Exploratory Workshop

SUMMARY REPORT

Agriculture Food Security and Climate Change

FACCE-JPI & ERA-NET Cofund SusCrop

Joint Exploratory Workshop on *Application of Novel Breeding Techniques in Crops in the context of Food Security and Climate Change*

INIA, Madrid 27-28 June 2019

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1. Introduction to FACCE/SusCrop and aims of the Workshop

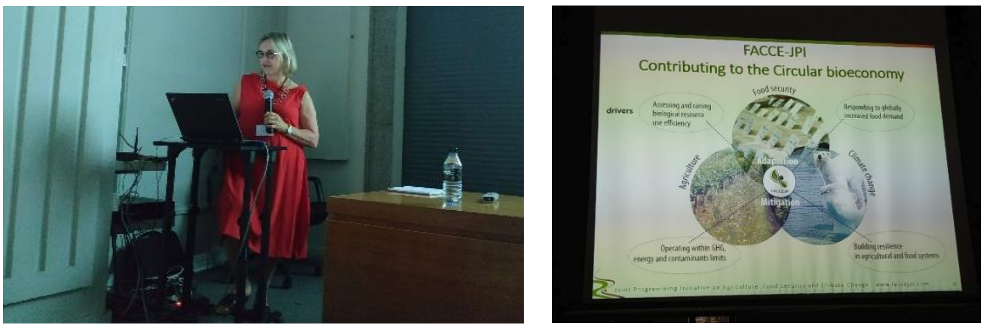
The **Joint Exploratory Workshop on Application of Novel Breeding Techniques (NBT) in Crops in the context of Food Security and Climate Change** was organized under the FACCE-JPI & ERA-NET Cofund SusCrop and hosted by INIA in Madrid in 27-28 June. The event brought together 42 experts from 16 countries representing different relevant sectors and actors.

The workshop participants were first welcomed by **Esther Esteban**, director of the Spanish National Agricultural and Food Research and Technology Institute (INIA). Afterwards, an introduction to the **Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI)** was given by **Heather McKhann**, FACCE Secretariat Coordinator. FACCE-JPI's mission concerns the promotion, integration, and alignment of national research resources under a common European Research Area (ERA) to address the diverse challenges in agriculture, food security and climate change in order to achieve sustainable and resilient food systems, provide healthy diets, contribute to an European circular economy and respect the local ecosystems and planetary boundaries. FACCE-JPI also promotes science-policy dialogues and that results can be accessed by stakeholders and society through communication and dissemination activities. Finally, FACCE-JPI also organizes conferences and workshops such as this one to update its strategic research agenda and implementation plan with relevant and concrete research needs.

The **ERA-NET Cofund on Sustainable Crop Production (SusCrop)** was introduced subsequently by its coordinator, **Christian Breuer**. The aim of SusCrop is to improve the sustainability and resilience of crop production. A first call was launched on January 17, 2018 and involves 24 funding organisations (19 countries) with national contributions amounting to about €12M and EC-cofunding of about €4M through 13 projects selected by an international expert panel. The scientific scope of the cofunded call was given by four subthemes:

- Enhancement of predictive breeding technologies and development of new genotypes leading to new phenotypes and crop varieties for improvement of plant health, protection, production and resilience
- Development and exploitation of novel integrated pest and crop management methods and practices
- Improvement of resource-use efficiency of crops and cropping systems
- Systemic research on agricultural crops as part of an ecosystem including interactions between plants and other organisms

In this context, the FACCE-JPI & ERA-NET Cofund SusCrop Joint Exploratory Workshop on Application of NBT in Crops helps to identify needs, challenges, barriers, gaps, potential and priorities for a potential SusCrop call.



An introductory presentation about FACCE-JPI was given by Heather McKhann at the beginning of the workshop

The **aim** of the exploratory workshop was to assess the **current state of the art of the novel breeding techniques in crops** conducted in the EU, to identify existing networks and their major stakeholders, and to explore **major challenges and specific opportunities** related to climate change adaptation from different perspectives. The workshop brought together **researchers, stakeholders and policy makers and outcomes of discussions are summarized in this** report comprising **concrete and actionable recommendations** for the decision-making boards of FACCE-JPI and SusCrop.
The workshop sessions included **key speakers' introductory lectures** to address the **research, stakeholders, end-users and policy perspectives** followed by **breakout sessions** focused on **gap/limitations** and **opportunities/strengths** group discussions on relevant key subtopics. The conclusion and plenary discussion were addressed to try to identify specific recommendations for FACCE-JPI future contributions and actions in this field. The event structure and session distribution can be consulted in the workshop agenda included in annex 1.

The introductory presentation for each one the sessions are summarised below.

2. Setting the Scene

Ralf Wilhelm, from the Institute for Biosafety in Plant Biotechnology from the Federal Research Centre (JKI) on Cultivated Plants in Quedlinburg (Germany) presented the prospect on **NBT and the future of plant biotechnology in Europe**. According to data collected from 1996 to mid-2018, China has the highest number of experimental studies, followed by the US and Europe. The crops that are most heavily investigated worldwide in association with NBT are rice, tomato, maize, wheat and soybean whereas in Europe barley figures first. Around 80% of the applications worldwide are basic research and only 21% of them are market-oriented which have been applied in 28 different plant species. In Europe, the predominant work is on product quality accompanied by some work on herbicide tolerance, agronomic value traits, biotic and abiotic stresses. The July 25th 2018 ruling of the Court of Justice of the European Union (CJEU) stated that all organisms created by directed mutagenesis fall under the regulation of genetically modified organisms (GMO) with the exception mutagenized plants either by the use of radiation or chemicals which are also considered GMO but are exempted from the further obligations of the GMO directive (Dir. 2001/18/EC) because they have conventionally been used and have a long safety record. The GMO directive implies that the requirements needed for approval and market release for each genome-edited plant in association with field trials may entail expenses of millions of euros. Besides, the procedures might vary depending on the member state. In contrast, in most of the American countries, plant genome editing is deregulated, there are announcements from Russia that they tend to deregulate genome editing techniques, the deregulation of the SDN1 system is under discussion in Japan since 2018 and has been deregulated in Australia in 2019. As for compliance with the law in Europe, the detection of genome editing in plants or feed is practically not feasible as there is not a typical genetic element to identify and agricultural goods are being imported in large scales including mixtures and unknown varieties. Some scientists and scientific associations such as the European Plant Science Organization (EPSO) are calling for rethinking of the ruling of the European court through position papers or open letters besides trying to organize meetings with the European Commission and policy makers of the member states to initiate a communication about the way forward as far as work could be done to identify flagship projects which are working on very interesting traits for consumers and society.

In order to have an early view of the current landscape, a preliminary mapping exercise was conducted ahead of the workshop. After setting the scene and introductory presentation, a brief **Preliminary Map & Gap Analysis Summary Results** was presented by **Pablo Gómez** from FACCE Secretariat/INIA. A brief questionnaire was distributed among participants and other networks ahead of the workshop. Key aspects raised from the questionnaire outcomes and a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for NBT in Crops in the EU in the context of Food Security and Climate Change were presented. Detailed information on the Preliminary Exploratory Exercise - Mapping and Gap analysis is available in Annex 3.

