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FUTURE FOOD

Policy brief

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GENETIC SCISSORS – a powerful tool to reach sustainability goals

Genetic scissors are biological tools that researchers use to make precise changes in the genomes of organisms. With genetic scissors, plant breeders can develop crops with traits that are more environmentally friendly and better adapted to a changing climate, much faster compared to using conventional plant breeding. The tool could contribute to more sustainable agriculture, and help us reach the goals of the European Green Deal and the Farm to Fork Strategy. For this to happen, the EU legislation needs to be revised.

Future crops, which for example contain more nutrients, can be grown with less impact on the environment or are adapted to different climates, are pieces of the puzzle for achieving the goals set out in the European Green Deal, the EU food strategy Farm to Fork and the UN's Sustainable Development Goals (1).

In plant breeding, genetic variation is needed to develop crop varieties with desirable traits. Genetic variation originates from mutations that occur spontaneously and randomly in the DNA of all organisms. It is also a prerequisite for evolution and biodiversity. Since the 1930s, random mutations in plant breeding have been induced, first with ionizing radiation and later also with chemical substances. According to the EU definition, plants produced using these classic mutation techniques are counted as genetically modified organisms (GMOs), but are exempt from the EU GMO legislation.

We need crop varieties that can be grown in a changing climate, give higher yields on less agricultural land, and are resistant to various plant diseases.

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RECOMMENDATIONS

1. **Allow gene-edited crops in the EU**
   Gene-edited crops developed using genetic scissors should be exempted from the GMO legislation, in the same way as organisms developed using other mutagenesis techniques.

2. **Focus on the traits of crops**
   When policymakers decide which crops farmers in the EU should be allowed to grow in their fields, the traits of the crops need to be in focus in the assessment, not which technique the plant breeder used to develop the traits.

3. **Weigh risks against benefits in the assessment of crops**
   When crops are assessed for approval on the European market, the valuation should be based on both the plant varieties' risks and benefits.

Making targeted mutations (precise changes) in the genome using genetic scissors is called gene editing (or genome editing). Examples of genetic scissors are TALEN and CRISPR/Cas9. Genetic scissors allow plant breeders to control precisely where the changes take place in the genome, and thus on what properties the mutations will act. In contrast, when generating random mutations, the plant breeder needs to screen for the desired mutations and use outcrossing to avoid the unwanted ones. This process is both expensive and time-consuming. At the molecular level, there is no difference between mutations that occurs naturally, are randomly induced, or are created using genetic scissors.

In July 2018, the European Court of Justice ruled that gene-edited crops should fall under the EU GMO legislation. This judgement prevents the commercial cultivation of gene-edited crops in the EU. The European Commission has thus, studied the consequences of the verdict and initiated a process to revise GMO legislation. The study concludes that the legislation needs to be adapted to scientific and technological progress (2). The purpose of a revised legal framework is to pave the way for innovation in the agri-food system and contribute to the goals of the European Green Deal and the Farm to Fork Strategy, and to maintain a high level of protection for human and animal health and the environment.

In 2022, the Commission will gather views on a new legal framework covering gene editing plants. The process may lead to a new legislative proposal in the spring of 2023.

Examples of crops that researchers develop using genetic scissors are potatoes with better starch quality, tomatoes with higher levels of healthy substances, and maize, rice and other crops with improved drought-tolerance (3). Crops giving higher yields (requiring less land for cultivation) and disease-resistant plants that reduce pesticide usage are other examples (4, 5).

1. Allow gene edited crops in the EU

Ever since July 2018, when the European Court of Justice ruled that gene-edited crops should fall under the EU GMO legislation, researchers in, for example, the areas of law, ethics, and biology have pointed out the negative effects of the verdict (6). As a result the Scientific Council of the European Commission has called for a revision of the legislation.

Gene-edited crops does not harbor any foreign DNA and should therefore not be regulated as GMOs. The directive stating that mutagenesis (induced mutations) under certain conditions are exempted from regulation, was formulated in the 1980s. It should, in a similar manner, be legally possible to exempt additional mutation techniques from this regulation.

In addition, gene-edited crops cannot be approved because the legislation requires that a genetic modification can be detected. In the EU, foods produced from GM crops must be labeled. Also, according to the rules there must be a DNA-based method that authorities can use to detect and trace the genetic modification. However, it is impossible to determine if a mutation in a plant is caused by radiation, chemicals, spontaneously or by using genetic scissors. Therefore, the analytical requirement cannot be fulfilled for products from gene-edited crops. As a result, companies can not apply for market approval for these crops in the EU, and the supervisory authorities cannot do their job.

