or policy maker	4
Farm support/advisor	1
Farmer	4
Farmer representative	5
NGO with a focus on farm-level concerns, such as the environmental impacts of farming	2
Other farm-level stakeholder	8
Scientific expert in resource use efficiency, environmental impacts, etc.	13

TABLE 6: COMBINED DATA FOR FARM SIZE AND SIZE OF FARMS USUALLY WORKED WITH

Response choices	Number of respondents	Percent of applicable	EU farm size distribution*
0 – 4.9 ha	7	41.2%	65.6%
5 – 9.9 ha	0	0	12.1%
10 – 19.9 ha	1	5.9%	8.3%
20 – 29.9 ha	0	0	3.5%
30 – 49.9 ha	1	5.9%	3.6%

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50 – 99.9 ha	2	11.8%	3.6%
100 ha or over	6	35.3%	3.3%
Not applicable	17		
Unsure	1		

*EU farm distribution data is taken from Eurostat (2019)

5.1 *Goal prioritisation*

When asked to rank Yield, Nutrition, and Sustainability in terms of importance to future-proofing European crops, a large majority of respondents (69.8%) selected Sustainability as the most important goal, and Yield as the least important goal (55.8%) (see **Figure 11**).

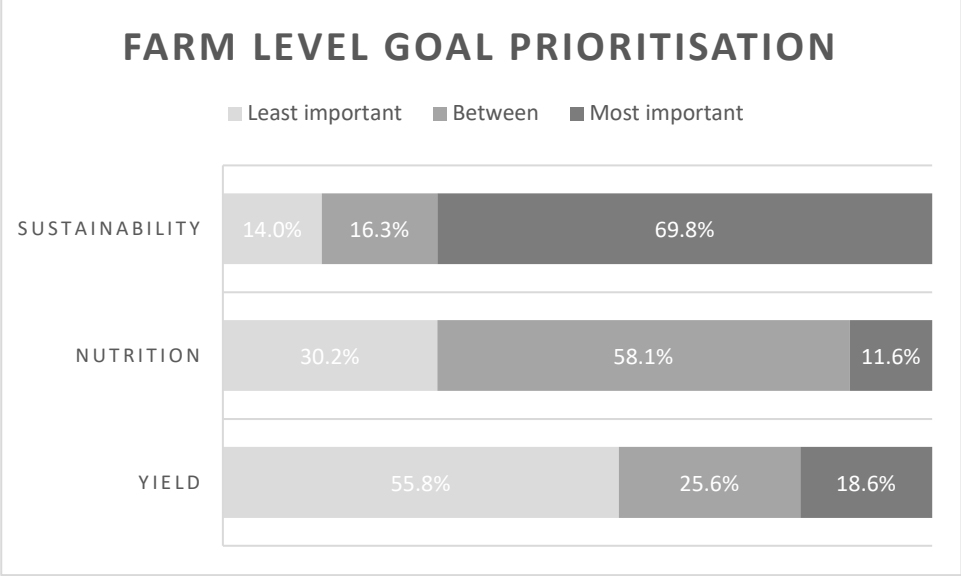

FIGURE 11: FARM-LEVEL GOAL PRIORITISATION

Participants were then asked to describe why they had prioritised their chosen goal of Yield, Nutrition, or Sustainability:

- More than half of respondents commented on the interconnection between these three goals in some way – frequently to highlight the need for all three goals to be achieved *in tandem*, or to point out that sustainability underpins the other two goals, and to use this to explain why they chose it as most important.
- The importance of climate change and it's impacts on the food system was mentioned by nearly half of participants, often in reference to the need to prepare for the future by improving resilience, yield stability, reducing input requirements, or managing land and resources sustainably.
- Concerns surrounding food security and the need to produce enough food for everyone while reducing input use and maintaining resilience were often raised – conversely, a number of participants felt that Europe already produces enough food and used this to explain why they had not selected yield as the most important goal.
- The importance of profitability and economics was highlighted by participants as an explanation for their chosen goal from each of the three goal perspectives, with some

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focusing on higher nutritional quality as a pathway to increased profit, some on higher yields for higher profits, and some on resilience and stability for higher profits.

- Several participants also stated that they felt plant breeding was not the best way to achieve one or more of the goals (e.g. nutrition could be better handled through dietary change; yield through sustainable land management and reducing food waste and loss, etc.) as an explanation of why they chose their priority.

"...All must be sustainable in longer term. These are not mutually exclusive and we should be aiming to have them all" – Survey participant (selected Yield as top priority)

5.2 *Option preferences*

When asked how important each of the fifteen crop improvement options identified by WP1 were, the most highly ranked options were:

1) Improving plant water use
2) Improving heat stress tolerance
3) Improving Nitrogen uptake and use
4) Improving Phosphorous uptake and use

Each had a median response of 1, equivalent to 'Very important'. The majority of options had a median of 2 ('Important'), with only one option, 'Increasing the size of harvestable parts' having a median of 3 ('Neither important nor unimportant'). The full list of options, ordered by the number of 'Very important' responses can be seen in **Figure 12**.

All four of the top ranked options fall under the category of 'Sustainability', which further emphasises the importance of this goal to this stakeholder group, following the large majority which identified it as their top priority (see **Figure 11**). The low number of 'Don't know' responses (the only option with more than 10% of responses falling into this category was 'Improving the use and movement of nutrients within the plant' with 10.5% of respondents choosing 'Don't know') suggests that respondents felt the options and their definitions were generally understandable. As 'Don't know' responses were recorded for options relating to each of the three goals, there are no clear patterns in the data to suggest that a certain type of options were more likely to fall into this category than others.

While some variation in option preference is visible by goal prioritisation grouping – for example, those who felt Nutrition was the most important goal also indicated that increasing vitamin and mineral content was very important – this was highly variable and did not show clear patterns of goal priority being consistently in line with option preferences. This may be due, in part, to the fact that many other ways of achieving a given goal exist beyond the five options presented in the survey, and these may be the mechanisms preferred by a respondent. However, given the low numbers of individuals choosing Nutrition (5 votes) and Yield (8 votes) as the most important goals, it is difficult to speculate further on the minor variation seen here.

Little variation in option preference was seen by sex, with 'Improving plant water use', 'Improving heat stress tolerance', and 'Improving Nitrogen uptake and use' having medians of 1 (Very important) in both male and female groups. Male respondents' selections for 'Improving Phosphorous uptake and use' and 'Improving photosynthesis' also yielded medians of 1, while for females these two options had medians of 2.