3. Research Perspective

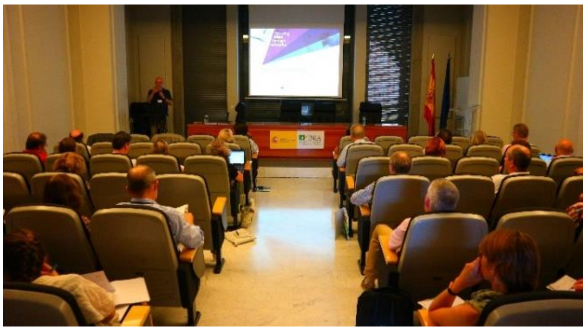
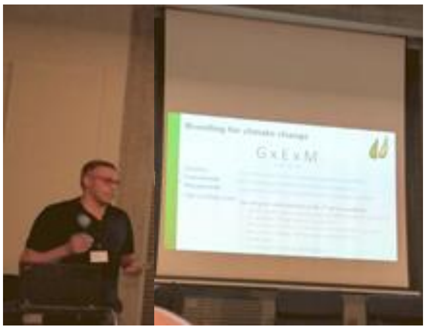
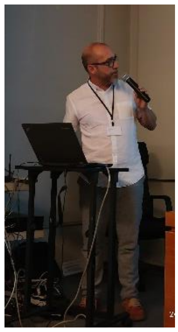
This section was initiated by **Diego Orzaez** from the Institute of Molecular and Cellular Plant Biology of the Higher Council for Scientific Research (IBMCP-CSIC) in Spain who presented some applications of new breeding techniques in crops from the Newcotiana project, a project that aims to develop multipurpose Nicotiana crops for molecular farming using new plant breeding techniques. In the frame of this project, work is being done to identify factors affecting recombinant protein quality traits and breed improved varieties of *Nicotiana benthamiana* to produce recombinant proteins in biocontainment. This project also aims to evaluate NBTs for enriching metabolite composition of *Nicotiana tabacum* and analyze the new metabolomes created and the sustainability of their integration in biorefining cascades. It was emphasized that biomanufacturing products are not far from the idea of bioeconomy and that plant biomanufacturies enable the transformation of a "bad reputation crop" into a "live saver" crop. It further provides a "way out" to farmers revitalizing tobacco areas with high added-value products more in line with the knowledge economy. There is another related project where IBMCP-CSIC is collaborating in the context of the ERA CoBioTech action which is the SUSPHIRE project. SUSPHIRE relates to the sustainable bioproduction of insect pheromones for pest control. Insect sex pheromones are successfully employed in environmentally-friendly pest control but their availability and sustainability is compromised as it is often impossible to avoid the use of toxic substances by current manufacturing systems. The SUSPHIRE project aims at bioproducing the "difficult to synthetize" pheromones by establishing methods to produce them in plants and filamentous funghi. Main conclusions of this presentation were that NBTs can "democratize" plant breeding contributing to local farming as it is a relatively easy and affordable technology accessible to small companies and laboratories with unprecedented precision and high potential for accelerated breeding; this NBTs' accelerated breeding capacity opens the way to new, high-tech, added-value crops which can also be local and can help to revitalize rural areas. Finally, the possibility to work with biofactories also opens the door to develop further NBTs such as CRISPR-Cas9 to produce high value crops and therefore, it is also a way to try to amend problems in the EU regulation.

Next, **Fabian Nogue** from the French National Institute for Agricultural Research (INRA) presented the GENIUS (Genome engineering improvement for useful plants of a sustainable agriculture) project which is an eight year (2012-2020) program involving 10 public and 4 private labs whose main objective is to provide proof of concept for improved traits useful for agriculture. The project involves 5 crops (maize, wheat, rice, rapeseed, camelina), 2 vegetables (tomato, potato), 1 tree fruit (apple), 1 forestry tree (poplar), and 1 ornamental species (rose). Besides SDN1 and SDN2 a third use of CRISPR systems was pointed out, base editing (BE), which uses enzymes that allow specific mutations of individual DNA bases without making double-stranded DNA breaks. Whereas true genome editing (SDN2) remains very challenging in plants, base editing provides a more limited but efficient alternative. Some specific examples of traits related to climate change and food security were given such as the knock out of the TFL1 gene to induce earlier flowering in apple trees (BE), the modification of the SAP9 gene in rice for tolerance to salt stress (SDN2), and the modification of eIF4E gene in tomato for resistance to the PVY virus (BE). It was observed that CRISPR-Cas9 has become a major tool in basic research and that is a good tool for gene function analysis through gene knock-out (SDN1) not only in model species but also in crops. Gene knock-in (SDN2) is coming and a breakthrough is expected but it is still very challenging whereas base editing in some case has the same purpose and it is already functional. It was concluded that CRISPR-Cas9 will have a major impact on agriculture under 4 conditions:

- There is sufficient knowledge on genes to try to find new traits.
- There is a sharp increase in SDN2 efficiency although base editing might provide solutions too.
- There is accessibility of breeding material (elite genotypes) for transformation or at least for transfection. To be able to deliver the CRISPR-Cas9 module it is still challenging for many crops.
- An adapted GMO regulation:
  - There is need for a product-based risk assessment instead of a project-based one.
  - Gene editing needs to be considered case by case. There is need of specific tools to reduce the significance of these factors.
  - Take into consideration the history of safe use of each incorporated mutation.

Afterwards, **Muath Alsheik** from GRAMINOR Ltd, Norway, talked about **Goals and technological approaches for breeding crops in Nordic countries**. Excluding Greenland, the combined area of Norway, Sweden, Denmark, Finland, Iceland and Faroe islands represents 13% of Europe with a low density population and most of the arable land concentrated in Denmark. The climate is unique comprising a short growing season with low temperatures, great variations in daylight and challenging winters. Plant varieties adapted to these northern climate conditions are essential for efficient and profitable food production. In this context, there are 9 breeding companies and 3 Nordic public institutions conducting plant breeding (the Natural Resources Institute of Finland-Luke, the Swedish University of Agricultural Sciences – SLU, the Agricultural University of Iceland – AUI) besides 8 plant breeding institutes. As of 2014, there have been 112 breeding programs in Nordic and Baltic countries involving cereal crops, forage crops, root crops, protein crops, oil crops, fruits, berries, vegetables, and energy crops although some of these are very small and subsidized. The existence of the Nordic Public Private Partnership (PPP) for pre-breeding was stressed which was started in 2010 and involves different institutions and breeding companies. Its purpose is to promote Nordic plant breeding satisfying the long-term needs of the agricultural and horticultural industries, specifically regarding adaptation to climate change, environmental policies, and demands from consumers. There is currently support to four principal research lines: apple, barley, ryegrass and phenomics. The ultimate goal is to incorporate genetic resources into the Nordic breeding programs enabling genomic and phenomic technologies. The main research and breeding programs in Graminors are in cereals such as barley, oats, rye and wheat but breeding services in forage crops, potatoes, fruits and berries are also delivered with the aim to increase its cost-efficiency and profitability. Graminors has been investing in various technologies such as molecular markers, protein analysis, tissue culture, phenomics and big data analysis/statistics to take advantage of the technology shift in plant breeding methods. For instance, in collaboration with Boreal Plant Breeding Ltd. (Finland) and Lantmännen (Sweden) it has produced an SNP array to enhance the development of better oat varieties. This SNP chip will be used by those breeding companies to accelerate variety development by using genomic and marker assisted selection. Graminors is also currently participating in the GENEinnovate project which has its base in the Norwegian animal and plant leading breeding cluster Heidner biocluster for innovations within sustainable food production. The purpose of GENEinnovate is to establish a research community with expertise in gene editing technologies for livestock, fish and plants in Norway as there is little or no experience of using editing technologies in Norwegian breeding companies. Graminors' part in the project is to use CRISPR to improve late blight resistance (*Phytophora infestans*) in Norwegian potato varieties and contribute to reducing the use of costly and environmentally harmful pesticides.

Finally, **Ralf Wilhelm** closed the session with a short introduction to the recently started Cost Action PlantEd on behalf of its coordinator, Dennis Eriksson from SLU. PlantEd is focused on **Plant Genome Editing as a technology with transformative potential**. This initiative aims to assess the innovative potential and impact of plant genome editing, identify research priorities and set out future research directions, promote the link between research and innovation in a socially responsible manner and examine the synergistic interactions with closely related fields. It was initiated in April 2019 and will last until March 2023. Therefore, it is an important activity with 234 participants involving 34 Cost Action countries, 3 near neighbor countries (Israel, Jordan and Armenia), and 4 international partner countries (United States of America, Canada, Australia and New Zealand).

