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Stakeholder questionnaire on new genomic techniques to contribute to a Commission study requested by the Council

Fields marked with * are mandatory.

Questionnaire on new genomic techniques to contribute to the study requested by the Council

Discussed and finalised in the Ad-hoc Stakeholder meeting on 10 February 2020

Background

The Council has requested [1] the Commission to submit, by 30 April 2021, "a study in light of the Court of Justice's judgment in Case C-528/16 regarding the status of novel genomic techniques under Union law" (*i.e.* Directive 2001/18/EC, Regulation (EC) 1829/2003, Regulation (EC) 1830/2003 and Directive 2009/41/EC).

To respond to this Council's request, the Commission is collecting contributions from the stakeholders through the questionnaire below. The study covers all new genomic techniques that have been developed after 2001.

Instructions

For the purpose of the study, the following definition for new genomic techniques (NGTs) is used: techniques that are capable of altering the genetic material of an organism and which have emerged or have been developed since 2001 [2].

Unless specified otherwise, the term "NGT-products" used in the questionnaire covers plants, animals, micro-organisms and derived food and feed products obtained by NGTs for agri-food, medicinal and industrial applications and for research.

Please substantiate your replies with explanations, data and source of information as well as with practical examples, whenever possible. If a reply to a specific question only applies to specific NGTs/organisms, please indicate this in the reply.

Please indicate which information should be treated as confidential in order to protect the commercial interests of a natural or legal person. Personal data, if any, will be protected pursuant to Regulation (EU) 2018/1725 [3].

[1] Council Decision (EU) 2019/1904, OJ L 293 14.11.2019, p. 103-104, https://eur-lex.europa.eu/eli/dec/2019/1904/oj
[2] Examples of techniques include: 1) Genome editing techniques such as CRISPR, TALEN, Zinc-finger nucleases, mega nucleases techniques, prime editing etc. These techniques can lead to mutagenesis and some of them also to cisgenesis, intragenesis or transgenesis. 2) Mutagenesis techniques such as oligonucleotide directed mutagenesis (ODM). 3) Epigenetic techniques such RdDM. Conversely, techniques already in use prior to 2001, such as Agrobacterium mediated techniques or gene gun, are not considered NGTs.
[3] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC, OJ L 295, 21.11.2018, p. 39–98

Guidelines

Please note that the survey accepts a maximum of 5000 characters (with spaces) per reply field. You might be able to type more than 5000 characters, but then the text will not be accepted when you submit the questionnaire. You will also receive a warning message in red colour below the affected field.

You have the option to upload supporting documentation in the end of each section. You can upload multiple files, up to the size of 1 MB. However, note that any uploaded document cannot substitute your replies, which must still be given in a complete manner within the reply fields allocated for each question.

You can share the link from the invitation email with another colleague if you want to split the filling-out process or contribute from different locations; however, remember that all contributions feed into the same single questionnaire.

You can save the draft questionnaire and edit it before the final submission.

You can find additional information and help here: https://ec.europa.eu/eusurvey/home/helpparticipants

Participants have until 15 May 2020 (close of business) to submit the questionnaire via EUsurvey.

QUESTIONNAIRE

Please provide the full name and acronym of the EU-level association that you are representing, as well as your Transparency Registry number (if you are registered)

If the name of the association is not in English, please provide an English translation in a parenthesis

The Committee of Professional Agricultural Organisations of the European Union, called "Copa", Transparency Registry Number 44856881231-49

Please mention the sectors of activity/fields of interest of your association

Copa is the representative organisation of agricultural producers from the Member States of the EU. Copa and Cogeca jointly defend a common position on new breeding techniques.Cogeca is the representative organisation of agricultural cooperatives in the Member States of the European Union.

If applicable, please indicate which member associations (national or EU-level), or individual companies /other entities have contributed to this questionnaire

If applicable, indicate if all the replies refer to a specific technique or a specific organism

All the replies refer to the agri-food sector, primarily and mainly to seed varieties obtained by New Breeding Techniques obtained after 2001. Like Cogeca, Copa defines New Breeding Techniques as man-made breeding techniques discovered after 2001. We know that New Breeding Techniques (NBTs) or New Genomic Techniques (NGTs) as defined for the purpose of this study can be used to insert genetic material from sexually non-compatible species into a plant genome (i.e. develop classical transgenic GMOs) as well as to induce targeted and small changes within the organism's genome (mutations). Unless stated differently, answers we provide focus on plants developed by the later application of NBTs which lead to plants that could also have been the result of earlier breeding methods, or might have been obtained from natural processes without human intervention. Plants obtained by these New Breeding Techniques cannot be distinguished from plants obtained by mutations that occur spontaneously in nature or that can be obtained through the following techniques listed in Annex I.B of Directive 2001/18: mutagenesis, cell fusion (including protoplast fusion) of plant cells of organisms that can exchange genetic material through traditional breeding methods.