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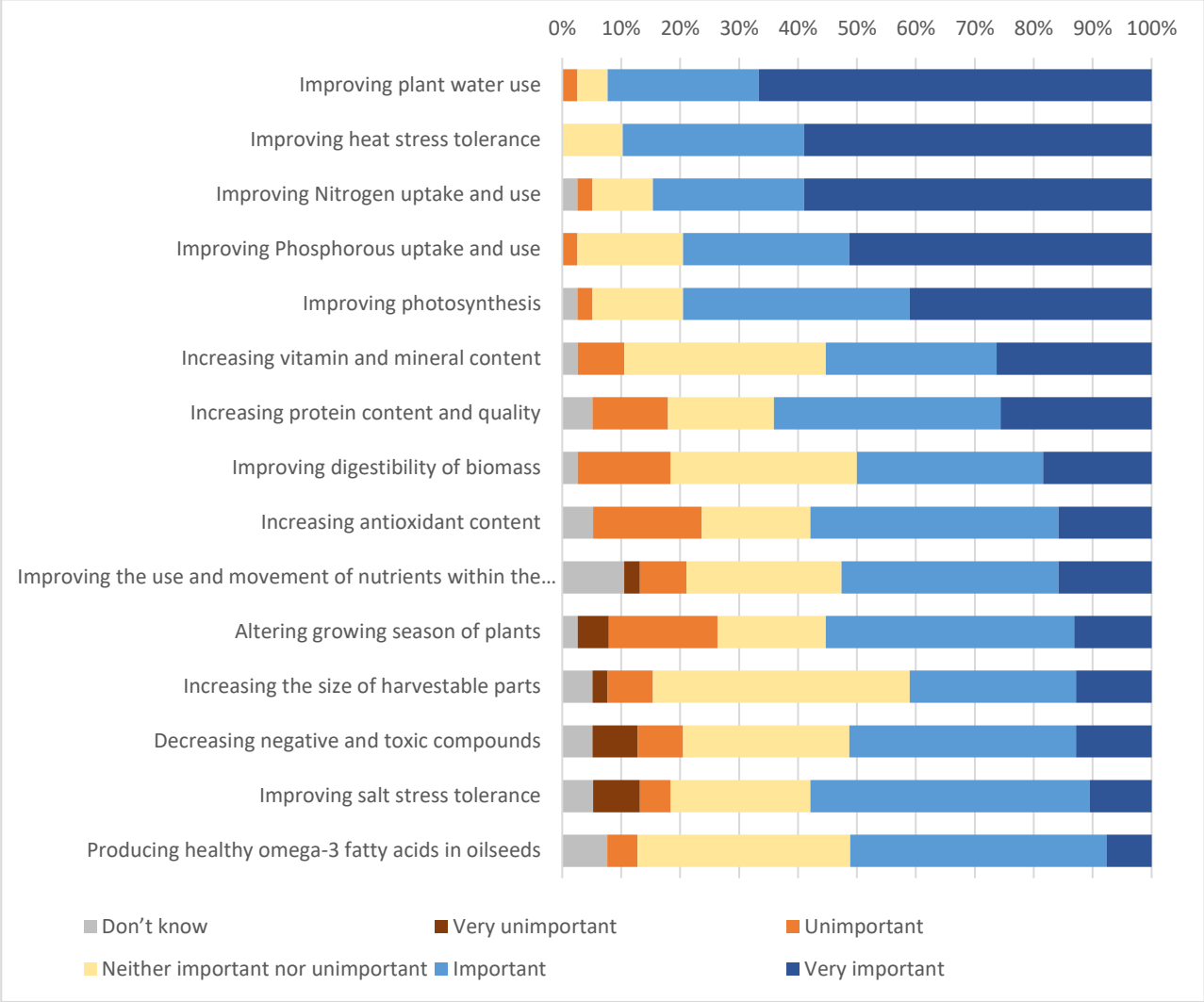

FIGURE 12: FARM-LEVEL STAKEHOLDER OPTION PREFERENCES (AS A PERCENT OF COMPLETED RESPONSES)

5.3 *Most important crops*

When asked 'Which crops do you feel are most important for the future of European agriculture?' (the question allowed for up to five crops to be selected by each participant) the most highly ranked crops were:

1) Wheat (21)
2) Potatoes (18)
3) Barley (12)
4) Tomatoes (12)

Table 7 provides the full results. These are similar but not identical to the crops which participants most commonly worked with or on: wheat (11), barley (11), maize (5), rice (4), and tomatoes (4).

Differences in option preference were assessed for the top four crops identified as most important for the future of European agriculture (wheat, potatoes, barley, and tomatoes).

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Little variation is seen in option importance – the most important options for the full farm-level category remain the most important options for each crop (see **Table 8**). However, some options may be considered of higher or lower importance to those prioritising specific crops, as in the case of those selecting wheat and potatoes as important crops also selected 'Improving photosynthesis' as a very important option (median of 1).

TABLE 7: CROPS DEEMED TO BE MOST IMPORTANT AND THOSE RESPONDENTS WORKED WITH OR ON*

***THOSE IN PALE GREY REPRESENT FREE-TEXT RESPONSES TO THE QUESTION: 'WHICH CROPS DO YOU FEEL ARE MOST IMPORTANT FOR THE FUTURE OF EUROPEAN AGRICULTURE?'**

****THOSE IN DARK GREY REPRESENT FREE-TEXT RESPONSES TO THE QUESTIONS REGARDING WHICH CROPS RESPONDENTS PRIMARILY WORK WITH OR ON**

	Number choosing this crop as one of the most important for the future of European agriculture	Number indicating that they primarily work with/on this crop
Wheat	21	11
Potatoes	18	2
Barley	12	11
Tomatoes	12	4
Grain maize and corn-cob mix	9	5
Soya	9	2
Oats	8	3
Rape and turnip rape seeds	8	3
Olives	7	3
Sugar beet	7	2
Carrots	6	1
Rice	6	4
Sunflower seeds	5	3
Grapes	4	3
Beans, lentils, legumes	3*	1**
Spelt	2	0
Sorghum	1	1
Triticale	1	1
Quinoa	1	0
Kenaf	1	0
Grass	1	2
Kale	1	0

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Various rotational crops		1
Various pasture crops		1
Various fruit, vegetables, agroforestry		1
Strawberries		1
Not applicable	N/A	12

TABLE 8: OPTION PREFERENCES BY CROP PRIORITY*

***DARK BLUE INDICATES A MEDIAN SCORE OF 1 (VERY IMPORTANT), LIGHT BLUE A SCORE OF 2 (IMPORTANT) AND YELLOW A SCORE OF 3 (NEITHER IMPORTANT NOR UNIMPORTANT) – FRACTIONS ROUNDED UP FOR COLOUR CODING PURPOSES**

		Farm-level Median	Wheat	Potato	Barley	Tomato
Sustainability	Improving plant water use	1	1	1	1	1
	Improving heat stress tolerance	1	1	1	1	1
	Improving Nitrogen uptake and use	1	1	1	1	1
	Improving Phosphorous uptake and use	1	1	1	1	1
	Improving salt stress tolerance	2	2	2	2	2
Yield	Improving photosynthesis	2	1	1	2	2
	Improving digestibility of biomass	2	2	3	2	2
	Improving the use and movement of nutrients within the plant	2	2	2	2	2
	Altering growing season of plants	2	2	2	2	2
	Increasing the size of harvestable parts	3	2.5	2.5	3	3
Nutrition	Increasing protein content and quality	2	2	2	2	2
	Increasing vitamin and mineral content	2	3	2	2	2

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	Increasing antioxidant content	2	2	2	2	2
	Decreasing negative and toxic compounds	2	2	2	2	2
	Producing healthy omega-3 fatty acids in oilseeds	2	2	2	2	2

