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Green Deal Call - public engagement platform for area 6: Farm to fork

Response on behalf of the Core Group of the COST Action PlantEd (CA18111)

Plant breeding is a cornerstone for successful implementation of the Farm to Fork (F2F) strategy. It is therefore important that the related statements in the F2F strategy are reflected in the Area 6 of the Green Deal call.

Plant breeding is a cornerstone for successful implementation of the Farm to Fork (F2F) strategy. This is reflected in several statements in the F2F strategy that was published on 20 May 2020, such as "*Sustainable food systems also rely on seed security and diversity. Farmers need to have access to a range of quality seeds for plant varieties adapted to the pressures of climate change.*" (F2F strategy, page 8). The F2F strategy also acknowledges that a systemic approach to plant breeding, enabling the use of all available technologies, is important to fulfil the potential of breeding for a sustainable agriculture and for sustainable healthy diets: "*New innovative techniques, including biotechnology and the development of bio-based products, may play a role in increasing sustainability, provided they are safe for consumers and the environment while bringing benefits for society as a whole. They can also accelerate the process of reducing dependency on pesticides.*" (F2F strategy, page 8).

We therefore encourage the European Commission to ensure that these statements of the F2F strategy are properly reflected in the dedicated Green Deal/F2F calls.

It is expressed in the topic draft for Area 6: Farm to fork that:

"*Projects shall test, pilot and demonstrate innovative systemic solutions (TRL 5-8) to one of the following five urgent and pressing food systems' challenges:*

1) Achieving climate neutral farms (on land, water and sea) by reducing GHG emissions and by increasing farm-based carbon sequestration and storage;

2) Achieving climate neutral food businesses by mitigating climate change, reducing energy use and increasing energy efficiency in processing, distribution, conservation and preparation of food;

3) Reducing the dependence on contentious pesticides and antibiotics; reducing the use and increasing the efficiency of fertilisers; reducing the losses of nutrients from fertilisers, towards zero pollution;

4) Reducing food losses and waste, while avoiding unsustainable packaging;

5) Shifting to sustainable healthy diets2, sourced from land, water and sea, and accessible to all EU citizens, including the most deprived and vulnerable groups."

There are multiple ways in which plant breeding can contribute to achieving several of these challenges, and we therefore request that the calls should be tailored accordingly. Below are listed a large number of examples for which both basic research, applied research, pre-breeding, and innovation-oriented activities are very important, in order to address many of the above-mentioned challenges.

1) Achieving climate neutral farms

Response to climate change can take place through breeding on various traits, such as tolerance to abiotic stress (including maize, rice, soy, wheat), other agronomic traits such as drought tolerance, seed dormancy, growth characteristics (among others in wheat, watermelon, cucumber, cotton, maize, rapeseed, kiwifruit, wild tomato, and rice). This depends on integration of genomic improvements of crops into circular systems which fully utilise all products including waste while providing foods and feeds. Molecular plant breeding plays an important role in this.

Technology Readiness Level 5: The native maize GOS 2 promoter, which confers a moderate level of constitutive expression, was inserted into the 5′-untranslated region of the native ARGOS 8 gene or was used to replace the native promoter of ARGOS 8. A field study showed that compared to the WT, the ARGOS 8 variants increased grain yield by five bushels per acre under flowering stress conditions and had no yield loss under well-watered conditions (*Reference: Shi J, Gao H, Wang H, Lafitte HR, Archibald RL, Yang M, Hakimi SM, Mo H, Habben JE (2017) ARGOS8 variants generated by CRISPR-Cas9 improve maize grain yield under field drought stress conditions. Plant Biotechnol J 15(2):207–216. https://doi.org/10.1111/pbi.12603*).

Technology Readiness Level 7-8: CRISPR/Cas9 system have been utilized to induce specific mutations in a thermo-sensitive gene TMS5 to develop 11 new TGMS indica rice lines within only 1 year (*Reference: Zhou, H., He, M., Li, J., Chen, L., Huang, Z., Zheng, S., et al. (2016). Development of Commercial Thermo-sensitive Genic Male Sterile Rice Accelerates Hybrid Rice Breeding Using the CRISPR/Cas9-mediated TMS5 Editing System. Sci. Rep. 6:37395. doi: 10.1038/srep37395*).

2) Reducing the dependence on pesticides

Technology Readiness Level 3-4: Knock-down TaEDR1 wheat lines were created with VIGS or RNAi and shown to have enhanced resistance to powdery mildew (*Reference: Zhang Y, Bai Y, Wu G, Zou S, Chen Y, Gao C, Tang D (2017) Simultaneous modification of three homoeologs of TaEDR1 by genome editing enhances powdery mildew resistance in wheat. Plant J 91(4):714–724. https://doi.org/10.1111/tpj.13599*).