A - Implementation and enforcement of the GMO legislation with regard to new genomic techniques (NGTs)

* **1. Are your members developing, using, or planning to use NGTs/NGT-products?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please provide details

Yes. European farmers are not using products obtained by NBTs because they are not available on the European market at the moment. However, European farmers have the intention to use primarily and mainly seed varieties obtained by NBTs if new seed varieties are tested according to the European registration, certification and inspection rules. Such new seed varieties must provide certain advantages, including those related to climate change, higher yields, disease tolerance, specific industrial uses and be accepted by the buyers (consumers or agro-food chain), meaning that the contractual buying conditions do not exclude the use of seed varieties obtained by NBTs.
European farmers aren't experts on NBTs, but they know what their needs are. Due to the reduction in plant protection products (PPPs), European farmers need new seed varieties and plant propagating materials that
o are better adapted to climate change, draught or excessive rainfall, greater intra-day temperature variations, fungi and insect resistance. Although PPPs have helped to resolve many problems, resistance to PPPs has increased, which is highly problematic. Moreover, European farmers want to become less dependent on PPPs and other external inputs which are used due to environmental issues and the decreasing number of authorized PPPs. We are aware of the projects of the Sveriges Stärkelseproducenter Förening (Swedish Starch Producers, SSF) regarding potato resistant to late blight disease. According to the risk assessment of their projects, SSF see no hazards that are different from traditional breeding;
o are capable of meeting the special demands of industries for food and non-food uses and consumer demands, including a more optimal utilization of plants or plant parts in order to reduce waste and food spoilage. For example, we are aware of development projects aiming at developing innovative food products with an improved nutritional value, such as a higher content of betaglucans in cereals, reduced content of anti-nutritional compounds in oilseed rape, or reduced levels of glycoalcaloids (possibility to use potato protein in food). Also, SSF is developing a potato seed where amylose has been eliminated, and so only amylopectin starch content with high stability is produced. The advantage of this is the elimination of the current chemical treatment in the starch facilities and thus a clean label starch product is produced, with the same properties as conventional chemically modified starch.
o have better yields, and a high level of productivity with fewer inputs, and keep EU farmers competitive in a global context because of the need to feed a growing population and substitute fossil fuels. Society needs more cereals to satisfy the growing demand. Cereal yields are stagnating in the EU. The EU committed to the 17 Sustainable Development Goals, and goal number 2 is Zero Hunger. European farmers therefore need a designated plan to reach these goals. If not, the EU could end up importing more and thus creating more starvation problems for other regions in the world. The COVID-19 pandemic highlighted issues related to the security of food supply. Society wants very rapid scientific progress in developing a vaccine against COVID-19. We would like society to extend this vision of rapid scientific progress also to agriculture. This approach is necessary to improve the resilience of the agro-food chain.
Like Cogeca, Copa takes the view that NBTs will help to secure global food supply, meet the sustainability goals and reduce the vulnerability of farmers to climatic variation and legislative restraints.

* **2. Have your members taken or planned to take measures to protect themselves from unintentional use of NGT-products?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please provide details

Yes. As the challenge is that there are no ways to detect if a mutation is induced by a NBT or is a spontaneous mutation. However, we have informed our member organisations about the European Court of Justice ruling and have discussed the upcoming challenges for the European farmers. In some Member States as Austria, retail chains wanted to force farmers to guarantee that the whole value chain is free from NBTs. Right now, detection methods are not available and the recommendations made by our members to farmers is not signing such contracts.

* 2 bis. Have you encountered any challenges?

- ( ) Yes
- (x) No

*** 3. Are you aware of initiatives in your sector to develop, use, or of plans to use NGTs/NGT-products?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please provide details

Yes. Copa does not have expert knowledge on all the NBTs because NBTs are evolving rapidly. However, products obtained by NBTs that cannot be distinguished from products obtained by mutations that occur spontaneously, may help European farmers, the environment and consumers. European farmers are ready to use new seed varieties and plant propagating material with new characteristics that meet the societal and market demands and that have economic advantages. If the current strict interpretation of the GMO directive continues to prevent European universities and seed breeders from making use of safe and precise mutagenesis techniques, European farmers will be left behind in the global development, because Europe will lose the know-how and the researchers in the public and private sectors that are able to work on biotechnologies, however biotechnologies are keys factors for adapting agriculture to the future challenges. For example, the use of NBTs to develop plants with stronger roots that will reduce vulnerability to drought will be key in securing the competitiveness of European farmers and food producers. Some concrete examples can be extracted from the report on NBTs et techniques d'édition du génome – impacts potentiels sur l'offre variétale et les activités du Comité Techniques Permanent de la sélection des plantes cultivées du ministère de l'agriculture de la République Française, Mélodie Gendre, novembre 2016. See https://www.geves.fr/wp-content/uploads/CTPS_CS_Etude_NBT_difCP-CS_Fev18.pdf