A new regulatory framework in the EU could allow new varieties of crops, developed with genetic scissors, to come to use. However, the legislation hinders practical use of ideas and findings among regional small plant breeding companies and researchers in the EU.

2. Focus on the traits of crops

From a biosafety point of view, it is the traits of the crops that matter. The traits of the crop varieties are important for their agricultural performance and how affordable, healthy and tasty they are. The technology – if a mutation occurs with the help of gene scissors or not – should actually only need to be important for the plant breeder.

When deciding which crops farmers in the EU should be allowed to grow in their fields, it should be the traits of the crops that are subject to risk

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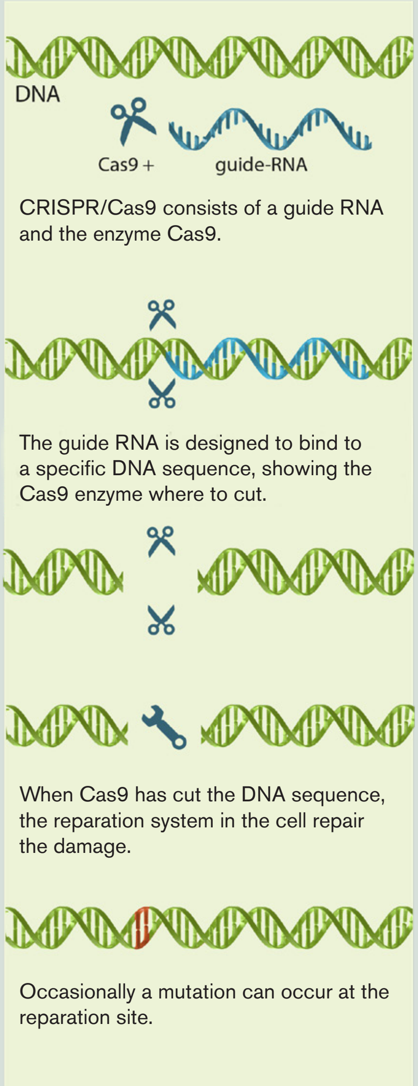
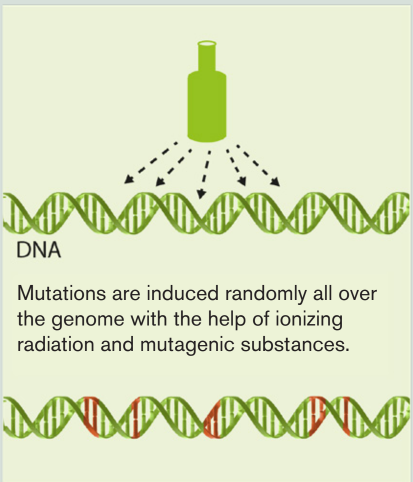
To achieve the global sustainability goals for agriculture and food supply, we need to accelerate the development of new varieties of crops. Genetic scissors open up many new solutions in plant breeding.

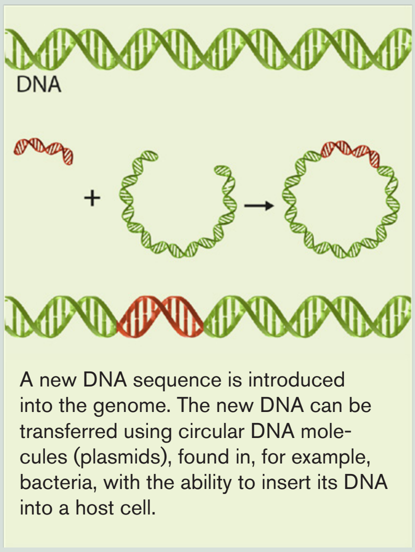
Gene editing



Traditional mutation breeding



Classical genetic modification



Illustrations: Gunilla Elam

Plant breeding techniques

Gene editing, traditional mutation breeding and classical genetic modification are three plant breeding techniques for developing crops with new traits. Unlike classical genetic modification, crops produced by gene editing do not harbour any new DNA sequence in their genomes. Instead, gene-editing creates mutations in specific DNA sequences. Traditional mutation breeding creates mutations randomly in different DNA sequences.

Nobel Prize-winning genetic scissors

Examples of genetic scissors are TALEN and CRISP/Cas9. The latter was discovered by the French researcher Emmanuelle Charpentier and the American researcher Jennifer Doudna. The two received the Nobel Prize in Chemistry 2020 for their research.

assessment. What technology the plant breeder has used to develop a crop is not a relevant criterion for assessing the crop's safety for health and the environment.

3. Weigh both risks and benefits in the assessment of crops

When GM crops undergo assessment for market approval in the EU, it would be appropriate if the risks were assessed against the benefits of the crop variety. Today, the assessment is all about risks without regard to the benefits of the crop.

