

BDP-Position

What Nature teaches us:

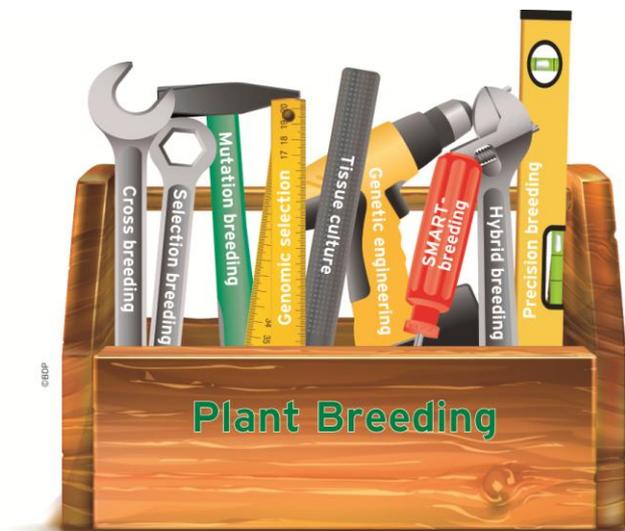
New Tools for Plant Breeding – to ensure Progress and Diversity

In the light of the rapid growth of the world population, climate change and increasing scarcity of resources as e.g. soil and water, progress in plant breeding has gained unprecedented importance. Agricultural crops are needed that produce higher yields and are more resistant against diseases, pests, heat, drought, combined with improved nutrient uptake and efficiency. All this needs to be developed as quickly and efficiently as possible, in order to enable sustainable and productive farming. This is why we cannot go without continuous progress in the tools used in plant breeding and their timely transposition into breeding practice. Gregor Mendel's discoveries – the Laws of Inheritance – marked the starting point for science based plant breeding: Scientists and plant breeders alike have been developing new tools for more efficient plant breeding ever since, and always along the same line: they discovered and studied the principles and mechanisms governing nature and thereby found ways to put them to good use in plant breeding. By and by, **a rich toolkit** has been developed from which to choose the most appropriate tool for the task at hand. The European plant breeding industry – mostly medium sized companies – as well as European plant research are playing the role of scientific pioneers in the development of such tools.¹

Plant breeders are following the current debate on the legislative classification of new breeding tools along the lines of European GMO legislation with great concern. They fear that more and more processes and products will have to undergo the same expensive and lengthy authorization procedures as genetically modified organisms – irrespective of whether foreign DNA can be found in the end product or not or whether it can at all be distinguished from a plant bred by conventional breeding methods.

The discussion refers to eight different methods which have all already found their way into breeding research and some also into breeding practice (see Annex). The European Commission has charged several scientific bodies with an assessment and evaluation of these methods. The plant breeders welcome the reports of the Expert Working Group of the EU Member States, of the European Food Safety Authority (EFSA) and of the EU Joint Research Center. These reports come to the conclusion that the current definition of a genetically modified organism does not apply to most of the new breeding tools or that they fall under the already existing exceptions from this rule, since the plants and seeds resulting from these processes do not differ from plants gained by means of conventional breeding.²

In addition the national Committee for Biological Safety (ZKBS) supports the outcome of the



¹ JRC-Report New Plant Breeding Techniques: State of the art and prospects for commercial development, 2011

² Final Report of the EU "New Techniques Working Group", 2012

Expert Working Group in its position statement issued in June 2012³. The plant breeders also support this interpretation and emphasize that it is crucial not to hamper the application of new breeding tools by subjecting them to the approval mechanisms applicable to genetically modified organisms. The European Commission is called upon to provide legal safety by issuing a guidance document on the adequate interpretation of Directive 2001/18. This guidance should confirm that most of the breeding tools under discussion do not fall under Directive 2001/18, as has been stated in the extant expert opinions.

Without legal binding guidance und clarifications with respect to the regulation of the new breeding tools

- the enormous costs and efforts involved in an authorization procedure will prevent plant breeding companies from using this technique, in particular small and medium-sized, i.e. the majority of all breeding companies and thus jeopardize their competitiveness.
- an incalculable legal framework will result, giving rise to a continued and increased exodus of companies, know-how and innovation to non-European countries.
- the number of innovative plant breeders in Europe are bound to decrease significantly, and in their wake competition and diversity of plant varieties, resulting in rapidly increasing market concentration.
- the portfolio of products developed in and for the Common Market would be severely curtailed, meaning less choice in products specifically targeted to the needs of farmers, processing industries and end consumers.