Copa is aware of the opportunities that are being explored in research. NBTs cover a large number of techniques within biotechnology that are being used widely in laboratories around the world. A global overview on the latest plant breeding methods: research, product development and regulatory frameworks was presented by a representative from the Institute for Biosafety in Plant Biotechnology, Julius Kuehn-Institute, Quedlinburg, 06484, Germany at the HLC which was organised by Copa-Cogeca and Euroseeds on 19th November 2019 in Brussels. See [SEM(19)10033rev.1 à joindre]. This PowerPoint provides a global overview of the latest plant breeding methods: research, product development and regulatory frameworks in the world. There are numerous initiatives in the crop sector to improve nutritional quality in crops, to meet the demands on healthy food products and a shift to meet a demand on protein supply from vegetable sources. Like Copa, Cogeca is aware that many third countries are major suppliers.

*** 4. Do you know of any initiatives in your sector to guard against unintentional use of NGT-products?**

- (x) Yes
- ( ) No

- [ ] Not applicable

* Please provide details

Yes. Like Cogeca, Copa is aware of the challenges with detecting NBTs as identified by the Joint Research Centre, numerous national experts and authorities. At present there are not NBT-products authorized for the EU market. As far as we know, not even an application has been submitted. However, agricultural products from third countries could already contain traces of NBT-products. As long as some of these products enter the EU market without an authorization, we see it as a clear responsibility of the competent national authorities to prevent these imports and it is not the responsibility of the farmers.

* 4 bis. Are you aware of any challenges encountered?

- [x] Yes
- [ ] No

* Please provide details

There are some mapping exercises at company level, to monitor the market of NBT-products. The challenge of the mapping exercise at company level can be only voluntary for the breeders and a lot of products will slip through. This will get worse with time, as more NBT-products become established in third countries that do not regulate them as GMOs.

* **5. Are your members taking specific measures to comply with the GMO legislation as regards organisms obtained by NGTs?**

Please also see question 8 specifically on labelling

- [ ] Yes
- [ ] No
- [x] Not applicable

* **6. Has your organisation/your members been adequately supported by national and European authorities to conform to the legislation?**

- [ ] Yes
- [x] No
- [ ] Not applicable

* What challenges have you encountered?

Like Cogeca, Copa is not aware of any supportive actions. Interpretation and implementation of the GMO Directive is largely left to Member States and EU harmonisation is poor. Copa’s member organisations in several Member States have been involved in dialogue with other stakeholders and national competent authorities regarding the interpretation of the GMO Directive and joint Copa and Cogeca actions are therefore being backed up.

* **7. Does your sector have experience or knowledge on traceability strategies, which could be used for tracing NGT-products?**

- [x] Yes
- [ ] No
- [ ] Not applicable

* Please describe the traceability strategy, including details on the required financial, human resources and technical expertise

Yes. For example, production of seed varieties is subject to a strict traceability protocol (certification) that covers the phases from field crop seeds to the users (farmers). Livestock breeders have already long-standing experience in tracing semen, pedigrees and performance records of animal breeds.
More generally, from farm level onward up to consumers, supply chain segregation and labelling based on particular crop or livestock production standards is common in the EU. Apart from organic production and quality standards such as Global GAP, sustainability schemes are implemented throughout the supply chain. Rather than providing a means for the tracing of NBT products in particular, these examples show that traceability within the supply chain can be very well organised nowadays and is standard, rather than the exception. Traceability strategies must allow farmers and consumers to make their own choices. European farmers and their cooperatives are currently subject to traceability rules that apply to food and feed and biofuel business operators. Any record keeping carries a financial and human resource cost and any costs will be passed down the chain to the primary producer. Costs must always be proportionate to the benefits and value they bring, be it for the supply chain, consumers, society or the environment. The principle and practice of using approved suppliers, of products being regulated and the supply chain being subject to traceability rules could be used.
Yes. For example, production of seed varieties is subject to a strict traceability protocol (certification) that covers the phases from field crop seeds to the users (farmers). Livestock breeders have already long-standing experience in tracing semen, pedigrees and performance records of animal breeds.

