Report and recommendations

European Plant Science Organisation
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2nd EPSO Workshop of Plant Health WG

Gene editing in plant resistance against pathogens and pests

Held 15.10.2024, Report by 20.3.2025

1. Background

The second workshop of the EPSO Plant Health working group took place on October 15, 2024, and dealt with the advances in gene editing technologies in plant resistance against pathogens and pests. The 75 participants attended online talks from nine experts in the field of plant gene editing (Table 1). The workshop was divided in two sessions, a first session devoted to the latest **technological advances** on genome editing in plants, and the second session presented success stories on how these technologies have been **applied to increase plant disease resistance**. A general discussion followed each session, with participants' questions and comments on the information presented. The workshop also included a brief update on projects funded under Horizon Europe and strategic work for future research and innovation programmes relevant to plant health by **Gisela Quaglia** from the **European Commission** (Table 1).

Table 1. Gene editing in plant resistance against pathogens and pests. Speakers at the 2nd workshop EPSO Plant Health WG

Session 1: Gene editing technologies towards plant resistance against pathogens and pests	
Jose-Antonio Daros (UPV Valencia, ES)	Virus-based tools to facilitate CRISPR-Cas genome engineering in plants
Eleni Koseoglou (WUR, NL)	Susceptibility reversed: modified plant susceptibility genes for resistance to pathogens
Frank Takken (Univ Amsterdam, NL)	CRISPR/Cas targeted gene editing goes viral
Alain Tissier (IPB Halle, DE)	Application of the Cas-Exo technology for allele replacement of disease resistance genes

Session 2: Gene editing applications in plant resistance against pathogens and pests	
Caixia Gao (Inst. Genetics and Developmental Biology, Beijing, China)	Genome-edited powdery mildew resistance in wheat without growth penalties
Ping Yang (CAAS, China)	Editing of host susceptibility factor genes increased wheat yellow mosaic virus resistance without yield penalty
Mariana Schuster (IPB Halle, DE)	Engineering of plant immune proteases for crop protection
Gisela Quaglia (European Commission, DG AGRI)	Update from the EC - Work programmes, strategy, upcoming activities
Kristina Grunden (NIB, SL)	miR160 regulates peroxidase expression in HR resistance response, and links salicylic acid, auxin, and ROS signaling pathways
Jochen Kumlehn (IPK Gatersleben, DE)	Improving barley resistance to bymoviruses by editing susceptibility genes

Regarding technological advancements, the recent report on improvement of the frequency of homologous directed repair upon Cas9 double stranded break via Cas9 fusion to 5' exonucleases was celebrated as it was shown to increase the efficiency of gene editing not only in the model plant Arabidopsis, but also in crop plants such as wheat and tomato. It was discussed that even though some technological developments like Cas9-exo might be suitable for editing of different plant species, given the diversity of crop plants, adjustments and even different strategies for genome editing will be needed for different crops. This was seconded by voices from the industrial participants who stressed the point that technologies developed for a particular species often do not work in other species. It was then highlighted that a bottleneck in genome editing is to transfer the molecular components required for the editing in the target plant. The use of viral vectors to overcome this difficulty was discussed. Virus induced gene editing (VIGE) also shortens the time required for generation of edited plants enormously and will not require the development and use of Cas-transgenic plants. Smaller, efficient Cas enzymes are needed to achieve the cargo requirement imposed by the viral vector. The scientific community is not sure on how the use of viral vectors will be perceived by breeders and the public. A further remaining challenge is the selection of edited, Cas9-free plants for vegetatively propagating crops.

Genome editing technology is at a stage where it is been used as a strategy for the generation of resistant crops. During the workshop, a report on CRISPR-edited wheat being approved in China has been presented, supporting the fact that the technology is "ready to go". This leaves the community with the challenge on how to select target genes for genome editing that would lead to durable resistance minimizing growth/yield trade-offs. Talks on modification of resistance genes, susceptibility genes, and other genes involved in immunity (***e.g.***, proteases) were presented in the workshop and the use of pathogen effectors as probes for possible editing targets was discussed. Most reports highlighted the need for basic research on the function of the genes to edit for successful editing and achieving resistance. Furthermore, it was discussed that research in each relevant crop is required. Finally, the challenge of the public appreciation of these strategies and technologies was addressed.