If the EU were to regulate new breeding tools along the lines of the GMO legislation, this would have no effect on the use of these techniques outside the Common Market. Products produced in third countries by means of these innovative tools and without the impediment of lengthy approval procedures will still be present in the Common Market – and ever more so, due to their competitive edge. They will be indistinguishable from products bred with conventional tools.

The German Plant Breeders' Association calls upon politics to take the stance of a high-performing, innovative and diversified plant breeding industry and to speak out in favour of a reasonable attitude towards new breeding tools, both in European politics and in the public debate. In this way, they could within the existing legal framework quickly create a basis for legal safety in the application of these techniques.

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Contact:

German Plant Breeders' Association (BDP)

Dr. Petra Jorasch

Kaufmannstr. 71-73

53115 Bonn, GERMANY

Phone: +49 (0)228 98581-64

Fax: +49 (0)228 98581-19

E-mail: petra.jorasch@bdp-online.de

www.bdp-online.de

³ Position statement of the ZKBS on new plant breeding techniques

http://www.bvl.bund.de/SharedDocs/Downloads/06_Gentechnik/ZKBS/02_Allgemeine_Stellungnahmen_englisch/05_plants/zkbs_plants_new_plant_breeding_techniques.pdf?__blob=publicationFile&v=2

Annex:

In the following, you will find an overview on new breeding techniques discussed by various institutions on EU level, plus some other new techniques developed in recent years. All these tools serve to improve already existing techniques. They enable a more targeted and precise plant breeding and help to increase plant diversity and to make better use of it. The breeding tools use natural mechanisms and principles, e. g. enzymes that exist in nature or the repair mechanisms of the cell itself.

1) Genome Editing techniques:

The following four techniques can be collectively addressed as “Genome Editing”. These techniques allow for the first time to imitate the process that is the basis of evolution, that is the natural process that has been going on since the advent of life in a very undirected and aleatoric way, but now in a targeted way: creating mutations in the genome that change the functioning of a gene or silence it, thereby creating new properties in organisms. When using these targeted tools to induce mutations, specific new and advantageous properties (and only these) can be generated and used.

- a) Oligonucleotide directed mutagenesis (ODM): This method changes single DNA nucleotides. This corresponds to what happens in natural mutations, and the plants bred with this technique do not differ from those resulting from natural mutation. The advantage of such methods designed in analogy to nature over natural mutations or mutagenesis induced by radiation or chemical means is that mutations caused by means of ODM can be targeted to specific parts of the DNA. A short sequence of nucleic acids (“oligonucleotide”) is provided to the cells own repair system as a template. No foreign DNA is introduced.
- b) Zinc-Finger 1/2 (ZFN 1/2): So-called zinc-finger enzymes are used to change single DNA elements – similar to what happens in natural mutation. The difference to natural mutations or mutations induced by radiation or chemical agents is that mutations caused by this Zinc-Finger 1/2 method, a process analogous to nature, is that it can be targeted to specific parts of the DNA. Plants produced in this way do not differ from plants resulting from natural mutation or mutation induced by other means. No foreign DNA is introduced.
- c) TALEN (“Transcription activator-like effector nuclease”): TALEN proteins are derived from natural DNA-cutting enzymes (so-called restriction enzymes). They are used to change single DNA components, as happens in natural mutations. In contrast to natural mutation or mutagenesis (mutations induced by radiation or certain chemicals, for example), this homologue of a natural technique allows to create a mutation directly at specific parts of the DNA. The plants do not differ from mutations that have occurred naturally or have been induced. No foreign DNA is introduced.
- d) CRISPR/Cas (“Clustered regularly interspaced short palindromic repeats”) is derived from an adaptive anti-viral defense mechanism of bacterial, i. e. from the bacterial immune system. In bacteria, it ensures that exogeneous genetic material, e. g. that of viruses, is removed. But it is not only in bacteria that the CRISPR/Cas system is useful. The system finds exactly certain sequences in the genetic code and cuts the DNA at this precise place. Very often errors occur when these cuts are being repaired, resulting in mutations, i.e. single DNA base pairs are being exchanged or lost in the DNA sequence. In contrast to natural mutation or mutagenesis (mutations induced by radiation or certain chemicals, for example), this homologue of a natural technique allows to create a mutation directly at specific parts of the DNA. The plants do not differ from mutations that have occurred naturally or have been induced. No DNA from other species is introduced. When compared to the techniques under sections a) – c), this technique is supposed to be quicker, more precise and cheaper, since it needs less components and is capable of recognizing longer DNA target sequences.