* **8. Are your members taking specific measures for NGT-products to ensure the compliance with the labelling requirements of the GMO legislation?**

- ○ Yes
- ○ No
- ◉ Not applicable

* **9. Do you have other experience or knowledge that you can share on the application of the GMO legislation, including experimental releases (such as field trials or clinical trials), concerning NGTs/NGT-products ?**

- ○ Yes
- ○ No
- ◉ Not applicable

Please upload any supporting documentation for this section here. For each document, please indicate which question it is complementing

The maximum file size is 1 MB

B - Information on research on NGTs/NGT-products

* **10. Are your members carrying out NGT-related research in your sector?**

- ◉ Yes
- ○ No
- ○ Not applicable

* Please specify including subject, type of research, resources allocated, research location

- Averis Seeds B.V. 100% subsidiary of AVEBE, an international cooperative of 2,225 Dutch and German growers, (member of COGECA via NCR see https://www.cooperatie.nl/leden/avebe/) develops new potato varieties that are more profitable and more resistant to disease. A crop that is more resistant to these fungal diseases needs 65-75% less crop protection agents. The result: less environmental impact and a good cost saving for the grower.
- Lyckeby Starch AB is owned by some 800 potato growing farmers in the southern parts of Sweden (member of COGECA via the LRF see https://www.lrf.se/om-lrf/organisation/lrfs-organisationsmedlemmar/organisationsmedlemmar/). In collaboration with the Swedish University of Agriculture (SLU), they develop new potato varieties obtained by site-directed mutagenesis CRISPR-Cas 9 , amylopectin-enriched starch potato. Amylopectin-enriched varieties would allow a reduction of energy and chemicals used in the processing of potato starch into ingredients (see above). SSF example in Q1).
- ALLICE is a French Umbrella Cooperative (Union of livestock cooperatives, a French professional livestock organization representing all sectors of cattle, goat, sheep and pig insemination), member of Cogeca via la cooperation agricole française, see https://www.lacooperationagricole.coop/fr/allice-corporate, they are carrying out an R&D project on Genome Editing aiming to optimize the technology, both in terms of yields and safety, and to evaluate its potential and drawbacks. Currently, no production of living animals and no commercial applications are planned. Putative applications would be for research purposes (validation of recessive mutations causing genetic defects).
- BRS (German Livestock Association see https://www.rind-schwein.de/brs-common/brs-home-gb.html) is a member of Copa via the DBV as BRS is an associate member of DBV. They are carrying out the following projects together with FBF: "Genome editing in the bovine embryo: Development of an efficient electroporation protocol" and "Use of DNA nucleases to generate hornless cattle". The University of Bonn is responsible for these projects.

*** 11. Are you aware of other NGT-related research in your sector?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please specify

There is a great deal of research underway all around the world, looking into new breeding techniques related to crops. It is not possible to list all this activity here. Suggested source of information https://www.oecd.org/environment/genome-editing-agriculture/
a) plant sector
NBTs will also help farmers to respond to the specific demands of consumers, such as wheat with less gluten, reducing the content of saturated fatty acids, allergens, fibers, protein, or vitamins. For example, Calyxt has done so in the US with Talen technologies. See https://calyxt.com/innovation-pipeline/
Research in the SLU Grogrund program also involves NGTs, see SSF example in the answer to question 3. See https://www.slu.se/en/Collaborative-Centres-and-Projects/grogrund/
In this survey among Canadian breeders (public and private), 66% stated that they were planning to use CRISPR/CA's over the next three years. See https://saifood.ca/gene-editing-plant-breeding-canada/
These 3 scientific publications list multiple applications of genome editing tools in different plant species to improve yield, biotic, and abiotic stress resistance, and nutritional quality, and elaborate on future prospects for Genome Editing. See
https://www.frontiersin.org/articles/10.3389/fpls.2019.00114/full
https://doi.org/10.1016/j.tplants.2019.09.006
https://doi.org/10.3389/fpls.2018.01607

Report of Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL), Julius-Kühn-Institut (JKI) and Friedrich-Löffler-Institut (FLI): https://www.bvl.bund.de/DE/Arbeitsbereiche/06_Gentechnik/02_Verbraucher/09_Monitoring_Molekulare_Techniken/gentechnik_molekulare_techniken_node.html
Topsector Horticulture Public-Private Project H 263& KV 1509-048: A genetic analysis pipeline for polyploids, involving several breeding companies – mainly of horticultural crops: https://topsectortu.nl/nl/genetic-analysis-tools-polyploid