2. Recommendations

Main message:
Gene editing is a technology at a stage that it is being used to generate disease resistant crops.

1) ***Plant genome editing requires further improvements of the technology***
   The current technical challenges for genome editing in plants include: a) increasing editing efficiency and b) adaptability to different crop plants. Advances in the tools (*i.e*., enzymes and necessary auxiliary molecules) will significantly improve the editing efficiency in plants. Agronomically relevant crops in Europe include: wheat and barley (for cereals, monocots), potato (for dicots), tomato (for vegetables), pea (for legumes), and strawberry (for fruit crops). Research with well-established model plants such as *Arabidopsis*, rice, and *Medicago* should be further pursued. More efforts are needed for underutilised / niche plant species. Transformation remains a bottleneck for many crop species and research targeted to improvements of transformation efficiencies must be strengthened. Research is needed for both fundamental improvements of gene editing efficiency as well as adaptation to different crop species.

2) ***Efficient virus-based gene editing needs to be established for a variety of crop species***
   Several talks described successful gene editing based on the use of viral vectors. This is a highly welcome addition to gene editing based on stable transformation. Research is needed to establish such approaches for a wide range of host plants, including niche crops. Improvements are needed for a variety of aspects such as efficiency and adaption to specific crop plant species.

3) ***Plant gene targets for gene editing must be identified at larger scale***
There is a variety of genes that have been edited to increase disease resistance. These include an increasing number of susceptibility (S) genes, modified resistance (R) genes, and other components of the plant immune system. Such examples were presented during the 2nd Plant Health workshop. Allele replacement by improved versions of resistance genes is now within reach and proof-of-concept results were presented. Further research is needed to identify target genes and to make such approaches broadly applicable.

4) ***The function of target genes-for-editing must be understood in detail for successful outcomes***
The detailed elucidation of the function of plant genes, their involvement in biosynthetic pathways, and interaction with other genes is the basis for selecting genes as targets for editing. The use of reverse genetics strategies (*e.g.*, knock-out lines obtained by gene editing, RNAi approaches) greatly improves the functional knowledge on plant genes. A key advance in this direction is the development of protein structure prediction (*e.g.*, Alphafold) that supports the identification of structural mutations, leading to functional alterations of the phenotypic trait. Research on these fundamental aspects of gene function must be further strengthened.

5) ***Target susceptibility genes must be examined for growth-defence trade-offs***
The modification or elimination of susceptibility genes may result in agronomically useful resistance, but possible negative, pleiotropic effects on growth must be carefully studied to identify mutations that have as little trade-off as possible. Negative effects can be subtle and might only be detectable under specific environmental conditions. Thus, field studies in early plant multiplication steps after editing are necessary to evaluate the agronomic value of gene-edited plants.

6) ***Public appreciation of the gene editing technologies and strategies is key to succes***
EU should be at the forefront in crop gene editing worldwide, given the enormous challenges for crop production globally in the next decades. Gene editing, as a novel technology, needs to be appreciated by the public to develop its full potential for improving agriculture and its products for the benefit of the society. Therefore, ways must be identified to discuss technologies and strategies with stakeholders and the wider public. This must be done by including experts from all aspects related to gene editing and at a national level in all EU states. This step is mandatory for public appreciation in the long term. Communication activities need to be detailed, well-planned and organized, and must allow sufficient time A first step are more national consumer engagement and surveys as already performed in Norway, Sweden, Finland and Spain.

3. Next Working Group Meeting

The next WG meeting will be held **online on 21st October 2025.**

The report was written by Andreas Voloudakis, Mariana Schuster, Beat Keller, and Karin Metzlaff, including input from participants during the EPSO workshop.

Brussels, 20.3.2025

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EPSO news:	www.epsoweb.org
EPSO Working Group Plant Health:	www.epsoweb.org/working-groups/plant-health/
EPSO member institutes and universities:	www.epsoweb.org/membership/members
EPSO representatives:	www.epsoweb.org/membership/representatives

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