- 2) **RNA-induced methylation or RNA-induced epigenetic mutation (RdDM)**: By means of an RNAi construct, methyl groups are built into the DNA. This process is analogous to natural processes and copies naturally occurring epigenetic changes (methylation of DNA). The DNA sequence (the base strand) itself will not be changed. The methyl groups will ensure that the respective genes will be deactivated for several generations. The RNAi construct will not remain permanently in the plants. It will not be present any more in the end product (the plants to be placed on the market). The methyl groups induced by this method are no different to naturally occurring methyl groups.
- 3) **Cisgenesis (strict sense)**: The only DNA sequences built into the genome are those of the same species or of a closely related species. This means that the same result could be achieved by means of conventional crossing of two plants. The advantage of the targeted transfer by means of cisgenesis is that the process is much quicker and the fact that only the desired DNA sequence will be transmitted, while conventional crossing will always transfer a multitude of DNA sequences which need to be eliminated in a lengthy back-crossing process – and usually cannot be completely removed. Plants which have been developed with the help of cisgenesis can only be identified when the respective DNA sequence data have been provided. The resulting plants are comparable to self-cloned micro-organisms which are exempted from the regulations of Directive 2009/41/EC (Annex II Part A (4)). EFSA considers cisgenetics as safe, in the same degree as conventional plant breeding. This means that no specific guidance is needed for the safety assessment of cisgenetic plants.⁴ There is no scientific reason to assess plants differently than micro-organisms and to put them under the scope of the GMO legislation. In the event of a possible revision of the GMO legislation, cisgenetic plants therefore should also be exempted from the scope of the GMO Directive
- 4) **Methods of targeted gene recombination (homological recombination)**

Zinc Finger 3, TALEN, CRISPR/Cas: Besides inducing mutations (see Section 1), these methods can also be used to exchange entire genes. For this, however, the genes to be exchanged need to be inserted into the cell first. These genes can be from the same species or – as in classical transgenic plants – from another species. Whenever same-species genes are used, these techniques are comparable to cisgenesis (see Section 3). Whenever genes from other species that cannot be crossed with the target species are used, the resulting organism is a genetically modified organism in the sense of the Directive 2001/18 currently in force.
- 5) **Grafting on a GMO rootstock**: For some species, grafting is used (e.g. many trees and shrubs, grape or tomato). This protects these plants e.g. against diseases. The scion itself is not resistant against these diseases, but the rootstock is. There are transgenic rootstocks that provide other resistance properties than are available naturally. When grafting a scion on such a transgenic rootstock, the resulting chimeric plant is considered as genetically modified in the sense of 2001/18. However, the fruit and seeds produced by the scion do not contain foreign DNA and are not genetically different to the non-transgenic scions which have initially been grafted on the rootstock.
- 6) **Reverse Breeding**: This method can accelerate the development of parent lines of a desired hybrid. The hybrid in question will be modified by means of a DNA construct that suppresses the mixing (recombination) of genes in the offspring. This offspring is selected for those which do not have the DNA construct and feature a genetics that is identical to that of the original hybrid. In this way, the hybrid can be reproduced. The produced hybrids hold no foreign DNA. They are genetically identical with the original hybrid and cannot be distinguished from it.

⁴ Scientific Opinion addressing the safety assessment of plants developed through cisgenesis and intragenesis, EFSA Journal 2012; 10(2): 2561

- 7) **Agroinfiltration:** This method is used to speed up the selection of plants with desired traits in a breeding process. For this purpose, vegetative tissue (e. g. a part of the foliage) will be treated with agro-bacteria which transfer DNA. The transferred DNA will be expressed in the treated tissue. After this, the reaction of the plants to the inserted DNA and/or the protein produced with this inserted DNA (e. g. a protein to trigger a resistance reactions against pests) is tested. If the tissue of the plant shows the desired effect (i. e. the plant shows no symptoms of the disease that should have been triggered by the proteins produced by the DNA) the plant will be used for further crossing. There is no foreign DNA in the flowers and seeds of this plant and it cannot be distinguished from plants which have not been treated.

- 8) **Synthetic Genomics:** Synthetic genomics are a sub-discipline of synthetic biology that may also include techniques of genetic modification. It comprises the synthesis of DNA fragments and their combination into functional larger synthetic DNA molecules which can then be inserted into an organism. The synthesis of molecules can be used to imitate genetic components found in nature or to generate completely new ones. Depending on how synthetic genomics are being used, it can result in a genetically modified organism.