b) Livestock sector
See previous example with Recombinetics and its subsidiary Acceligen Also cattle resistant to Bovine tuberculosis and Foot-and-mouth disease virus. The Bill Gates Foundation: modify the genes of tropical cows in order to increase their milk production and their heat resilience.
The Roslin Institute is working actively on sheep gene editing. See https://www.ed.ac.uk/roslin
INIA in Spain and the University of Bonn in Germany are working on genome editing of cattle embryos.
Several publications mention gene edited sheep and goats, mainly regarding muscle mass, fiber length, coat color and litter size/prolificity.
See: https://www.ncbi.nlm.nih.gov/pubmed/3203404 for a global (non-exhaustive) overview.
The following homepage provides an overview: (https://crispr-gene-editing-regs tracker.geneticliteracyproject.org/european-union-animals/)
Products/Research • Human disease research in pigs: Technische Universität München in Germany used gene edited pigs to study human diseases, including cardiovascular diseases, cancers, diabetes mellitus, Alzheimer’s disease, cystic fibrosis and Duchenne muscular dystrophy. • Sheep with larger muscles: Center for Research in Transplantation and Immunology
(ITUN) used gene editing to develop larger sheep with more developed muscles. • Organs in pigs: Researchers in multiple European countries (Spain, Italy) have studied how to develop humans organs for transplantation in pigs. • Gene editing research in pigs: Researchers in Germany studied how to silence genes in pigs using a gene editing technique called ZFNs as a first step to gene edited pigs for agriculture. • Virus-resistant pigs: Researchers at Edinburgh University’s Roslin Institute and the UK company Genus developed pigs resistant to the virus that causes Porcine Reproductive and Respiratory Syndrome (PRRS), one of the costliest animal diseases. • Swine fever-resistant pigs: Researchers at the Roslin Institute used ZFNs to develop pigs resistant to African Swine Fever. • Influenza-resistant chickens: Researchers at the Roslin Institute and Imperial College London took first steps in developing influenza-resistant chickens to help curb the spread of avian flu to humans. • Chicken research: Researchers at the Roslin Institute used a gene editing technique called TALENs to begin developing hens that do not produce their own chicks, for use as surrogates to lay eggs from rare breeds, as well as hens that produce human proteins in their eggs for medical purposes. • Pigs with organs for humans: Researchers at the Center for Innovative Medical Models Facility of Ludwig-Maximilians University used CRISPR to begin developing pigs with organs that are more likely to be accepted when transplanted into a human.

*** 12. Has there been any immediate impact on NGT-related research in your sector following the Court of Justice of the EU ruling on mutagenesis?**

Court of Justice ruling: Case C-528/16 http://curia.europa.eu/juris/documents.jsf?num=C-528/16

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please describe

Copa is aware of concerns in the scientific community that the decision is hampering its work and putting up barriers and costs that do not have a commensurate benefit for society or the environment. See http://www.vib.be/en/news/Pages/Open%20Statement%20for%20the%20use%20of%20genome%20editing%20for%20sustainable%20agriculture%20and%20food%20production%20in%20the%20EU.aspx
Coppa is aware of research projects using NBTs being put on hold or delayed due to the ECJ ruling. Due to strict regulations in the EU and bleak outlook regarding possibilities in the near future, product development tends to be moved outside Europe. A particular example is a large Dutch potato breeding company that recently announced it would be moving its research on NBT potatoes with multiple resistance against phytophthora to Canada, in as far as it concerns field trials. https://www.boerderij.nl/Akkerbouw/Nieuws/2020/2/HZPC-verplaatst-aardappelonderzoek-naar-Canada-544771E
Even in the absence of data and information, it is obvious that the current regulatory framework is a strong deterrent for any research that our members may have undertaken, or had wished to undertake. For example, the project of Lyckeby Starch AB (SSF) on amylopectin-enriched potato varieties started in 2014. Field production should have started in 2019 and industrial production in 2022, see [AMI(19)10480rev.1 à joindre]. Field trials have so far been possible within the GMO regulation even though most of the regulation is not applicable to NBTs. To move into industrial production will not be possible with the existing legal situation because the cost of approval of a GMO classified crop is too high. Labelling requirements will also impede the projects. The logical consequence will be moving the production out of the EU.
In livestock breeding, the ALLICE research project for example has been resized and reorganized, putting less emphasis on the identification of commercial applications and technical advances compliant with routine use. Equally, research institutes like INRAE in France seem to be reluctant to produce and house products of NBTs in their experimental facilities. Many internal administrative rules are necessary requirements for allowing such experiments.
In general terms, the ECJ's ruling entails a risk that research and innovation activities may be relocated outside the EU. The EU may also have to do without the use of genetic material from third countries in order to improve plant varieties, including material for conventional cross-breeding techniques. The costs of the cultivation trials of products obtained by new targeted mutagenesis techniques commonly amount to EUR 35-50 million, like for the approval of one GM trait at EU level. These high costs are not affordable for SMEs. Innovative developments that stem from NBTs can only be shared if the costs of regulating their placing on the market are acceptable and proportionate to the size of the target markets.