On the left hand picture, Ralf Whilhelm (JKI) setting the scene about novel breeding techniques in crops in the EU. In the central picture, Muath Alsheik (Graminor) talking about goals and technological approaches for breeding crops in Nording countries. On the right hand picture, Diego Orzaez(CSIC-IBMCP) talking about Application of Novel Breeding Techniques in crops

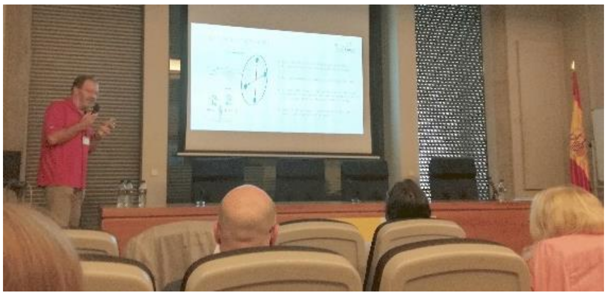
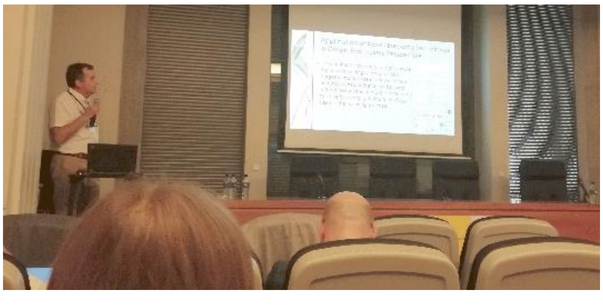
4. Stakeholders and End-Users perspectives

Marc Cornelissen from the Plants for the Future European Technology Platform/BASF-Belgium (Plant ETP/BASF) gave a presentation on the **Stakeholders' perspective**. This presentation stressed that sustainable agriculture in EU demands a multi-faceted approach and that gene editing could be one of the core technical enablers of future agriculture. However, the CJEU ruling on gene editing use does not let European farmers cultivate crops that have been subjected to gene editing. At a European scale, this affects an important change driver for the Agricultural innovation system and will cause innovation push and IP development to slow down. In 15-20 years breeding in Europe will be less competitive and this will favor importing raw materials against using local materials. At a global scale the issue is complex as well and there could be an influence on the behavior of multinationals concerning products with EU destination. Besides, there is lack of technology to set up QC platforms to handle detection, and traceability from the farmer to the retailer and this will bring logistic challenges as well. There is an enormous output capitalizing on more than 20 years of plant science but there is yet an equally impressive need for further build out for gene editing (e.g. in depth understanding of the genomic make up and of the biological processes and participating genes that affect trait performance; access to a large battery of enabling molecular, cell-biology, phenotyping and breeding technologies). However, the CJEU ruling reduces the scope to a discovery tool leaving most findings without a perspective on commercial enablement. There is need to explain collectively in Europe how gene editing fits into the breeding processes and what it means for European breeders in the short and long term. As of today, it can be observed that there is much talk about amazing promises, but farmers in Europe are totally inhibited to make use of this technology and understanding of these technologies is highly limited in the society. Therefore, there is need to do the best effort at explaining from a unanimous basis what is happening and where this technology could lead us, and find the right people. The final four take home messages given were:

- It is important to understand that the reach of the CJEU ruling goes far beyond preventing European farmers from cultivating gene edited crops.
- Damage control - minimizing the negative effect caused by an event or series of events- is as important as to find solutions.

- The potential of gene editing will grow over time and will enable entrepreneurs inside and outside Europe to innovate and market products addressing unmet societal needs internationally.
- Predictability of time-to-market is possibly more important than deregulation per se.

Next, **Ignacio Solís** from Agrovegetal-Spain, a small seed company working with 10 Spanish cooperatives, gave a presentation on the **End-Users' perspective** summarizing the perspective of farmers in Europe about NBTs and their application in Europe. It was emphasized that most farmers and cooperative members do not have specialized training that allows them to position themselves in favour or against the new technologies objectively. Their perception of novel techniques related to plant breeding depends on the vision given to them by the media, and agricultural and health authorities. The advances in plant breeding throughout the 20th century (hybridization, mutagenesis, molecular markers, etc.) were perceived as positive while their use and consumption were not regulated restrictively as something dangerous. However, the creation of transgenic varieties in the late twentieth century and the opposition shown by environmental associations, led to a rejection by an important part of the public opinion and the media that in turn "dragged" legislators to develop a regulation that makes their cultivation practically unviable. Despite this, the only genetic modification approved in Spain (Bt Maize) is used by most farmers affected by corn borer (*Ostrinia nubilalis*). Furthermore, more and more farmers perceive that the regulation of GMOs has been a mistake and that they should be authorized in a simpler way once it has been proven that they are not harmful to health or the environment. Only those who consider that the future of agriculture must be "ecological" maintain their reluctance towards GMOs. For farmers and their cooperatives, the segregation of crops according to whether they are GMOs or not is a big problem that hinders a clear positioning in favour of this technology. Given the arrival of new technologies such as Gene Editing (CRISPR-Cas9) and other similar techniques, the ideal situation would be to return to the situation prior to GMOs in which, once the use of a technology has been approved, it can be used without restrictions and without the need to classify according to the technology used in the breeding process. The farmers would also prefer the risk assessment procedures to be associated with the product and not with the ways the product is obtained. The ruling of the European Union court that considers gene editing with the same restrictions as GMOs goes against what is desirable for farmers and will mean a halt to its use in Europe to improve crops. Still, there are some people who think that giving up the use of new technologies would be an advantage for European farmers because they could set prices different from those of international markets (as is now the case with non-transgenic soy and corn) but this would cause an increase in the prices of food that would only be accepted by a small part of the population. According to Ignacio Solis' experience, the majority of farmers welcome novel breeding techniques such as targeted mutagenesis and they consider that they could be used without restrictions and without the need to classify the products according to the technology used in the breeding process. Thus, many Spanish farmer organizations would also be ready to support an open letter to the Member States on the EU Court Ruling on Mutagenesis calling for innovation-friendly rules such as that issued by over 20 EU business organizations last April 23rd.

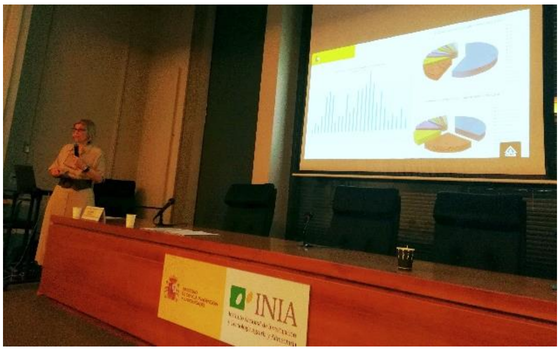
On the left hand picture, Mark Cornelissen (Plant ETP/BASF) presenting on stakeholders perspective. On the right hand picture, Ignacio Solís (Agrovegetal) talking about end-users perspective.