Further examples:

- ✓ Disease resistance in plants can be achieved by either editing genome of the pathogen or genes encoding susceptibility factors (S-genes).
- ✓ Pseudomonas in tomato.
- ✓ Powdery mildew in wheat and grape.
- ✓ Downy mildew in tomatoes.
- ✓ Phytophthora (late blight) in tomato and potato.
- ✓ Botrytis in tomato and fruits.
- ✓ Megaporthe (rice blast) in rice.
- ✓ Virus diseases where insecticides used to control vectors (cucumber yellow vein virus, rice tungro virus).

3) Reducing the losses of nutrients from fertilisers

Molecular breeding to improve plant utilisation of nutrients, e.g. nitrogen utilisation in wheat.

4) Reducing food losses and waste

Technology Readiness Level 3-4: CRISPR/Cas9 editing of endogenous banana streak virus in the B genome of Musa spp. CRISPR/Cas9 system was successfully applied to edit the integrated sequence of eBSOLV in plantain cultivar Gonja Manjaya (*Reference: Tripathi, J. N. et al. (2019) CRISPR/Cas9 editing of endogenous banana streak virus in the B genome of Musa spp. overcomes a major challenge in banana breeding. Commun. Biol. 2, 46)*.

Further examples:

- ✓ Non-browning mushroom and apple.
- ✓ Resistance to Botrytis disease (see also above) for reducing post-harvest losses in other fruits e.g. strawberry, tomato.
- ✓ Control of bacterial diseases (not currently controlled with pesticides) e.g. rice bacterial blight causes crop and post harvest storage losses.
- ✓ Virus genome, targeting genes associated with virus replication, large range of RNA and some DNA viruses (e.g. gemini viruses and begemo viruses in a wide range of crops including banana, cotton, cereals, fruits, etc).

5) Shifting to sustainable healthy diets

Technology Readiness Level 3-4: Generation of high-amylose rice through CRISPR/Cas9-mediated targeted mutagenesis of starch branching enzymes. SbeII mutants showed higher proportion of long chains presented in debranched amylopectin, significantly increased AC and RS content to as higher as 25.0 and 9.8%, respectively, and thus altered fine structure and nutritional properties of starch (*Reference: Sun, Y., Jiao, G., Liu, Z., Zhang, X., Li, J., Guo, X., et al. (2017). Generation of high-amylose rice through CRISPR/Cas9-mediated targeted mutagenesis of starch branching enzymes. Front. Plant Sci. 8:298. doi: 10.3389/fpls.2017.00298*).

Technology Readiness Level 3-4: The accumulation of lycopene in tomato was promoted by knocking down some genes associated with the carotenoid metabolic pathway. Five genes were selected to be edited in genome by CRISPR/Cas9 system using Agrobacterium tumefaciens-mediated transformation. The lycopene content in tomato fruit subjected to genome editing was successfully increased to about 5.1-fold. The homozygous mutations were stably transmitted to subsequent generations (*Reference: Li X, Wang Y, Chen S, Tian H, Fu D, Zhu B, Luo Y and Zhu H (2018) Lycopene Is Enriched in Tomato Fruit by CRISPR/Cas9-Mediated Multiplex Genome Editing. Front. Plant Sci. 9:559. doi: 10.3389/fpls.2018.00559*).

Technology Readiness Level 5: Two sgRNAs to target a conserved region adjacent to the coding sequence for the 33-mer in the α-gliadin genes were designed. Twenty-one wheat mutant lines were generated, all showing strong reduction in α-gliadins. Up to 35 different genes were mutated in one of the lines of the 45 different genes identified in the wild type, while immunoreactivity was reduced by 85% (*Reference: Sánchez-León S, Gil-Humanes J, Ozuna CV, Giménez MJ, Sousa C, Voytas DF, Barro F (2018) Low-gluten, nontransgenic wheat engineered with CRISPR/Cas9. Plant Biotechnol J 16:902–910. https://doi.org/10.1111/pbi.12837*).

Further examples:

- ✓ Coffee beans without caffeine.
- ✓ Enhanced flavour in tomatoes.
- ✓ Hypo-allergenic properties of gluten in wheat (i.e. suitable for consumption by people with coeliac disease).
- ✓ Low acrylamide potatoes.
- ✓ Modified, healthier oil in soybean and maize (saturated and unsaturated fatty acids).
- ✓ Reduced arsenic content in rice.