*** 13. Could NGT-related research bring benefits/opportunities to your sector/field of interest?**

- (●) Yes
- ( ) No
- ( ) Not applicable

* Please provide concrete examples/data

Copa can see potential benefits from NBT related research. For example,
a) The use of NBTs in research can greatly accelerate the speed with which the genome of a crop is understood, e.g. in relation to susceptibility or resistance against a particular disease. This knowledge can then be used to develop a more targeted/efficient traditional breeding program.
b) For breeding new seed varieties, NBTs can be used to significantly reduce the time needed to breed 'traditional' new seed varieties. E.g. for fruit trees or grape wine, it takes several years to grow a tree even to the stage where it produces flowers (needed for traditional breeding). With NBTs, the genome can temporarily be altered to shorten this time to maturity, and 'switched back' afterwards before the new variety is brought into production.

In the livestock sector, NBTs could make it possible to improve resistance to disease and to breed animals without horns, which would positively contribute to animal welfare. The currently available results show that the NGTs can be used successfully for each gene in any organism. ZFNs, TALENs and CRISPR/Cas have therefore become valuable tools for inducing and studying genetic modifications even in complex mammalian organisms within a short period of time. In the future, gene editing may also enable the rapid correction of unfavourable allele combinations and thus the resolution of trait antagonisms as well as the moving of useful alleles and haplotypes between breeds in the absence of linkage drag. The use of DNA nucleases requires the integration into the existing breeding systems based on genomic breeding value. First simulation calculations (Jenko et al. 2015) for integration into existing breeding systems are already available.To stay competitive, European farmers and their cooperatives must rely on public and private research activities to achieve the goals to develop pest-and stress resistant crops, obtain specific qualities, adapt to climate change, to use fewer PPPs etc. and they must demand seed varieties that can solve these issues. Europe must therefore invest in R&D in this field. Developing new seed varieties that make optimal use of the genetic potential within the crops is key to meeting market demands, social sustainability goals and overcoming challenges resulting from climate change and strengthening the resilience of European agriculture.
In addition, more and more crop plant genomes are being fully sequenced and reference genomes as well as sequence based diversity is now available and this resource will increase. A major bottleneck for better understanding genomes remains functional analysis of the 10000s genes in a plant nucleus. Here NBTs will play a significant role. In the near future, NBTs will be a key tool for functional genomics, particularly deciphering gene functions in a targeted and highly efficient manner. Improved knowledge on gene function will lead to targets for plant breeding, particularly key genes for adaptation, stress resistance, quality, resource efficiency, etc. This knowledge can be utilized for plant breeding in two important ways: 1) development of functional markers for ‘key-genes’ with agricultural/agronomic importance and 2) generation of novel alleles in such genes that have potential for crop improvement.

* **14. Is NGT-related research facing challenges in your sector/field of interest?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please provide concrete examples/data

The biggest challenge is the European Court of Justice’s ruling on 25th July 2018 in case C-528/16, which stipulates that mutagenesis techniques must be considered as pertaining to Directive 2001/18/EC on the deliberate release into the environment of GMOs.
Also, research using NBTs is currently made more expensive and time consuming, due to the demand to apply the GMO Directive on contained and confined use according to the ECJ ruling.
For example, from an SSF perspective, the current situation is stressful, as commercial production will not be possible without a change of legislation. This might force us to move some production outside of the EU. Other projects, such as disease resistance in potato, will be closed down.
As regards competition, this is of concern to the potato starch industry. We will see an increasing demand for Clean Label starch from the food industry because they do not want to label E-numbers on the final product. Without pure amylopectin potato starch, the industry will not be able to fulfil this demand, while other crops such as corn will. Potato starch will consequently lose market shares.
Also, the market has a preference for food products with no E-numbers. In a situation where the EU does not allow NBTs, imported food products will have a competitive advantage over products produced in the EU, as no analytical method exists to identify if NBT raw materials have been used.
If other modifications like disease resistance are stopped, we will have to use more pesticides and will not be able to reduce CO2 emissions to the same extent.

*** 15. Have you identified any NGT-related research needs/gaps?**

- (x) Yes
- ( ) No
- ( ) Not applicable

* Please specify which needs/gaps, explain the reasoning and how these needs/gaps could be addressed