5.4 *Option card #16 survey results*

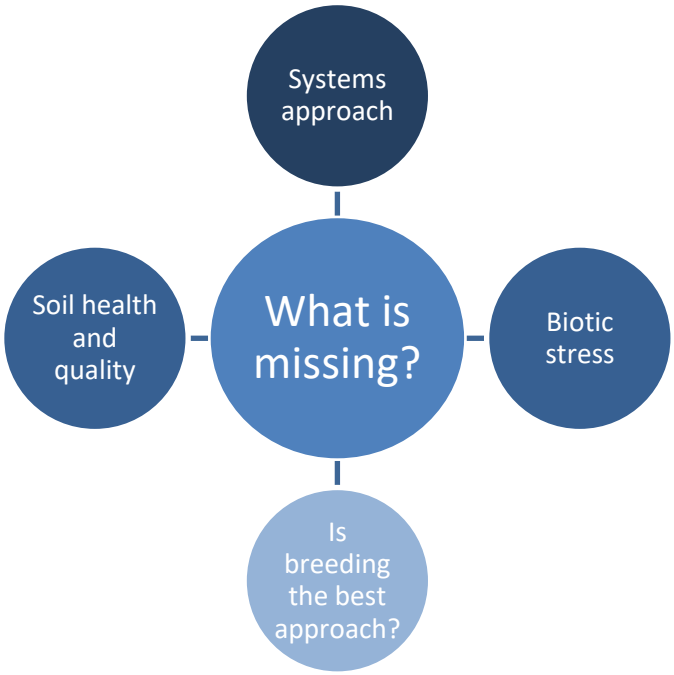

FIGURE 13: OPTION CARD 16 SURVEY KEY THEMES (DARKER BLUE CORRESPONDS TO A THEME BEING MORE FREQUENTLY MENTIONED)

Respondents raised a number of important issues which they felt were missing from the options presented – the four most frequently cited concerns are shown in **Figure 13**. The question of taking a higher-level systems approach to breeding, one which avoided tradeoffs, and focused on issues such as increasing agrobiodiversity and considering the inter-connectedness of crops, pollinators, and beneficial microbes was raised by many respondents. Biotic stress, encompassing pests, diseases, and weeds, was also frequently raised as a key concern for plant breeding, particularly in light of changing biotic stress patterns and emerging pests and diseases due to climate change. Soil health and quality and maintaining and developing carbon and nutrient stores was also a frequently raised aim. Several comments urged the need to consider whether plant breeding was the best way of accomplishing key aims, and suggested alternative mechanisms, such as nature-based solutions, be explored first.

Additional issues raised included: maintaining genetic diversity, including the re-introduction of landraces; cover crops; processing qualities; reducing inputs; and yield stability.

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6 FARM-LEVEL CONCLUSIONS

- The most preferred options in the survey were: 'Improving plant water use', 'Improving heat stress tolerance', 'Improving Nitrogen uptake and use', 'and 'Improving Phosphorous uptake and use' – each with a median of 1 ('Very important').
- All four of the top options fall under the category of Sustainability, the importance of which is further highlighted by the fact that nearly 70% of survey respondents chose Sustainability as the most important of the three goals.
- Little variation in option importance was seen based on the goals prioritised; a fact which may be linked to the number of respondents who stated that all three goals were important, and/or that certain goals, such as Sustainability, underpinned the delivery of the other goals.
- Several of the key themes arising from the workshop discussions – importance of the environment and climate change, the need to breed for multiple objectives, the pre-existing alternatives to some options – were also seen in the survey results.
- The importance of preparing European food systems to cope with climate change and future stresses through a combination of breeding more resilient crops, reducing the use of inputs, and sustainable land, farm, and consumer practices were highlighted throughout.
- The need to avoid negative externalities and trade-offs in plant breeding, and to find ways of achieving all three goals in tandem was also an important message from both datasets.
- Stakeholders highlighted that options will have variable importance and impact depending on the region and context in which they are deployed.
- Key potential impacts of the options discussed include:
    - Trade-offs, such as yield increases co-occuring with quality decreases, or yield increases at the cost of sustainability and resilience, including yield stability
    - Negative impacts and externalities, including:
        - consumer expectations not being met
        - agro-ecosystems being degraded, particularly due to input use in agriculture and the impacts of climate change on production systems in the context of extreme weather events
        - reduced biodiversity
        - increased incidence and/or severity of pests and diseases
        - consequences for crop harvest, storage, or processing systems
    - Potential positive impacts varied considerably with the option being discussed. These included:
        - Reduction in input use leading to reduced environmental degradation
        - Increased yields
        - Increased resilience to exteme weather, particularly drought and heat waves
        - Increased food security and sovereignty
- There is a need for crops to be designed which are resilent, balance trade-offs between the three goals, and which consider the wider implications for agro-ecosystems.

A further synthesis of the outputs of these two sources of data, and with the results from the other stakeholder groups, will be presented in D2.4 of this workpackage in 2021.

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8 REFERENCES

Boone, H. N., & Boone, D. A. (2012). Analyzing Likert Data. *Journal of Extension*, *50*(2).

Breen, R. L. (2006). A Practical Guide to Focus-Group Research. *Journal of Geography in Higher Education*, *30*(3), 463–475. https://doi.org/10.1080/03098260600927575

EUROSTAT. (2019). Distribution of EU farms and utilised agricultural area according to farm size, 2016. Retrieved August 10, 2020, from Farms and Farmland in the European Union website: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics

Harkness, J. a, & Schoua-Glusberg, A. (1998). Questionnaires in Translation. *ZUMA-Nachrichten Spezial*, (1), 87–126.

Rabiee, F. (2004). Focus-group interview and data analysis. *Proceedings of the Nutrition Society*, *63*(4), 655–660. https://doi.org/10.1079/pns2004399

Ritchie, J., & Lewis, J. (2010). *Qualitative Research Practice* (3rd ed.). SAGE Publications Ltd.

Srivastava, A., & Thomson, S. B. (2009). Framework Analysis : A qualitative methodology for applied policy research. *Journal of Administration & Governance*, *4*(2), 72–79. https://doi.org/10.7748/nr2011.01.18.2.52.c8284

Survey Research Center Institute for Social Research. (2016). *Guidelines for Best Practice in Cross-Cultural Surveys*. *Survey Research Centre*. Ann Arbor, MI.

Woodyatt, C. R., Finneran, C. A., & Stephenson, R. (2016). In-Person Versus Online Focus Group Discussions: A Comparative Analysis of Data Quality. *Qualitative Health Research*,

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26(6), 741–749. https://doi.org/10.1177/1049732316631510

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9 ANNEXES

CropBooster-P

Annex 1: Workshop Protocol

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	Online workshop outline	The purpose of these workshops is to understand the potential economic, social and environmental impacts of CropBooster-P crop improvement options, which fall under three headings: yield, nutrition and sustainability. The workshops are an opportunity for stakeholders – farmers, NGOs, breeders, agri-food industry and others – to discuss issues around these options and feed into a roadmap for the future. We will be showing stakeholders 15 crop improvement options identified by CropBooster scientists as possible and desirable for future plant breeding efforts. These are: $$Yield \begin{cases} Improving\ photosynthesis \\ Increasing\ the\ size\ of\ harvestable\ parts \\ Improving\ the\ use\ and\ movement\ of\ nutrients\ in\ the\ plant \\ Increasing\ the\ growing\ season\ of\ the\ plant \\ Improving\ digestibility\ of\ biomass \end{cases}$$ $$Nutrition \begin{cases} Increasing\ vitamin\ and\ mineral\ content \\ Increasing\ protein\ content\ and\ quality \\ Decreasing\ negative\ and\ toxic\ compounds \\ Increasing\ antioxidant\ content \\ Increasing\ omega-3\ fatty\ acid\ content \end{cases}$$ $$Sustainability \begin{cases} Improving\ nitrogen\ uptake\ and\ use \\ Improving\ plant\ water\ use \\ Improving\ phosphorous\ uptake\ and\ use \\ Improving\ heat\ stress\ tolerance \\ Improving\ salt\ stress\ tolerance \end{cases}$$ The workshops will also help us determine which options will be explored in a systematic literature review later.
	Main questions	1. *What are the CropBooster option priorities for key stakeholder groups?* 2. *What are the potential social, economic and environmental impacts of the CropBooster options?* 3. *What important issues do the CropBooster options leave out?*