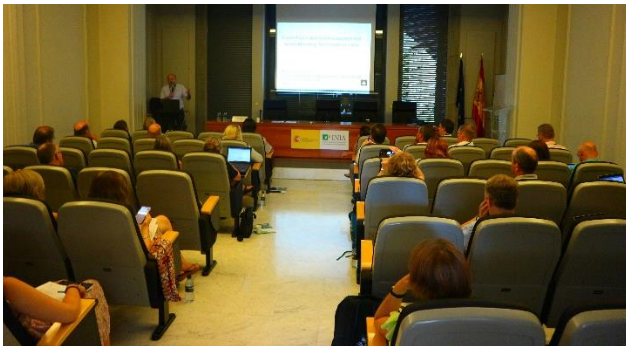
5. Policy Perspective, Networks and Initiatives

This session was initiated by **Lucía Roda**, member of the Spanish National Biosafety Commission (CNB) of the Ministry for Ecological Transition (MITECO) who first reviewed the regulatory framework on GMOs and NPBT in EU and Spain concerning authorisation, traceability, and labelling. Organisms obtained by mutagenesis are GMOs within the meaning of Directive 2001/18/EC. The mutagenesis exemption is only applicable for conventional methods used in a number of applications and with a long safety history. Therefore, organisms obtained by new mutagenesis techniques are subject to the obligations of the GMO legislation. There are still discussions between the European Commission and Member States on pending challenges such as how to ensure compliance of products on the market, and how to implement ongoing and future field trials. The European Commission has also asked the member states to provide their opinion on the ruling and its impact for each country. A preliminary assessment on the impact of the ruling of the EU court of justice has been already performed by the Spanish inter-ministerial council of GMOs. The Spanish CNB has also issued two reports stating that genome editing techniques do not pose additional safety concerns when compared to conventional mutagenesis and calling for a revision of the current GMO regulation to reflect the latest scientific and technical evidence to ensure health and environment safety. Concerning international trade, there could be a situation where identical products could be regulated in different ways which could cause possible complaints within the World Trade Organisation (WTO) from various trade partners. It was also recalled that the feed sector in EU is highly dependent on the import of raw materials, especially those which are sources of protein, such as soy and its by-products. Therefore, the impact of ceasing or reducing the imports of raw material from biotech countries could be a reduction of the amount of raw material and an increase of feed prices (previously estimated over 9% in the case of soy and derived products and 6% for maize). A questionnaire gathered from Spain's biotechnology sector represented by National Association of Bioenterprises (ASEBIO) and the National Association of Crop Breeders (ANOVE) reflected that 80% of the participants expressed their interest in research activities with genome editing technologies to develop new products and believe that the CJEU ruling will have a negative impact on their turnover and will discourage research in the EU while other countries with more favourable regulations will continue to make progress in innovation.

Afterwards, **Pere Puigdomenech**, from the Agrogenomic Research Center of the Higher Council for Scientific Research (CSIC-CRAG) in Spain talked about **Scientifically sound risk assessment of Novel Breeding Techniques in Crops**. Puigdomenech's presentation started with a historical review on the points of view and regulatory frameworks concerning genetically modified plants from 1983 until 2000 including the USA 1986 coordinated framework for regulation of biotechnology, the 90/220/EC directive, the assessments of the European commission on plants for specific genetically modified crops, and the 2000 US-EU biotechnology consultative final report. The presentation continued with studies concerning the cultivation of insect resistance (GM) maize in Spain and Portugal where no problems have been detected concerning coexistence with other maize crop varieties and where a clear economic benefit for farmers has been generated. Emphasis was placed on the change brought by Directive 2001/18 which also affected genome edited plants and where an increasingly longer risk assessment procedure has been placed which at times has taken several years unresolved (e.g. the GM Maize glufosinate herbicide tolerant Pioneer 1507 case). Even GM approved crops have been later the centre of important discussions such as Maize glyphosate tolerant nk603. Some sources of these conflicts is that there has been a lot of industrial consolidation and there has been a perception of monopoly. There is also a perception of appropriation concerning patenting and plant varieties. Finally, some NGOs have seen these products as an industrial problem. Recently, there has been several reports and statements calling for a more proportionate and scientifically sound risk assessment of gene-edited plants (e.g. EASAC 2017, EPSO 2019, Rathenau institute 2019). In the meanwhile, there are calls to further relax regulation in the US (2019 executive order on modernizing the regulatory framework for agricultural biotechnology products) which continue to pose problems when importing these new products into Europe concerning quality control and traceability as already pointed out in other presentations.

Subsequently, **Elena Rodríguez** from INIA presented the last topic of the session: **European Initiatives related to SusCrop ERA-NET and to Novel Plant breeding Technologies**. SusCrop is funding 13 projects under the 1st call and Spain is importantly involved in 6 of them. INIA is in charge of mapping past and present related European international research actions. The main objective of this task is to seek synergies with other research initiatives affecting sustainability of crop production systems. The initial approach was to compare the SusCrop call topics with ongoing ERA-NETs and research initiatives with emphasis on SusCrop call topic I 'Enhancement of predictive breeding technologies and development of new genotypes leading to new phenotypes and crop varieties for improvement of plant health, protection, production and resilience'. Among 15 ERA-NETS and 2 Thematic networks mapped, which included 28 calls and 319 projects, the followed initiatives related to SusCrop topic I were identified: EIP-AGRI (2014-19) with 13 related projects, ERA-CAPS (3rd) with 7 related projects, ARIMNET (2nd-3rd) with 4 related projects, FACCE ERA-NET PLUS with 4 related projects, C-IPM (1st-2nd) with 2 related projects, FACCE SURPLUS (1st), Euphresco II (1st-3rd) with 1 related project, and Core Organic II (1st-3rd) with 1 related project. Some details of these initiatives were given. Final remarks from these preliminary results were that European Research Initiatives in sustainable crop production have complementarities and common interests: NBT, management methods, resource-use efficiency, pest control, and climate change among others. On the other hand, each one of these initiatives has different scope and objectives due to the programmatic specifications they have to fulfil. This can produce duplications or gaps of research activities. Joining of these efforts could be a role for FACCE-JPI to play.





On the left hand picture, Lucía Roda (CNB-MITECO) talking about policy perspective of the regulatory framework on GMOs and NBTs in EU and Spain. On the right hand picture, Pere Puigdomenech (CSIC-CRAG) talking about scientifically sound risk assessment of NBTs in crops

The introductory presentations described above were followed by two working group breakout sessions and one plenary discussion. The main conclusions and key aspects raised from the practical sessions are reported in the following sections 6-8 below for each session and working group topic. Further information on the breakout session topics and structure is included in Annex 4. The summary of the discussions and the final conclusions of the workshop are presented in sections 9 and 10 respectively.

Finally, Annex I portrays the workshop's agenda, Annex II lists the workshop's participants, Annex III presents the results of a preliminary exploratory mapping and gap analysis exercise, Annex IV illustrates the working group sessions and plenary discussion structure, and Annex V lists potential instruments and tools for FACCE-JPI and ERA-NET SusCrop.

6. Plant breeding techniques, NBT genome editing and detection methods

6.1. Research gaps, needs, potential and challenges

Gene editing in non-model crops, elite lines and wild varieties

Gene editing currently makes use of transformation methods developed for classical transgenesis. Protocols are only available for some model organisms and are highly genotype-dependent. Knowledge on tissue culture and plant transformation has been disappearing from Europe because of retirement and lack of interest in transgenesis. Gene editing offers the most benefit if it can be applied directly to elite lines or alternatively in wild varieties for de novo domestication or redomestication. Supporting research on plant regeneration will also benefit non-gene editing plant research and applications such as clonal propagation and double haploid technology. Recently, it was shown for several monocot crops that expression of transcription factors (BABY BOOM, WUSCHEL) can be used to improve regeneration, overcome genotype-dependence and support plant transformation and gene editing. This forms a proof of concept that identification and development of morphogenic regulators is possible.

Research topics:

Delivery of CRISPR/Cas9 to plant cells:

- Improve Agrobacterium-based methods (eg. develop “stealth” Agrobacterium, optimized Virulence genes)
- Identify alternative bacteria (non-plant pest) for Agrobacterium
- Develop DNA-free delivery methods (especially for clonally propagated crops)

Plant regeneration:

- Protocols for non-model crops, elite and wild varieties
- Development of new regeneration technology. Identification of new regulators and/or development and implementation of Baby Boom.
- Keep or re-develop expertise in plant tissue culture and transformation

Further develop nuclease technologies

Companies are hampered by the intellectual property associated with CRISPR-Cas9. They suggest that alternative nucleases are further developed for use in plants. In this way more competition can lead to more favorable licensing agreements. Currently, most gene editing in plants take place in SDN-1, but SDN-2 and SDN-3 are more difficult and might need additional support. Base editing might form an alternative for SDN-2.