Researchers in European universities and European breeders need to have access to the same techniques as in other parts of the world.
The use of NBTs is essential for research on functional genetics. Enabling technologies, such as cell- and tissue culture, to be able to develop plants after the use of NBTs. This could be addressed by funding research in Member States.
Another example for cereals, plant breeding and research into seeds in the cereals sector are the primary levers for achieving higher protein self-sufficiency. This strategy shall encompass forage maize which has an average yield of 0.9 t of crude protein/ha. There are three priorities here:
• Increasing the cereal yields which are currently stagnating, notably by adapting wheat and barley to climate change;
• Enhancing the protein content of cereals, targeting higher physiological efficiency in the nitrogen uptake of crops;
• Improving the quality of cereal proteins, notably by increasing the content of lysine, an amino acid required in pig and poultry feed.
Regarding Detection methods: Nucleotide changes (down to single nucleotide polymorphisms (SNPs)) are detectable by standard PCR based, hybridization based or sequencing methods, but the genomic changes induced by NBTs cannot be distinguished from naturally occurring variation or from changes derived from conventional mutagenesis. The resulting organisms carry mutations, which are not distinguishable in a meaningful way from what is present in nature and existing germplasm, and from what can spontaneously arise in nature. Products generated by NBTs cannot be distinguished from products generated by other breeding practices not falling under Directive 2001/18/EC. Regulation of NBTs products under Directive 2001/18/EC therefore results in a situation in which exactly the same product (with exactly the same combination of genetic material) – one resulting from a modern technique, and the other resulting from a conventional technique –, is treated in a different manner.

In livestock breeding, NGT-related research could also help improve the efficiency and safety of the technology. Research is also valuable to elucidate gene function and validate genes and mutations of interest for both monogenic traits and QTL (e.g. when several putative causative variants have been identified in a QTL region).

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C - Information on potential opportunities and benefits of NGTs/NGT-products

* **16. Could NGTs/NGT-products bring benefits/opportunities to your sector/field of interest?**

- (●) Yes
- ( ) No

* Please describe and provide concrete examples/data

NBTs are not currently bringing benefits to European farmers because there are no products nearing commercial application. However, the EU commits itself to the Sustainable Development Goals including Zero Hunger. If European farmers do not have an appropriate toolbox, the EU will import more, putting at risk food security in other regions of the world. While PPPs have provided many good solutions, PPP resistance has increased, generating problems for farmers related to managing crop protection. There are new political movements and new market demands such as those for plant-based proteins, zero PPPs and other specific demands for industrial uses.
We see NBTs as a major part of the solution to the intractable production challenges facing our sector in its efforts to produce food, fibre, energy and other products for the market; to produce environmental goods and services; to become more resource efficient; to be part of the solution as well as to be more resilient to climate change. For the seed potato sector, NBTs are seen as the principal method for overcoming the challenges mentioned. To produce results (quickly, most importantly), other breeding methods must be used.
NBTs offer many new possibilities in plant breeding genetic enhancement, provide opportunities to speed up genetic progress for a variety of traits, including traits related to climate change, environmental footprint reduction. For instance, they make it possible to precisely edit plants, thus allowing the development of new functions to optimise existing features or identify and develop new traits within the current genetic variation of the crops. They also enable genes that present disease susceptibility in one crop to be edited. By permitting a greater use of genetic variability and a better use of existing genetics, NBTs can provide solutions to the numerous challenges that European agriculture is facing.
NBTs could thus help reduce the cost of selection programs and thus contribute to the competitiveness of the sector.
By making it possible to induce more targeted genetic variations, NBTs provide more predictable genetic results than conventional traditional breeding techniques.
Conventional plant breeding takes up to twenty years. Faster plant breeding is therefore important, because market demands change considerably over a 10-year period and political ambitions create great pressure regarding the speed with which crop production need to become more sustainable. Without the availability of NBTs to develop better adapted plants, the production of healthy and safe crops cannot keep up with the speed at which the use and impacts of inputs like PPPs and fertilisers is being restricted. NBTs allow breeders to develop plants that are similar to those that derive from conventional breeding, but more quickly and in a more precise manner. They are therefore vital tools that make it possible to accelerate the process, thus replying to the various needs of farmers in a better and swifter manner. NBTs contribute to developing varieties that use fewer inputs, improving the quantity and consistency of yields, adapting to climate change, producing sufficient and high-quality food, and diversifying crops for production in order to optimise crop rotations.
NBTs go hand in hand with other technological developments, such as precision farming, digital and smart farming, and bio-control.

* Are these benefits/opportunities specific to NGTs/NGT-products?

- (●) Yes
- ( ) No

* Please explain

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NBTs go hand in hand with other technological developments, such as precision farming, digital and smart farming, and bio-control.