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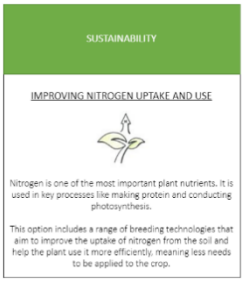
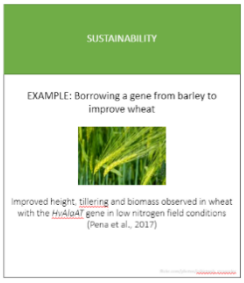
	Details	There will be up to 15 online workshops: 1. *2.1A: farmers (X3)* 2. *2.1B: regulators, policy makers and NGOs (X3)* 3. *2.2A: plant breeders (X3)* 4. *2.2B: agri-food supply chain (X3)* 5. *2.3A: consumer interest organisations (X3)* We are aiming for 4-5 participants at each online workshop, which will be moderated by one of three postdoctoral researchers in charge of recruiting for and hosting the event Participants will cycle through three "virtual stations" on *Mural* before moving onto a final activity, Option Card #16. Moderators must begin the workshops at a different station every time. The stations will represent either yield, nutrition or sustainability. At each station there will be four or five 'option cards' (see below) that describe one of the options for that station:   To facilitate this process, six *Mural* whiteboards have been created, each with different station and option card ordering. This has been done to reduce any *order bias* and the effects of tiredness as participants move through the session.
	Materials	Make sure:

		• You have sent the PIS to all participants by email at least 24 hours in advance of the online workshop; preferable attached to the invitation email.
		• You have created the event as a Teams meeting (this is mandatory for video recording)
		• You have created a back-up meeting in Webex
		• You have a draft of an email to all participants with the back up Webex link prepared and ready to be sent in case of any issues with Teams
		• You have sent a follow-up email that details the **time**, Teams **link** and **agenda** for the meeting
		• Make sure:
		  ○ You have **screen capture software** set up or a **voice recorder to record audio via laptop/tablet speakers (this is back up in case Teams doesn't record properly)**
		  ○ You know how to use the voice recorder
		  ○ You have checked that the voice recorders work (**battery**)
		  ○ You have provided participants with a link to consent form
		  ○ You have checked in advance that all participants have filled in the online consent form
		  ▪ Have links to consent forms ready in case anyone has not yet done it/wants to remind themselves of what was in it
		  ○ You have links to option card materials and are comfortable using them
		  ○ You have a **note pad**
		  ○ **You have the printed/written out notetaking sheet**
		  ○ **You have two pens**
		  ○ List of (expected) attendees
		• Partner organisation is either A. attending to give a short presentation, B. sending a prepared video which you have ready, or C. not attending and you have added a thank you slide to the presentation
		• You have a spare computer already switched on, with the links for the Teams and Webex calls ready to activate if need be
		• You have an LAN to connect to the internet directly
		• You have a set of headphones (preferably with a microphone) - unless you are using the dictaphone as a back up, in which case check that your audio quality is acceptable

		• You know who is attending and who is missing
Allow ~30 minutes for people to arrive and mingle	**Before starting**	Ensure that you: • Greet people as they arrive and make them feel welcome • Chat with them, try not to leave anyone out • You explain to participants that you will be recording the event • Check everyone's microphone and video connections individually • We have a designated backup moderator ready to help out • Send out a link to consent forms in advance of the meeting

1-15	**Welcome presentation**	• Hosting partner can give a quick introduction (1-2 minutes) or provide a video
		• Explain project
		  ○ Focussing on three areas of crop improvement: yield, nutrition and sustainability
		• Explain ground rules
		  ○ There are no wrong answers
		  ○ We're video/audio recording so we don't miss anything but your responses will be kept anonymous
		  ○ Online meetings aren't as fluid as in-person meetings, so please be patient with each other and I'll try to make sure everyone gets a turn speaking.
		  ○ Glitches usually resolve quickly – here's how we will deal with them
		  ○ If you have issues with audio during the call, please use the chat function to alert the moderator
		  ○ If the moderator drops out of the call and does not return within 5 minutes, please: 1) check your email to see if we have sent you anything and if not, 2) contact the emergency moderator (put the emergency moderator's email in the chat)
		[REMIND EVERYONE THAT THEY NEED TO SIGN THE CONSENT FORM IF THEY HAVEN'T DONE SO]

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15-20	**Introduction (only at option station #1)**	**JM: YIELD STATION** **AN: NUTRITION** **SS: SUSTAINABILITY** **[START TEAMS RECORDING AND VOICE RECORDER/SCREEN CAPTURE SOFTWARE]** I would like each person to briefly introduce themselves: 1. Can you tell us your first name and a little about your organisation? **[MAKE A NOTE OF PEOPLE'S NAMES – YOU'LL NEED THEM]**
20-25	**Warm-up question**	OK, now I would like to ask about what you think about the challenges for European food and agriculture: 2. What do you think the biggest challenges will be over the next 30 years?
25-45	**Appraisal of Cropbooster options and impact assessment**	**[PROVIDE A LINK (ABOVE) TO THE APPROPRIATE MURAL START – EXPLAIN THAT YOU WILL ALSO SHARE YOUR SCREEN. ENSURE EVERYONE CAN SEE OPTION CARDS]** Here are some targets for crop improvement that our team have highlighted as important. We'll go over them together but it might be useful to make a note of those you find interesting. **[ALLOW EVERYONE TO READ THE CARDS]** **[ON 'SUMMARY PAGE' ASK PARTICIPANTS TO MAKE A NOTE OF WHICH OPTION THEY THINK IS MOST AND WHICH LEAST IMPORTANT]** 3. Which option strikes you as the most important? Which option is least important? **PROMPT:**

		WHY IS [OPTION] THE MOST IMPORTANT/UNIMPORTANT? **DID ANYONE ELSE HAVE THAT OPTION AS THE MOST/LEAST IMPORTANT?** **NOBODY HAS SAID [OPTION]. WHY?** Now, thinking about the potential impacts of these options: 4. What would be the impact of [option] be? **PROBE:** **WHY DO YOU THINK THAT?** **WHAT ABOUT [SOCIAL/ECOMOMIC/ENVIRONMENTAL] IMPACTS?** **PROMPT:** **DOES ANYONE DISAGREE ABOUT THE IMPACT OF THAT OPTION** **WHAT ELSE WOULD HAVE TO HAPPEN FOR [OPTION] TO HAVE IMPACT?**
45-50	**Insurance question**	Lastly, I would like to know: 5. How do these options meet the challenges you outlined earlier?
50-80	**Option station #2**	**[MOVE GROUP TO NEXT OPTION CATEGORY]**
80-110	**Option station #3**	**[MOVE GROUP TO NEXT OPTION CATEGORY]**