Research topics:

- Develop use of Cpf1, MAD7, etc in plants
- Identify new nucleases in order to establish an ”open platform” for gene editing
- Develop SDN-2 and SDN-3 for plants

Enable engineering of complex traits

The advantage of CRISPR-Cas9 is the possibility of multiplexing. This is also needed to control complex traits that are often needed in the context of food security and climate change (drought tolerance, water use efficiency, yield, nutrient use efficiency, etc.). In addition, multiplexing might be needed for polyploid crops and to modify gene families often expanded in plants.

To be able to tackle these complex traits, more predictive knowledge is needed. Based on available knowledge, predictive models should be constructed to predict allele combinations needed to be edited. In order to do so, databases are needed that integrate existing data of multiple crops, model systems etc.

In order to know what genes to edit and what edits to make, QTL mapping should be supported to the level of nucleotides (QTN). From earlier experience, QTNs are often associated with *cis*-regulatory variation. Plant research is behind in exploring editing of *cis*-regulatory elements and this could be supported.

Research topics:

- Develop strategies for CRISPR multiplexing
- Generate predictive knowledge (using eg. AI)
- Identify mutations underlying QTLs
- *de-novo* domestication of wild varieties as alternative for editing complex traits
- Data integration from various crops and model organisms
    - Traits and genes
    - Develop SNP databases/pan genomes
    - Study of *cis*-regulatory variation
    - Data management

6.2. Barriers and solutions

Funding has been decreased deeply for 2 years, two possible reasons:

1. Legislation of the European court of justice in July 2018 defined genome editing as transgenic techniques. Since this decision, especially small companies are no longer interested in developing breeding projects using genome editing. It is not yet clear what is the overall position of private companies regarding genome editing, and a survey should be done using the existing private networks, and platforms. What is also not clear is if the decrease of funding is affecting genome editing technology improvement or breeding programs using genome editing or both.
2. Problems of communication: most communications have been done presenting genome editing as an accomplished technique that everyone should perform in his kitchen. Communication on the topic should be done explaining the different steps for improving the techniques and applications.

Lack of exchange between communities

There is a lack of an interface which should bring together biological communities and the produced data with feedback from users of the new varieties (especially farmers). In the research community, a mix of geneticists and physiologist should be favored and the basic network between genes has to be deciphered especially for answering negative feedbacks. Relationships between geneticists and agronomists/farmers should be developed in order to record feedback on new varieties too. For that purpose, a research program should be launched with a first round of funding to produce new varieties. If the project is successful, a second funding round should be given for assessing these varieties in relation to users.

Regarding data, there is a lack of exchange between private and public sectors where the private sector is not always willing to release their data into the public domain. Besides, even if most programs make their data publicly available (a prerequisite in a lot of programs for eligibility of projects), there is still difficulty concerning their integration and aggregation due to the different ways the data are recorded following different standards which are not harmonized. Furthermore, the software for analyzing data are in general not free.

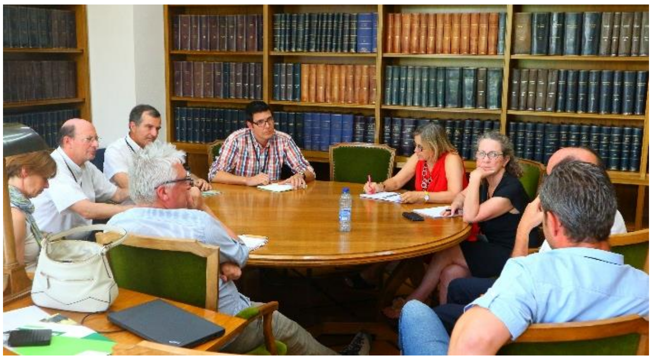
Communication

Communication to society needs discussion and specific work packages in projects with end users and other disciplines involved (like organic agriculture or agroecology) in order to promote and explain the advantages, goals, and applications of genome editing. It should also be useful to define specific labels promoting new varieties from genome editing (less pesticides, less water, improved organoleptic or nutritive quality…)

Miscellaneous

There is a lack of knowledge concerning the different networks of genes and QTL components and genetic background's influence.

A last issue that was raised is the lack of convenient indicators to compare trials between conventional and genome edited plants.



Working group session on Plant breeding techniques, NBT genome editing and detection methods.

7. Infrastructures, Facilities and Sharing expertise/knowledge

7.1 Research gaps, needs, potential and challenges

The importance of research networks was highlighted as well as the different ways to generate them.

Societal involvement

It is important to get the research out into the street, improve trust quickly and lower the barriers among different stakeholders (e.g. academia, basic science, industry, society). The importance to organize focus groups or workshops associated to gene-editing projects was emphasized. A systemic thinking approach can also be applied to define the problems, the structure of the projects and how society or end users are involved with them. There is need of better communication strategies stating clearly the economic value of the initiatives.

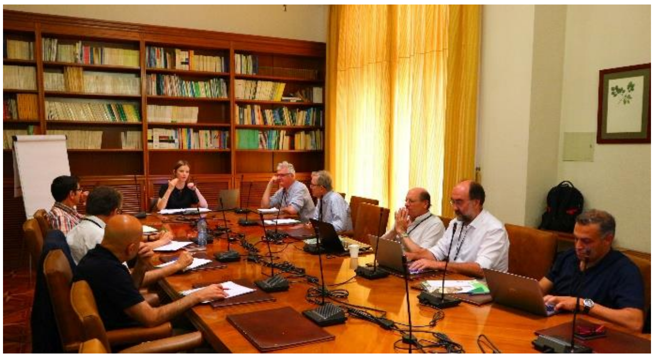
Research, Development and Innovation (R&D&I) platforms

Another point for debate and discussion was how several R&D&I platforms or facilities could be integrated or used in the context of NBT, whether they already exist, how they can be used, who can use them, the associated costs, the possible outcomes, whether companies can use the platforms, and how it could be made that these platforms relate to each other and how the people could know about them. In this sense, several platform examples were mentioned such as the EU Bioinformatics platform and how it would be needed in the NBT context. Similarly, there are already two or three existing Phenomics platforms. Some other suggestions were that of a European field network to evaluate crop performance and test gene editing, or an EU genomic transformation or gene editing platform –which could provide service for constant development of genome editing products.

There is also need for a predictive breeding workflow and linking researchers with the pre-breeders to address how gene-editing can be used in pre-breeding, which is associated to great debate –can it be used or how can it be used, the right application of it, the suitability of the different varieties to be used for exploitation-. It was acknowledged that successful use of Novel Breeding Techniques requires insights into the biological processes that ultimately determine crop performance and its response to the environment. The latest insights when captured in the appropriate format and accompanied with the appropriate tools in an open-access interface platform can offer hypothesis-based breeding starting points in a broad variety of crops. User feedback loops and new academic inputs would increase scope and predictive power of the interface platform over time. A knowledge hub could also be a good mechanism for bringing people and expertise together.

Miscellaneous

Other points addressed by this discussion were the need to perform more research for specific crops which have been subjected to less genomic development even when they are very important (e.g. potatoes, fruits, protein crops), and the need to increase the trust between industry and academia as the industry needs applicable research. There was also debate concerning detection of gene edited material and off target prediction which are also issues that need to be better explained so that gene-editing can be promoted within society.



Working group session on Infrastructures, Facilities and sharing expertise/knowledge about NBTs

8. Crop varieties, climate change and harmful organisms

8.1. Research gaps, needs, potential and challenges

This workshop session reflected on crop traits as they are necessary to cope with climate change. The first sub-group focused on traits, the second sub-group talked about social aspects picking up from the first group, and the third group talked about how to come up with a very integrative view toward agricultural management.

Traits

With focus on research and industry, there is need to develop essential traits for adaptation to climate change such as traits that facilitate nutrient/water use efficiency, energy management, as well as traits which improve pest/disease resistance and/or the reduction of pesticide/fungicide usage. Besides yield, it is also important to take into account the quality or chemical composition or nutritional value of crops which are also affected by climate change.