An advantage of genetic scissors is that we can use them to adapt our crops according to the European Green Deal (for a climate-neutral Europe) and the Farm to Fork Strategy (for a fair, healthy and environmentally friendly food system). Access to genetic scissors in plant breeding can also increase the competitiveness of European agriculture and make us less dependent on imported foods and animal feed.

An analysis of the long-term risks associated with not approving gene-edited crops is missing in the GMO approval process. However, we also expose ourselves to a risk (to the environment and the food supply) when we prevent innovation in plant breeding.

The CRISPR/Cas9 genetic scissors are relatively new molecular tools. EFSA has concluded that targeted mutations do not constitute any further risks, compared with conventional plant breeding methods. Genetic scissors rather entail lower risks of unintended mutations occurring compared to the random mutation methods (7).

Gene-edited crop varieties should be tested for market approval and cultivation in the same system as other new plant varieties. According to a proposal from the European Commission, the valuation of gene-edited crops should include the sustainability aspect. However, if the sustainability criterion becomes a requirement, it should apply to all new varieties regardless of plant breeding technology.

The approval of gene edited crops is urgent

Countries outside the EU regulate genetic scissors in different ways. For example, Kenya has recently exempted gene-edited crops from its GMO legislation. Others which have already followed the same path are Nigeria, India, China, USA, Argentina, Brazil, Chile, Colombia and Australia. After leaving the EU, England has revised its GMO legislation and started paving the way for gene-edited crops.

Consumers want environmentally friendly, locally grown food products at a reasonable price. Techniques used in plant breeding are not something that the general public thinks about daily, when making choices in the grocery store. When researchers and organizations have asked people about their attitudes to the genetic scissors (after giving the survey participants an introductory text about gene-editing) it was shown that it matters a great deal to consumers who use the technology and for what. Many participants could consider buying foods that contain gene-edited crops if they are healthier and more environmentally friendly than other crops (8, 9).

To achieve the global sustainability goals within agriculture and food security, we must accelerate the development of new varieties of crops. We need crops that can be grown in a changing climate, which give higher yields and can resist the attack of harmful organisms without using large amounts of chemicals. The genetic scissors open up many new solutions for plant breeding (10). European politicians need to recognize the importance of using Crispr/Cas9 genetic scissors for the benefit of the environment, consumers and farmers, and for helping to reduce Europe's dependence on imported foods and animal feeds.

References

1. Harbinson, J., Parry, M.A., Davies, J., Rolland, N., Loreto, F., Wilhelm, R., ... & Klein Lankhorst, R. (2021). Designing the crops for the future; the cropbooster program. Biology, 10(7), 690.
2. The European Commission report on new genomic techniques (2021) "Study on the status of new genomic techniques under Union law and in light of the Court of Justice ruling in Case C-528/16".
3. Sami, A., Xue, Z., Tazein, S., Arshad, A., He Zhu, Z., Ping Chen, Y., ... & Jin Zhou, K. (2021). CRISPR–Cas9-based genetic engineering for crop improvement under drought stress. Bioengineered, 12(1), 5814-5829.
4. Karavolias, N. G., Horner, W., Abugu, M. N., & Evanega, S. N. (2021). Application of gene editing for climate change in agriculture. Frontiers in Sustainable Food Systems, 296.
5. Zaidi, S. S. E.A., Mahas, A., Vanderschuren, H., & Mahfouz, M. M. (2020). Engineering crops of the future: CRISPR approaches to develop climate-resilient and disease-resistant plants. Genome biology, 21(1), 1-19.
6. Eriksson, D., Custers, R., Björnberg, K. E., Hansson, S. O., Purnhagen, K., Qaim, M., ... & Visser, R. G. (2020). Options to reform the European Union legislation on GMOs: Scope and definitions. Trends in Biotechnology, 38(3), 231-234.
7. EFSA GMO Panel (2020). Applicability of the EFSA Opinion on site-directed nucleases type 3 for the safety assessment of plants developed using site-directed nucleases type 1 and 2 and oligonucleotide-directed mutagenesis. EFSA J. 2020, 18, 06299.
8. Report from the Swedish Gene Technology Advisory Board, the analysis company Novus and the Department of Plant Biology at the Swedish University of Agricultural Sciences (2021): Svenskars inställning till genomredigering inom växtförädling.
9. Report from the Norwegian Biotechnology Advisory Board (2020): Norwegian consumers' attitudes toward gene editing in Norwegian agriculture and aquaculture.
10. Gao, C. (2021). Genome engineering for crop improvement and future agriculture. Cell, 184(6), 1621-1635.

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