110 - 125	**Option Card #16 activity**	Now you have an opportunity to tell us what **else** should be included in these options for future-proofing European agriculture. **[SCROLL TO OPTION CARD #16 AND ASK THEM TO DISCUSS WHAT SHOULD BE ON IT]** **PROMPT:** **CAN WE AGREE ON WHAT OPTION #16 SHOULD INCLUDE?** **WHAT PROBLEM WAS RUNNING THROUGH PREVIOUS DISCUSSIONS?** **[YOU CAN ADD A POST-IT NOTE BY DOUBLE-CLICKING IN MURAL]**
	Debrief	• Inform participants that you have now reached the end of the formal workshop. • Ask if they have any remaining questions. • Thank participants for their time and tell them ways in which they can stay in touch. • Mention the integrative workshop and/or second workshop. **[END RECORDING]**
	Contingencies	1. What should I do if a participant(s) do not join the online workshop? What is the minimum number which we will run the call with? At <2 participants, switch to an alternative protocol. 2. What should I do if Teams does not work? Send participants a link to Webex (or other backup software).

		3. What should I do if neither Teams nor the back up software works? Ask backup moderator if they can take over or find another suitable date with participants by email. 4. What should I do if there is a glitch and a participant drops out? Continue and make a note of when they left the call – if they manage to reconnect, then bring them up to speed with what has been said. Invite them to join a subsequent workshop (if possible). 5. What should I do if there is a glitch and the moderator drops out temporarily? Send them a chat/email informing participants that you will reconnect. If you cannot reconnect after 5 minutes, inform the back-up moderator and ask them to take over. 6. What should I do if a participant's video does not work? Continue with audio only. 7. What should I do if a participant's audio does not work? Ask them to reconnect – if problem persists, ask them to check their audio settings. Invite them (by chat/email) to subsequent workshop. 8. What should I do if one or more participants can't use Mural/see the option cards? Use screensharing – if fidelity is still too low, send the option card PPT slides to the Teams group. 9. What should I do if a voice recorder does not work? Use your mobile phone to record audio (most have applications for dedicated audio recording, otherwise record a video).

		10. What should I do if too many participants come to the event? Take their details, give them a name tag and have them join any of the other focus groups. 11. What should I do if someone is very late? If they join before or while the group is reviewing the options for the first category, allow them to join and bring them up to speed while the rest of the group reviews the options, giving them time to look at these as well. If they join after this point, ask them to join another focus group at a later date. 12. What should I do if there is a fire alarm or other emergency during the call? Inform participants that this is not a drill and tell them that you will have to leave the building and that the back up moderator will take over shortly. Ask them to wait in the call and review the option cards for that section while they wait. Exit the building, bringing the voice recorder and laptop with you. Once safe, contact the back up moderator and ask them to take over the call if your participants have not already done so. 13. What should I do if one person is dominating the focus group? Start by asking for direct responses from other participants (e.g. "Does anyone have a different view?"). If it persists, you can directly ask the disruptive person to give others a chance to speak or throw them a stern look. As a last resort, they can be asked to leave.
	Transcription	Video/audio files should be uploaded to the secure shared drive ASAP in the following format: *[moderator initials] – [date] – [workshop #] – [number participants]*

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		Example: **JM – 09032020 – 22A - 4**

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CropBooster-P

Annex 2: Option Cards

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SUSTAINABILITY

Improving how plants use resources and cope with stresses like heat or drought.

SUSTAINABILITY

IMPROVING NITROGEN UPTAKE AND USE

Nitrogen is one of the most important plant nutrients. It is used in key processes like making protein and in photosynthesis.

This option includes a range of breeding technologies that aim to improve the uptake of nitrogen from the soil and help the plant use it more efficiently, meaning less needs to be applied to the crop.

SUSTAINABILITY

EXAMPLE: Borrowing a gene from barley to improve wheat

Improved height and biomass has been seen in wheat with the Barley *HvAlaAT* gene in low nitrogen field conditions (Pena et al., 2017)

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SUSTAINABILITY

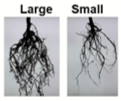
IMPROVING PLANT WATER USE

Lack of water affects plant productivity and can decrease crop quality.

This option includes a range of breeding technologies that aim to improve uptake of water from soil, reduce water loss in the plant and help it use water more efficiently.

SUSTAINABILITY

EXAMPLE: Improving roots to cope with water stress



Larger root systems can extract more water and nutrients under stress conditions in crops – improving root systems could improve plant stress tolerance (Ye et al., 2018).

SUSTAINABILITY

IMPROVING PHOSPHOROUS UPTAKE AND USE

Phosphorous is one of the most important plant nutrients. It is used in key processes like respiration and photosynthesis.

This option includes a range of breeding technologies that aim to improve the uptake of phosphorous from the soil and help the plant use it more efficiently, so less will need to be applied to the crop.

SUSTAINABILITY

EXAMPLE: A gene from traditional rice can improve crop performance

The gene *PSTOL1* enhances root growth and phosphorous uptake in traditional rice varieties. By incorporating this gene into modern varieties, productivity could be improved in regions with low phosphorous content (Gamuyao, 2012).

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SUSTAINABILITY

IMPROVING HEAT STRESS TOLERANCE

Plants can be damaged by being exposed to high levels of heat. Too much heat can harm plant reproduction.

This option includes a range of breeding technologies that aim to improve the plant's ability to cope with high temperatures.

SUSTAINABILITY

EXAMPLE: Heat stress targets in wheat

Researchers have identified wheat varieties with high levels of resistance to heat stress.

These varieties are better able to continue photosynthesis and cooling their leaves during heat stress. Breeders can use these traits to develop better varieties in the future. (Sharma et al., 2014)

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SUSTAINABILITY

IMPROVING SALT STRESS TOLERANCE

Plants can be damaged by being exposed to too much salt. For example, too much salt in water can mean that plants end up absorbing salt instead of nutrients.

This option includes a range of breeding technologies which aim to reduce crop sensitivity to and improve tolerance of salt.

SUSTAINABILITY

EXAMPLE: Salt stress targets in rice

Researchers have identified several DNA regions which are linked to the uptake of different salts in rice. These can be used to breed varieties of rice which are more resistant to high levels of salt (Koyama et al., 2001).

flickr.com/photos/matsuyuki

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YIELD

Increasing the total amount of edible or usable material produced by the plant.

YIELD

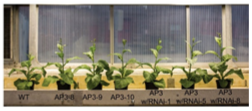
IMPROVING PHOTOSYNTHESIS

Photosynthesis is the process of turning the energy from the sun into usable energy in the form of sugar.

This option includes a range of breeding technologies that aim to increase the efficiency of photosynthesis.

YIELD

EXAMPLE: Improving photosynthesis for more biomass



By reducing the amount of energy the plant spends on respiration, scientists were able to increase plant biomass by 40% in tobacco (South et al., 2019).