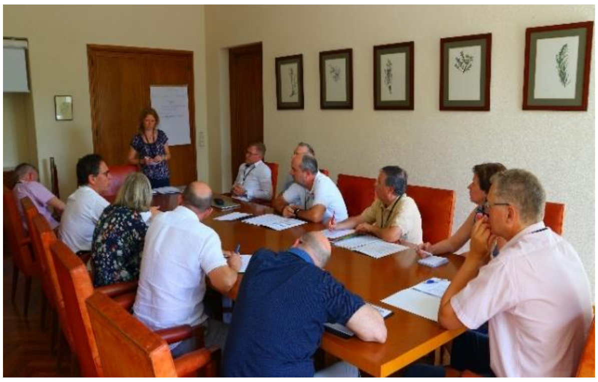
Societal aspects and communication

Considering the consumer's perspective it was assumed that the perception on new agricultural products will increase if certain benefits will be generated. For instance the reduction of allergenicity or antinutrients and the cultivation of orphan crops, which are currently less grown in the European agricultural system because of some shortcomings in the past, can provide incentives and increase the demand of a greater variety of crops. Also, climate change is more tangible in the southern part of Europe than in the northern part of Europe so that crop traits might vary in different areas. The question arose, whether the societal view on the impacts of climate change on crop traits and on responsible changes of crop traits differ in different areas of Europe and if this affects the attitude of the public view with regard to NBTs and modified crops.

It was considered important to communicate further and more intensively on agricultural research and GM applied methods within the society. Fostering the Science-Society dialogue will create trust. Socioeconomics should be included to better understand needs and fears of the society. It was emphasised that the society needs to understand that climate change will impair food security and agriculture and that sustainable agriculture is in need of applying new methodologies. There were also thoughts on using the 'system thinking approach' to identify societal needs and to use it for the further transfer of these needs to the innovative process, the agricultural systems and plant breeding. The idea, that a greater public perception of new traits and of the application of NBT in crop production can create incentives to relax the current legislation system, was seen as an advantage. However, concerns were expressed, that precipitate action might lead to the opposite effect and therefore careful and deliberate communication was seen as key to success.

Agricultural management

The final sub-group combined the previously discussed aspects to raise concerns on how we could open up the whole thinking to the levels of crop management tests or more systematic ways we could approach modification or management of agricultural systems in the future. These might not only focus on single traits but also on what could be the confirmation for different crops, different crop systems, or whole agricultural systems, and not only in the field of nutrition, but also taking into account environmental or societal benefits. For instance, the benefits from further development of plant breeding or the modification of plant traits should also incorporate an evaluation whether there are losses or drops across the value chain for the different crops subjected to NBT. Many new products are possible, but some or many of them might not be economically feasible. Therefore, there is need to have a global view about how to bring agricultural crops to the market and how different types of crops fit in for the benefit of society considering different dimensions such as nutritional or environmental value.



Working group session on crop varieties, climate change and harmful organisms

8.2. Barriers and solutions

Knowledge on susceptibility genes and other traits is not sufficient and needs to be increased. The knowledge, which exists, is often available but not always in a commonly structured way. Hence, data needs to be systematically integrated into databases using a big data network accessible to scientists. An option would be to implement projects, which focus on a small number of representative or bridging species including field trials to initiate a systematic process. Generally, there should be an open science policy which allows for sharing data, standards and databases.

Another barrier is the time period to prove safety of plants. Obviously, risk assessment is important for evidence based policy making and needs to be considered when advancing scientific results. The time lag of ensuring safety and security and the legal constraints behind it are often considered as problems for small companies. SMEs therefore might consider rather investing in 'rare' or unusual crops. Changes in legislation to allow for faster and easier approval of new traits in crops are needed, but of course they need to be in line with safety and security aspects of the society. Generally, field releases/trials need to be supported better by public funding. Transnational approaches are needed to further accelerate plant breeding.

Successful development of crops with new traits could also be improved by better communication with diverse NGOs to discuss openly the benefits of NBT in comparison with organic farming which still greatly depends on copper to control certain fungal and bacterial diseases.

Eventually, there is also need to launch public funded projects which explore the cost/benefit and societal perspective of NBT to provide support for policy makers.

9. Summary of the discussions

Taking the point of view of FACCE-JPI and SusCrop, Heather McKhann (FACCE secretariat coordinator) recalled that there is need to update the respective strategic research agendas and implementation plans, besides the additional calls of these European research initiatives. Although SusCrop is more or less already settled, there are plans for another call. So, there are possibilities to integrate feedback and interaction from researchers and stakeholders into new activities of SusCrop and FACCE-JPI. The following main points discussed at the workshop were emphasized:

1. There are very important **regulatory and policy issues** that have to be resolved. There are efforts being made, but obviously presented from a very scientific context and, right now, the use of NBT is somewhat limited.
2. Because of the limiting regulations, there is a lack of **fundamental research** with regard to NBTs but also with regard to identification and characterisation of new traits as the CJEU ruling reduces the scope of gene editing to a discovery tool leaving most findings without a perspective on commercial enablement.
3. Concerning more applied research, there is need to know which **traits** need to be addressed in the context of food security and climate change. Drought tolerance and perhaps salinity tolerance are important in this regard but further traits need to be considered equally.
4. Platforms to synthesise and organize data in a structured way are of great demand. A systematic development of a **data base** to store and analyse genomic and phenomic data of multiple plants as well as their cause of development would accelerate the progress in plant breeding.
5. **Field trials** and experimental facilities can only be implemented under limited conditions since legislation rules are complicated and due to the lack of funding of time consuming research. There is need for transnational networks and the simplification of rules between European member states.
6. There is need to facilitate a better **dialogue with the society.** The acceptance of NBTs in society needs to be improved by clearly demonstrating the benefit and potential drawbacks of new approaches and by increasing consumer's awareness and perception of new approaches
7. The interaction between researchers must be improved. A **transnational network**, which enables exchanges between researchers on data, methodologies and outputs, and which enables mobility actions and thereby fosters the building of capacities was seen as advantageous.

10. Final conclusions

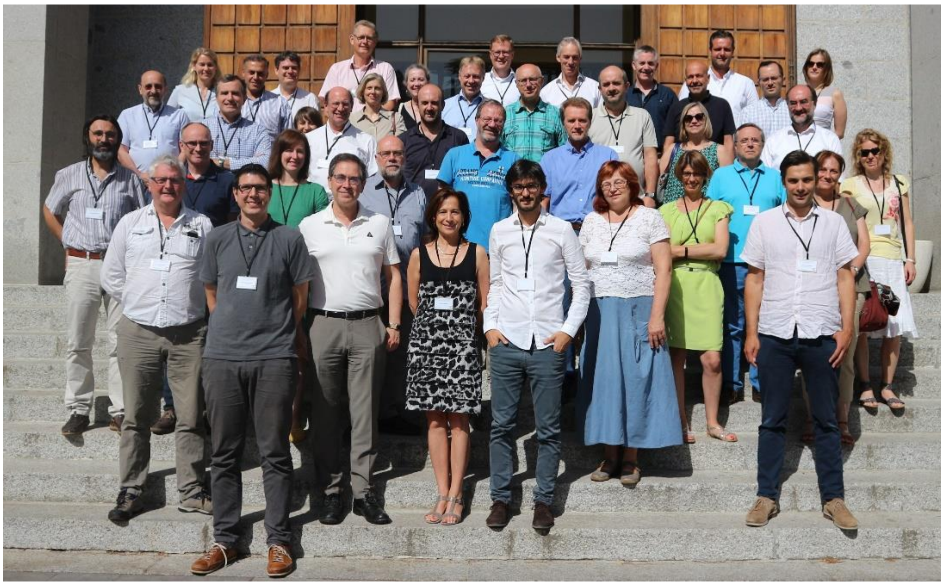
The development of new varieties with improved agronomic, environmental, industrial and quality traits is essential in the context of food security and climate change. Future calls should consider pre-breeding, new traits, post-harvest traits; insect resistance (ban on pesticides); CO_2 fixation in crops also in a context to face rural depopulation in Europe, as NBTs could also help to facilitate and attract new settlers. It was also highlighted the importance of directing efforts towards a protein-shift to achieve a diet based on a higher consumption of proteins of plant origin which could also bring less pressure on livestock production and lower GHG emissions.