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YIELD

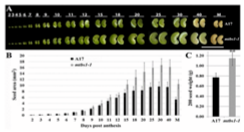
INCREASING THE SIZE OF HARVESTABLE PARTS

Increasing the size of harvestable parts of crops could increase the total yield that can be produced by a single plant.

This option includes a range of breeding technologies that aim to increase the size of grains, fruits and tubers.

YIELD

EXAMPLE: Removing a gene leads to bigger seeds



The *BS1* gene regulates plant growth. Removing the gene has been shown to increase the size of leaves and seed in soybeans (Ge et al., 2016).

YIELD

IMPROVING THE USE AND MOVEMENT OF NUTRIENTS WITHIN THE PLANT

This option includes a range of breeding technologies that aim to help plants use and move nutrients to the parts of the plant where they are needed.

For example, plants do not always maximise their storage of carbon in the harvestable part of the plant; changing where plants store key nutrients could help to increase yield.

YIELD

EXAMPLE: Improving the flow of nutrients to the grain

The NAM-B1 gene helps to control the flow of nutrients like iron, zinc and magnesium from leaves to grain (Waters et al., 2009). By boosting this gene, it may be possible to improve grain filling in cereal crops.

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YIELD

ALTERING GROWING SEASON OF PLANTS

Plants suffer different stresses at different times of the growing season, such as damage caused by heat during flowering.

This option includes a range of breeding technologies to change when the plant emerges, flowers, and dies.

YIELD

EXAMPLE: Heat tolerance and earlier grain emergence a priority

Gouache et al. (2012) show that heat tolerance and early grain emergence are more efficient than earlier planting for coping with heat stress. These could be future wheat breeding aims.

flickr.com/photos/tillwe

YIELD

IMPROVING DIGESTIBILITY OF BIOMASS

Plant material can be broken down into sugars and used for a wide range of purposes, including bio-fuels.

This option includes a range of breeding technologies that aim to produce plants which are easier to process into sugars.

YIELD

EXAMPLE: Reducing lignin content

Lignin is an important for plants and helps make their stems rigid. However, high levels of lignin make digesting plants difficult. Reducing lignin production in alfalfa has been found to nearly double sugar yield from plant digestion (Chen and Dixon, 2007).

flickr.com/photos/86953562@N00

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NUTRITION

Increasing the amount of plant components which are beneficial to human health (or decreasing the amount of those which are harmful to human health).

NUTRITION

INCREASING VITAMIN AND MINERAL CONTENT

This option includes a range of breeding technologies that aim to increase the content of vitamins and/or minerals which are beneficial to human health, whilst maintaining plant health.

NUTRITION

EXAMPLE: Improving carotenoid content in potato

By supressing the CHY1 and CHY2 genes, researchers have been able to boost the amount of beta-carotene in potato (Diretto et al., 2007). Humans are able to convert carotenoids into Vitamin A.

flickr.com/photos/sethoscope

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NUTRITION

INCREASING PROTEIN CONTENT AND QUALITY

Protein is an essential part of the human diet and is made of amino acids. Certain types of protein are useful because they contain high levels of specific amino acids that humans need to build muscle.

This option includes a range of breeding technologies that aim to increase the protein content of crops whilst maintaining yield.

NUTRITION

EXAMPLE: Improving protein content of wheat

The *NAM-A1* gene has been linked to grain protein content in wheat (Uauy et al., 2006). By boosting this gene, it is possible to improve grain protein content in cereal crops.

flickr.com/photos/alphazeta

NUTRITION

DECREASING NEGATIVE AND TOXIC COMPOUNDS

Antinutrients are produced by plants to defend themselves from pests, but these can reduce the nutrient uptake in humans.

Toxic metabolites can cause harm to humans who eat them.

This option includes a range of breeding technologies that aim to reduce antinutrient and toxic metabolite production, so that more parts of the plant can be eaten safely.

NUTRITION

EXAMPLE: Reducing the content of phytic acid in maize and soybean

The *LPAR1* gene controls the production of phytic acid, which negatively affects animal nutrition.

Supressing this gene leads to crops with lower phytic acid content (Shi, 2007).

flickr.com/photos/unitedsoybean

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NUTRITION

INCREASING ANTIOXIDANT CONTENT

Antioxidants are found in fruits, vegetables and cereal crops. They provide a range of human health benefits, such as protection against cancer, diabetes and heart disease.

This option includes a range of breeding technologies that aim to increase the amount of antioxidants found in the edible parts of plants.

NUTRITION

EXAMPLE: Anthocyanin in tomato

The *ANT1* gene in tomatoes controls the production of the antioxidant *anthocyanin*. By editing this gene, scientists were able to produce tomatoes with much higher levels of anthocyanin than normal (Čermák et al., 2015).

NUTRITION

PRODUCING HEALTHY OMEGA-3 FATTY ACIDS IN OILSEEDS

Omega-3 fatty acids are essential components of a healthy balanced diet. At the moment, these are mainly found in seafood.

This option includes a range of breeding technologies which aim to produce omega-3 fatty acids in oilseeds, providing a new dietary source for humans.

NUTRITION

EXAMPLE: Omega 3 production in Camelina

By introducing the FAH12 gene into *Camelina sativa* oilseed plants, scientists have created a variety which can produce beneficial omega-3 fatty acids without reducing total oil yield (Usher et al., 2015).

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OPTION CARD #16

NAME: _____

Description: _____
_____
_____
_____
_____
_____
_____

OPTION CARD #16

EXAMPLE: _____

Description: _____
_____
_____
_____
_____
_____
_____

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Improving nitrogen uptake and use
Improving phosphorous uptake and use
Improving heat & stress tolerance
Improving water use
Improving salt stress tolerance

Sustainability

Improving photosynthesis
Improving use and movement of nutrients
Altering growing season
Improving digestibility of biomass
Increasing size of harvestable parts

Yield

Nutrition

Increasing antioxidant content
Increasing protein content and quality
Decreasing negative and toxic compounds
Producing healthy omega-3
Increasing mineral and vitamin content

Option Card #16

Where: Farming?

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CropBooster-P

Annex 3: Standardised Workshop Invitation

Invitation to participate in CropBooster-P workshop

Dear [participant],

You are invited to take part in a two-hour workshop on [date, location, timing].

The workshop is part of CropBooster-P, a European Union project bringing together researchers and stakeholder across Europe to map and assess current and future strategies for crop genetic improvement. You can find out more about the project on our website, at https://www.cropbooster-p.eu/.

As a member of [insert occupation/relevant group], we want your opinions on the potential impacts of several strategies for crop improvement that we have identified.

The workshop will involve a brief presentation, followed by short discussions in small groups around key options previously identified by the project for improving yield, nutritional quality, and sustainability. These discussions will be audio recorded for later analysis by Lancaster University (United Kingdom) and Wageningen University (Netherlands) teams. Your contributions will be fully anonymised.

By taking part in this workshop, you will help us to understand the priorities you have for crop improvement and will help steer European plant breeding and policy.

If you are interested in taking part, please confirm by email to [contact] by [date], and read the attached participant information sheet, which contains more details about the study and data protection prior to the workshop.

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If you have any questions, please do not hesitate to contact [contact].

Best wishes,

[contact – this will vary depending on workshop]

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CropBooster-P

Annex 4: Survey

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CropBooster-P Survey

Start of Block: Shared Demographic Questions

Q8 This survey is part of CropBooster-P, an EU project bringing together researchers and stakeholders across Europe to map and assess strategies for crop improvement. You can find out more about the project on our website at www.cropbooster-p.eu. As a member of the European food system, we want your opinions on the potential importance of several strategies for crop improvement that we have identified around improving the yield, nutritional quality, and sustainability of European crops. By completing this survey you are agreeing to have your results analysed as part of this project. Individual responses will be kept anonymous and will be used by the CropBooster-P team to better understand priorities for crop improvement in Europe. They may also form the basis of publications. Your data will be stored securely and anonymously and may be used in future research projects. The results of this survey will be analysed by researchers at Lancaster University (United Kingdom) and Wageningen University (Netherlands). You may request to have your response removed from the survey during the data collection phase. To do this, you must email iss@lancaster.ac.uk before 18 May 2020 with the email address you used when filling in the survey. Beyond this date, your data will no longer be able to be removed from the analysis. If you have any questions, please do not hesitate to contact Dr Stacia Stetkiewicz, Dr Jonathan Menary, or Dr Abhishek Nair - s.stetkiewicz@lancaster.ac.uk; j.menary@lancaster.ac.uk; abhishek.nair@wur.nl. Click here to view the survey in French Click here to view the survey in German

Q3 What is your current age?

▼ Under 18 ... Over 100

Skip To: End of Survey If What is your current age? = Under 18

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Q9 Which of the following best describes you?

- ○ Involved in farm-level activities
- ○ Involved in agri-business or the food supply chain
- ○ Consumer or consumer representative
- ○ Plant scientist

End of Block: Shared Demographic Questions

Start of Block: Ranking

Q38
In this section, you will be asked about how important different crop improvement options are in terms of future-proofing European crops.

Future-proofing crops is used to refer to improving crops in order to prepare them for the future needs of society and the challenges which will be faced by food systems between now and 2050.
Please rank the following goals in terms of importance to future-proofing European crops, with 1 being most important and 3 least important.

_____ Increasing yield
_____ Improving nutritional quality
_____ Improving sustainability

Q39 Please briefly describe why you have prioritised your chosen goal (in 1000 characters or less).

_____

_____

_____

_____

_____

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Q42 Please indicate how important you feel each of the following options are for future-proofing European crops.

Q57
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q47
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q55
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q49
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q54
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q51
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q56
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q52
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q46
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q53
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q48
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q41
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q44
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q50
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q90
Please indicate how important you feel this option is for future-proofing European crops:

- ○ Very unimportant
- ○ Unimportant
- ○ Neither important nor unimportant
- ○ Important
- ○ Very important
- ○ Don't know

Q59 Are there any other goals which were not included in the above list, but which you feel are important for future-proofing crops? If so, please provide a brief description below. (in 1000 characters or less)

_____

_____

_____

_____

_____

End of Block: Ranking

Start of Block: Shared demographic questions part 2

Q2 Are you contributing to a CropBooster-P focus group in spring 2020?

- ○ Yes
- ○ No
- ○ Unsure
- ○ Other, please specify: _____

Page Break

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Q1 Capacity in which you are filling in this survey (this could be your job title, an organisation you represent, or simply as an interested individual)

_____

_____

_____

_____

_____

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Q4 What is your sex?

Why are we asking? - We are collecting this information in order to check the representation of different age, gender, and geographic groups in our survey - for example, if the majority of our responses are coming from one particular region of Europe, this might be important when interpreting our results.

- ○ Male
- ○ Female
- ○ Prefer not to say

Q5 What is your home postcode? (UK respondents, please give at least the first three characters of your postcode)

_____

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Q6 Formal education level (please indicate the highest applicable to you - hover over the answer choices for examples / or click here for examples)

- ○ Less than primary education
- ○ Primary education
- ○ Lower secondary education
- ○ Upper secondary education
- ○ Post-secondary non-tertiary education
- ○ Short-cycle tertiary education
- ○ Bachelor's or equivalent degree
- ○ Master's or equivalent degree
- ○ Doctoral or equivalent degree
- ○ Other, please specify: _____

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Q78 Which country do you live in? (if you split your time between multiple countries, please indicate the country of your primary residence)

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

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Q15 Which crops do you feel are most important for the future of European agriculture? (choose up to 5)

- ☐ Barley
- ☐ Carrots
- ☐ Grain maize and corn-cob mix
- ☐ Grapes
- ☐ Oats
- ☐ Olives
- ☐ Onions
- ☐ Potatoes
- ☐ Rape and turnip rape seeds
- ☐ Rice
- ☐ Rye and maslin
- ☐ Sorghum
- ☐ Soya
- ☐ Spelt
- ☐ Sugar beet
- ☐ Sunflower seeds
- ☐ Tomatoes
- ☐ Triticale

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☐ Wheat

☐ Other, please specify:

_____

End of Block: Shared demographic questions part 2

Start of Block: Farm level questions

Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

Q11 Which of the following best describes you:

○ Farmer

○ Farmer representative

○ Farm support/advisor

○ Environmental regulator or policy maker

○ Scientific expert in resource use efficiency, environmental impacts, etc.

○ NGO with a focus on farm-level concerns, such as the environmental impacts of farming

○ Other farm-level stakeholder, please specify:

_____

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

Q12 What is your highest level of agricultural education?

- ○ Only practical experience on-farm
- ○ Basic agricultural training (this includes a completed agricultural apprenticeship)
- ○ Full agricultural training (two or more years of full-time higher education)
- ○ Other, please specify: _____
- ○ Not applicable

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: = Farmer

Or Which of the following best describes you: = Other farm-level stakeholder, please specify:

Q13 Is your farm mixed animal and crop farming, or solely crops?

- ○ Mixed crop and animal farming
- ○ Crop specialist
- ○ Animal specialist
- ○ Not applicable

Page Break

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: = Farmer representative

Or Which of the following best describes you: = Farm support/advisor

Or Which of the following best describes you: = Other farm-level stakeholder, please specify:

Q14 What types of farms do you primarily represent/work with?

- ○ Mixed crop and animal farming
- ○ Crop specialists
- ○ Animal specialists
- ○ Not applicable

Page Break

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

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Q16 Which crops do you primarily work with or on? (choose up to five)

- ☐ Barley
- ☐ Carrots
- ☐ Grain maize and corn-cob mix
- ☐ Grapes
- ☐ Oats
- ☐ Olives
- ☐ Onions
- ☐ Potatoes
- ☐ Rape and turnip rape seeds
- ☐ Rice
- ☐ Rye and maslin
- ☐ Sorghum
- ☐ Soya
- ☐ Spelt
- ☐ Sugar beet
- ☐ Sunflower seeds
- ☐ Tomatoes
- ☐ Triticale

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- [ ] Wheat
- [ ] Other, please specify: _____
- [ ] Not applicable

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: = Farmer

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Q17 What country is your farm located in?