It is essential to address the lack of knowledge about fundamental biological processes through greater support for basic research. It was considered that the structure of research projects should cover two phases: the development of new varieties and communication with users. Additionally, it is important to progress towards a multidisciplinary nature of the research teams including biologists, bioinformatics, breeders, agronomists etc. There is also need for field trials and a network of experimental facilities.

The efficiency of the results in the works is limited by the reduction in the financing of the projects. This, in turn, is aggravated by the current European regulation regarding genetically modified organisms (GMOs) and by inadequate media communication that does not sufficiently reflect the difficulty and the need for resources required by NBT.

The possibility of creating a shared network of services and experimental platforms was indicated. To address the deficiencies in data exchange, the need to improve the availability of public and private data through a Big Data network system was highlighted. The need for standardization of these data was also pointed out in order to facilitate their study and comparison.

Finally, the need to design a more efficient, modern and innovative communication strategy that includes, among other elements, mobility programs for a greater exchange of knowledge and experiences, focus groups for a two-way debate and exhibitions for the public and stakeholders aimed to meet users' and consumers' needs and expectations was stressed. These communication strategies should not be the first goal, but they should definitely address the needs of the users.



Workshop participants at the main building entrance of the National Institute for Agriculture and Food Research and Technology (INIA)

11. Annexes

11.1 Agenda

DAY 1 – 27 June

08:30 - 09:00		**Registration**
09:00 - 09:30	 **5'** **25'**	**INTRODUCTION** **Welcome INIA** *Esther Esteban (INIA Director)* **Welcome, introduction to FACCE/SusCrop and aims of the workshop** *Heather Mckhann (FACCE Sec. Coordinator) / Christian Breuer (SusCrop Coordinator)*
09:30 - 10:10	 **30'** **10'**	**SETTING THE SCENE** **Context. Novel Breeding Techniques in Crops in the EU** *Ralf Wilhelm (JKI)* **Preliminary Map & Gap Analysis Summary Results** *Pablo Gómez (INIA / FACCE Secretariat)*
10:10 - 10:40	**30'**	**Coffee break**
10:40 - 11:45	 **15'** **15'** **15'** **10'** **10'**	**RESEARCH PERSPECTIVE** **Application of Novel Breeding Techniques in crops** *Diego Orzaez (CSIC-IBMCP)* **Towards precise engineering of plant genomes (GENIUS Project)** *Fabien Nogue (INRA)* **Goals and technological approaches for breeding crops for Nordic countries** *Muath Alsheik (GRAMINOR)* **Genome editing in plants, a technology with transformative potential (Cost Act)** *Ralf Wilhelm (JKI)* Q&A
11:45 - 13:00	**75'**	**GROUP ACTIVITY. BREAKOUT SESSION** **Research gaps, needs, potential and challenges**
13:00 - 14:00	**60'**	**Lunch**
14:00 - 14:30	**30'**	**WRAP UP RESEARCH PERSPECTIVE SESSION** **Prioritize needs / requirements**
14:30 - 15:10	 **15'** **15'** **10'**	**STAKEHOLDERS & END USERS PERSPECTIVE** **Stakeholders Perspective** *Marc Cornelissen (Plant ETP/BASF)* **End-Users Perspective** *Ignacio Solís (Agrovegetal)* Q&A
15:10 - 15:40	**30'**	**Coffee break**
15:40 - 17:00	**80'**	**GROUP ACTIVITY. BREAKOUT SESSION** **Gaps, needs, potential and priorities**
17:00 - 17:30	**30'**	**WRAP UP STAKEHOLDERS & END USERS PERSPECTIVE SESSION** **Prioritize needs / requirements**

DAY 2 - 28 June

09:00 - 10:15	 **30'** **30'** **15'**	**POLICY PERSPECTIVE, NETWORK & INITIATIVES** **Policy Perspective** *Lucía Roda (National Biosafety Commission-MITECO/INIA)* **Scientifically sound risk assessment of Novel Breeding Techniques in Crops** *Pere Puigdomenech (CSIC-CRAG)* **Networks & initiatives** *Elena Rodriguez (INIA / SusCrop Representative)*
10:15 - 10:45	**30'**	**Sum up discussions, Plenary Results & Conclusions** *Heather Mckhann (FACCE Secretariat Coordinator)*
10:45 - 11:15	**30'**	**Coffee break**
11:15 - 12:15	**60'**	**GROUP ACTIVITY. PLENARY** **Needs, Priorities & Potential Actions**
12:15 - 13:00	**45'**	**WRAP UP** **Results & Conclusion** **Outcome: Specific recommendations for FACCE-JPI/SusCrop ERA-Net**
13:00 - 14:00	**60'**	**Lunch**

The meeting is hosted by INIA on behalf of the FACCE-JPI Secretariat

The main contact person for the workshop organization is: **Pablo Gómez G.** (pablo.gomez@inia.es)

11.2. List of Participants

Last Name	Name	Organisation	Country
Alcalde	Esteban	Syngenta	Belgium
Alsheikh	Muath	Graminor Ltd.	Norway
Arroyo	Rosa A.	INIA - CBGP	Spain
Asp	Torben	Aarhus Univ.	Denmark
Barker	Guy	Warwick Univ.	United Kingdom
Broggini	Giovanni	ETH Zurich	Switzerland
Cannell	Martin	DEFRA	United Kingdom
Cornelissen	Mark	BASF	Belgium
Crevillén	Pedro	INIA-CBGP	Spain
De Loose	Marc	ILVO	Belgium
Escudero	Jesús	INIA	Spain
Falk	Jon	Saaten Union Biotec	United Kingdom
Hippolyte	Isabelle	ANR	France
Jarillo	Jose A.	INIA-CBGP	Spain
Lansac	Rocío	INIA	Spain
Loit	Evelin	Estonian Univ.	Estonia
Millenaar	Frank	BASF	Netherlands
Morgante	Michele	Univ of Udine	Italy
Mullins	Ewen	Teagasc	Ireland
Nogue	Fabien	INRA	France
Orzaez	Diego	UPV - IBMCP	Spain
Palmgren	Michael G.	Univ. of Copenhagen	Denmark
Pauwels	Laurens	VIB-UGent Center for PSB	Belgium
Piñeiro	Manuel	INIA-CBGP	Spain
Pueyo	José J.	AEI - CSIC	Spain
Puigdomenech	Pere	CSIC / CRAG	Spain
Roda	Lucía V.	MITECO / INIA	Spain
Rodríguez	Elena	INIA	Spain
Salava	Jaroslav	Crop Research Institute	Czech Republic
Schubert	Sebastian	BMEL	Germany
Schulman	Alan	LUKE / Univ. of Helsinli	Finland
Skrabule	Ilze	AREI	Latvia
Smulders	René	WUR	Netherlands
Solís	Ignacio	Agrovegetal	Spain
Valstar	Marien	MINEZ	Netherlands
Van Laere	Katrijn	ILVO	Belgium
Vancanneyt	Guy	INIA	Spain
Wilhelm	Ralf	JKI	Germany
ORGANIZATION COMMITTEE *			
Breuer	Christian	Jülich	Germany
Gómez	Pablo	INIA	Spain
Malyska	Aleksandra	ETP Plants for the future	Belgium
Margraf	Stefanie	Jülich	Germany
McKhann	Heather	INRA	France
Metzlaff	Karin	EPPO	Belgium
INIA SUPPORT *			
Blanco	Daniel	INIA	Spain
Carrasco	Violeta	INIA	Spain
Murua	Amaya	INIA	Spain

* Acknowledgment: Thanks to the organization committee members above and Anne Marte Tronsmo for their support in the workshop preparatory work and the INIA`s team.