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

Page Break

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Display This Question:

If Which of the following best describes you: = Farmer

Q18 What size is your farm in total? (including rented land)

- ○ 0 – less than 2 ha
- ○ 2 – 4.9 ha
- ○ 5 – 9.9 ha
- ○ 10 – 19.9 ha
- ○ 20 – 29.9 ha
- ○ 30 – 49.9 ha
- ○ 50 – 99.9 ha
- ○ 100 ha or over

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Display This Question:

If Which of the following best describes you: = Farmer

*

Q19 What are the current primary markets for your crops? (choose up to three)

- ☐ Animal Feed
- ☐ Human food
- ☐ Fuel
- ☐ Drinks industry
- ☐ Other, please specify: _____

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Display This Question:

If Which of the following best describes you: = Farmer

Q20 Does your farm have any specific certifications or organisational affiliations, or are you a member of any specific agri-environmental schemes, such as Organic, LEAF, etc? (please indicate any which apply, even if they do not apply to your entire farm)

- ○ Yes, please specify: _____
- ○ No
- ○ Unsure

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Display This Question:

If Which of the following best describes you: = Farmer

Q21 Do you own or rent your farm?

- ○ Own
- ○ Rent
- ○ Own some, rent some (please specify approximate hectares for each) _____
- ○ Other, please specify _____

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: != Farmer

Q22 Which country do you primarily work in?

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: != Farmer

Q23 If you are a farm advisor, or frequently work with farmers, what is the average size of farm you usually work with?

- ○ 0 – less than 2 ha
- ○ 2 – 4.9 ha
- ○ 5 – 9.9 ha
- ○ 10 – 19.9 ha
- ○ 20 – 29.9 ha
- ○ 30 – 49.9 ha
- ○ 50 – 99.9 ha
- ○ 100 ha or over
- ○ Unsure
- ○ Not applicable

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: != Farmer

Q24 What are the primary markets for the crops you usually work with or on? (choose up to three)

- ☐ Animal Feed
- ☐ Human food
- ☐ Fuel
- ☐ Drinks industry
- ☐ Other, please specify: _____
- ☐ Unsure
- ☐ Not applicable

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Display This Question:

If Which of the following best describes you? = Involved in farm-level activities

And Which of the following best describes you: != Farmer

Q25 Which of the following best describes the company or organisation you work for/are a part of?

- ○ Farm/farmer
- ○ NGO
- ○ Research institute
- ○ Higher education institute
- ○ Business
- ○ Farm advisory group
- ○ Other, please specify: _____

End of Block: Farm level questions

Start of Block: Business level questions

Display This Question:

If Which of the following best describes you? = Involved in agri-business or the food supply chain

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Q26 Which of the following best describes you?

- ○ Agri-food business member (other than farmers)
- ○ Agri-food business representative
- ○ Trade or supply chain expert
- ○ Agricultural technology expert
- ○ Agricultural economist
- ○ Plant breeder
- ○ NGO with a focus on business-level concerns, such as sharing of genetic material for breeding
- ○ Other business-level stakeholder, please specify: _____

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Display This Question:

If Which of the following best describes you? = Involved in agri-business or the food supply chain

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Q28 Which crops do you primarily work with or on? (choose up to 5)

- ☐ Barley
- ☐ Carrots
- ☐ Grain maize and corn-cob mix
- ☐ Grapes
- ☐ Oats
- ☐ Olives
- ☐ Onions
- ☐ Potatoes
- ☐ Rape and turnip rape seeds
- ☐ Rice
- ☐ Rye and maslin
- ☐ Sorghum
- ☐ Soya
- ☐ Spelt
- ☐ Sugar beet
- ☐ Sunflower seeds
- ☐ Tomatoes
- ☐ Triticale

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- [ ] Wheat
- [ ] Other, please specify: _____
- [ ] Not applicable

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Display This Question:

If Which of the following best describes you? = Involved in agri-business or the food supply chain

Q29 Which country do you primarily work in?

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

Page Break

Display This Question:

If Which of the following best describes you? = Involved in agri-business or the food supply chain

Q30 Which of the following best describes the company or organisation you work for:

- ○ Seed breeding and supply
- ○ Fertiliser or chemical input supplier
- ○ Non-governmental organisation or advocacy
- ○ Processing or packaging
- ○ Food safety
- ○ Agricultural economics research institute
- ○ Retail or distribution
- ○ Other, please specify: _____

End of Block: Business level questions

Start of Block: Consumer level questions

Display This Question:

If Which of the following best describes you? = Consumer or consumer representative

Q31 Which of the following best describes you?

- ○ Consumer body representative
- ○ Consumer research agency representatives
- ○ Expert in consumer behaviour and choice
- ○ Individual
- ○ NGO with a focus on consumer-level concerns, such as consumer awareness campaigns
- ○ Other, please specify: _____

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Display This Question:

If Which of the following best describes you? = Consumer or consumer representative

Q32 Which country do you primarily work in?

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

Page Break

Display This Question:

If Which of the following best describes you? = Consumer or consumer representative

Q33 Which of the following best describes the company or organisation you work for?

- ○ NGO
- ○ Consumer representation group
- ○ Consumer research agency
- ○ Research institute investigating consumer behaviour and choice
- ○ Other, please specify: _____
- ○ Not applicable: I am an individual, completing this survey in my capacity as a consumer

End of Block: Consumer level questions

Start of Block: Plant Scientist questions

Display This Question:

If Which of the following best describes you? = Plant scientist

Q40 Which of the following best describes the company or organisation you work for?

- ○ University
- ○ Public research institute
- ○ Private research institute
- ○ NGO
- ○ Other, please specify: _____

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Display This Question:

If Which of the following best describes you? = Plant scientist

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Q34 Which crops do you primarily work with/on? (choose up to 5)

- ☐ Barley
- ☐ Carrots
- ☐ Grain maize and corn-cob mix
- ☐ Grapes
- ☐ Oats
- ☐ Olives
- ☐ Onions
- ☐ Potatoes
- ☐ Rape and turnip rape seeds
- ☐ Rice
- ☐ Rye and maslin
- ☐ Sorghum
- ☐ Soya
- ☐ Spelt
- ☐ Sugar beet
- ☐ Sunflower seeds
- ☐ Tomatoes
- ☐ Triticale

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- [ ] Wheat
- [ ] Other, please specify: _____
- [ ] Not applicable

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Display This Question:

If Which of the following best describes you? = Plant scientist

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Q35 Which country do you primarily work in?

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Iceland
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Montenegro

- ○ Netherlands
- ○ Norway
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Switzerland
- ○ United Kingdom
- ○ Other, please specify: _____

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Display This Question:

If Which of the following best describes you? = Plant scientist

Q77 Are you directly involved with the CropBooster-P project?

- ○ Yes
- ○ No
- ○ Other, please specify: _____

End of Block: Plant Scientist questions

Start of Block: Thank you

Q74 Any other comments?

_____

_____

_____

_____

_____

Q76 If you would like to receive information about the results of this project directly, please leave your email address below. Your input will always remain anonymous.

_____

Q75 Thank you for taking the time to complete this survey. **Please share this survey!** We are looking for as many responses and views on these issues as possible, so that we can provide useful data to the EU about priorities for future research in crop breeding. Please consider sharing this survey with colleagues, friends, and connections anywhere in Europe – a sharing link to the survey is available here, and a QR code is

below. The survey is available in English, French, and German. Thank you for your support. QR code link to the survey

Q91 Browser Meta Info

Browser
Version
Operating System
Screen Resolution
Flash Version
Java Support
User Agent

End of Block: Thank you