11.3. Preliminary Exploratory Exercise: Mapping and Gap analysis

A preliminary mapping exercise has been conducted in order to determine the current state of the art of **Novel Breeding Techniques (NBT) in Crops** in the EU and to identify gaps and barriers as well as potentials and priorities in the context of **Food Security and Climate Change.** With this purpose a **questionnaire** was distributed among participants and other networks ahead of the workshop.

Key Questions:

- What NBT is developed, improved or applied in your project/programme/action?
- What NBT do you apply in this your research project(s)
- What are the main benefits or contributions of this those breeding techniques for agriculture?
- What problem do(es) this technique(s) or project(s) address?
- Is the application of this technique limited to certain crops or applicable to a broad range of species?
- How well is your research connected to food security in the context of research on climate change?
- Which difficulties do you encounter when moving your project forward?
- What is the expected added value for European agriculture and crop production?

QUESTIONNAIRE OUTCOMES ANALYSIS

35 questionnaire answers received*. Some of them partially filled in and with different degree of detail and dedication in the answers*

General perspective

Plant breeding depends upon genetic variability within crops as a basis for developing new plant varieties with improved characteristics. Conventional breeding is resource-limited in finding the genes and alleles required to meet the agricultural challenges.

New breeding techniques (NBT) overcome many of classical breeding weaknesses. NBT are a suite of methods that could increase and accelerate the development of new traits in plant breeding. Based in plant genetic engineering, they often involve 'genome editing' which means that they modify plant genes at specific locations so that new traits and properties are produced in crop plants. Genome editing improves on conventional breeding by making intentional, specific and beneficial changes in the plant genome providing the desired traits in a faster and more directed way.

Nowadays, most of the work and efforts made in NBT aim to create new crop varieties that can contribute to food security and to adaptation to climate change.

Novel breeding techniques used or applied

Among techniques included under NBT category, CRISPR/Cas genome editing systems should be mentioned. CRISPR/Cas systems has been the last revolutionary discovering in gene editing and from the preliminary questionnaires it is the most used technique of directed mutagenesis among involved researchers, referred by the 70% (25/35) of them.

Next most referred technique is cisgenesis: around 12 % of the involved researchers are using it. Intragenesis and transgenesis are less present in the consulted researchers' daily work.

We also found many other techniques referred in the questionnaires. They are not directly involved in plant breeding but they are essential to uncover genes mutations and functions and to develop new plant varieties:

- NGS (Next Generation Sequencing)
- GWAS (Genome-wide association study)-
- ddPCR (Digital Droplet PCR)
- QTL (Quantitative trai loci) mapping by RAD-sequencing DNA
- TILLING (Targeting Induced Local Lesions in Genomes)
- MAS (Marker assisted selection)

SWOT (Strengths, Weaknesses, Opportunities y Threats) ANALYSIS

	HELPFULL	HARMFUL
INTERNAL	**STRENGTHS** Safety and efficiency Specificity, reducing unpredictable results Fast transfer of special trait into elite material Gain of time comparing to classical breeding No linkage drag No use of foreign DNA Creation of allelic diversity Applicable to a broad range of species	**WEAKNESSES** Application limited in some species Limitations in vegetatively propagated plants Insufficient understanding of some genes role Low genetic diversity available Insufficient engagement academia-breeders Insufficient communication stakeholders-farmers
EXTERNAL	**OPPORTUNITIES** Increase genes function understanding ,regulatory mech. Identify more genes useful for plant breeding Improve allelic diversity New crop varieties for food security Plan Protection Products reduction More resilient crop varieties for CC adaptation Create added value to European agriculture	**THREATS** EU GMO regulatory framework limitation for NBT Risk for EU competitiveness facing China and USA Decreasing government support, low long-term funding Low interest in breeding for agronomic/consumer traits Low consumer and social acceptance of GMO products Activism rejecting NBT

11.4. Working Group Sessions and Plenary

	Topic 1	**Topic 2**	**Topic 3**
	Plant breeding Techniques, NBT genome editing, Detection Methods	Collaborative activities, Infrastructures, Facilities, Sharing expertise/knowledge	Traits with regards to: Climate Change, Crop Varieties, Harmful organisms
Session 1 (World Café)	**Group A**	**Group B**	**Group C**
	Moderator: H. McKhann Rapporteur: L. Pauwels	Moderator: A. Małyska Rapporteur: M. Alsheikh	Moderator: S. Margraf Rapporteur: R. Wilhelm
	List respective topics, opportunities, strength, e.g safety	List respective topics, opportunities, strength	List respective topics (Which crop traits should be targeted in the context food security and climate change?), opportunities, strengths
Session 2 (World Café)	**Group A**	**Group B**	**Group C**
	Moderator: H. McKhann Rapporteur: I. Hippolyte	Moderator: A. Małyska Rapporteur: M. Alsheikh	Moderator: S. Margraf Rapporteur: R. Wilhelm
	Gaps and limitations, weaknesses and threats	Gaps and limitations, weaknesses and threats; Multi-stakeholder approach?	Gaps and limitations, weaknesses and threats; E.g. identification of traits? Access to data? Forecast?
Session 3 (Plenary)	**Plenary Discussion**		
	Moderator: Heather		
	• Can FACCE / SusCrop address challenges in terms of specific research challenges? If yes, how? • What is needed to achieve a multi-stakeholder approach? How can FACCE / SusCrop support the identified weaknesses in collaboration? • How can FACCE / Suscrop support research in i) identifying CC relevant traits, ii) gaining better access to data, ii) supporting trait relevant research?		

11.5. List of potential instruments adn tools for FACCE-JPI

Knowledge hub: A knowledge hub is a network of researchers from JPI member countries within a specific area of research. The Knowledge Hub is an instrument for alignment, in which many participants are already (nationally) funded to carry out (national) research. The instrument aims to align at operational level to support exchange of information among actors, thus creating a critical mass, avoiding duplication and adding value to existing national research through cooperation.

Knowledge network: While a Knowledge Hub is based on a combination of new and existing activities and is a restricted scientific community comprising one consortium focussed on a specific goal, a Knowledge Network is a broad expert community represented by national research and funder leads. The general objectives are to facilitate collaboration across Europe, to increase return on investment of public R&D funding, to create synergy and avoid duplication, and to enable complex research.

Calls:

- **FACCE-JPI based**
- **Joint call** with other networks and initiatives (e.g. International call with the Belmont Forum on food security and land use change)
- **ERA-NET Cofund:** Cofunded by the European Commission
- For specific calls, FACCE-JPI could put in place **policies or guidance** to maximise use/reuse of data, or to encourage working with industry/end-users where relevant

Alignment of National Programmes: An example for an alignment programme is FACCE JPI's Thematic Annual Programming (TAP) which aims to foster the alignment of National research programs, promoting the international cooperation and coordination of national research projects. Basically, research agencies agree on a common scope and select projects on this area according to their national criteria. The national funded projects will be requested to join an international cluster and coordinators of these projects have to participate in annual working meetings to exchange on approaches, methods, data and results.

Mobility actions support researchers, students or even larger groups visiting a place different from the one they belong to (foreign Institutes, other sectors) and therefore enable capacity transfer and increase the communication on bilateral or multilateral successful initiatives.

Research Infrastructures are facilities, resources and related services used by the scientific community to conduct top-level research. Research infrastructures may be 'single-sited' (a single resource at a single location), 'distributed' (a network of distributed resources), or 'virtual' (the service is provided electronically). Research infrastructures provide facilities at disposal to be used by researchers as a platform to carry out an experiment. Cost sharing conditions, reporting, data and IPR may be included.

Exploratory workshops are important tools to identify gaps and needs, to scope future actions and to discuss cooperation with relevant initiatives. **Stakeholder workshops** can be used as platform to strengthen the exchange of information but also support mutual learning particularly on methodological issues (e.g., on joint foresight, impact evaluation and stakeholder engagement).