*** 17. Could NGTs/NGT-products bring benefits/opportunities to society in general such as for the environment, human, animal and plant health, consumers, animal welfare, as well as social and economic benefits?**

- (•) Yes
- ( ) No

* Please describe and provide concrete examples/data

In the EU, the authorisation of many PPPs has not been renewed. European farmers have lost the tools that they need to protect agricultural crops. This situation seriously puts food security and safety at risk as well as the competitiveness of European agriculture. Meanwhile, new pests, such as weevils and the stink bug, are threatening crop production. Farmers need an efficient toolbox to ensure crop production and food security and safety at affordable prices for the 450 million EU consumers. NBTs are part of the toolbox that European farmers need. The EU Farm to Fork strategy calls on European farmers to significantly reduce the dependency on as well as the risks and use of plant protection products, fertilisers. Generally speaking, genetic progress provides a benefit to society in terms of food security & quality, environmental footprint and farming competitiveness… NBTs can speed up genetic progress, increasing thus these benefits.
NBTs also provide opportunities to expand the naturally occurring available genetic diversity and to produce

novel alleles, conferring plant disease resistance for instance. This can help tackle challenges related to reduced use of PPPs.
Crop production starts with seeds that are more tolerant/resistant to pests, diseases and to changing climatic conditions. NBTs must feature in the breeders' toolbox. See examples below

1) Disease and insect resistance

a. Bacterial blight-resistance in rice [R. Oliva et al. Broad-spectrum resistance to bacterial blight in rice using genome editing, Nat. Biotechnol. 37 (2019) 1344–1350. doi:10.1038/s41587-019-0267-z.]

b. Viticulture is a highly conservative branch where growers and producers favour the maintenance of existing, highly popular grape varieties. However, cross-breeding for new disease-resistant varieties (that will not need to be sprayed as much) takes well over a decade and the final new variety will most likely be different from the original variety also in other aspects. New techniques for site-directed mutagenesis (e.g. CRISPR/Cas or other) will enable the introduction of disease- and pathogen resistance while maintaining original grape varieties.

2) Drought-tolerant maize

3) Salt-tolerant rice

4) Agronomic traits

5) Podshatter-resistant oilseed rape

6) Food quality/food health traits

a. Non-transgenic, CRISPR/Cas9-developed wheat with much reduced immunoreactivity for people with coeliac disease [Sánchez-León S et al (2018). Low-gluten, nontransgenic wheat engineered with CRISPR /Cas9. Plant Biotechnology Journal, 16: 902-910.]

b. Recovering lost, wild tomato quality traits by de novo domestication of wild tomato [Zsögön A et al (2018). De novo domestication of wild tomato using genome editing. Nature Biotechnology, doi:10.1038/nbt. 4272.]

c. Root chickory producing more and healthier inulin food fibre as well as medicinal terpenes (http://chicproject.eu)

d. High-amylose starch potato suitable for industrial applications [Andersson M et al, 2018. Genome editing in potato via CRISPR-Cas9 ribonucleoprotein delivery. Physiologica Plantarum doi: 10.1111/ppl. 12731]

e. Vitamin A-enriched rice [O.X. Dong, et al, Marker-free carotenoid-enriched rice generated through targeted gene insertion using CRISPR-Cas9, Nat. Commun. 11 (2020) 1178. doi:10.1038/s41467-020-14981-y.]

f. Waxy maize [H. Gao et al, Superior field performance of waxy corn engineered using CRISPR–Cas9, Nat. Biotechnol. (2020). doi:10.1038/s41587-020-0444-0.]

g. NBTs are well suited to improve quality and nutritional traits in crops. These are often governed by few genes and a mutation disrupting a gene may have positive effects. Problems with obesity and demand for functional food are increasing, and NBTs can play a vital role in improving crops in these respects.

h. NBTs could help to reduce food waste (e.g. by enhancing shelf life of products) and to make optimal use of biomass (e.g. by utilising plant parts as much and efficiently as possible).

NBTs could be used in a given population to increase the frequency of rare alleles of interest, which could otherwise progressively be lost (due to their low frequency, their effect is undetected or underestimated and these alleles are thus not selected). Like Cogeca, Copa sees a risk of NBT-based crops being imported into the EU at large scale, while they are sometimes not even distinguishable from 'traditional' crops. This creates unfair competition with EU domestic production. It is important to increasingly provide a level playing field.

* Under which conditions do you consider this would be the case?

There is an urgent need of an updated interpretation of the mutagenesis exemption in Annex 1.B. of the Directive 2001/18/EC.

* Are these benefits/opportunities specific to NGTs/NGT-products?

- (selected) Yes
- No

* Please explain

NBTs offer many new possibilities in plant breeding genetic enhancement, provide opportunities to speed up genetic progress for a variety of traits, including traits related to climate change, environmental footprint reduction. For instance, they make it possible to precisely edit plants, thus allowing the development of new functions to optimise existing features or identify and develop new traits within the current genetic variation of the crops. They also enable genes that present disease susceptibility in one crop to be edited. By permitting a greater use of genetic variability and a better use of existing genetics, NBTs can provide solutions to the numerous challenges that European agriculture is facing.

*** 18. Do you see particular opportunities for SMEs/small scale operators to access markets with their NGTs/NGT-products?**

- (selected) Yes
- No

* Please describe and provide concrete examples/data

SMEs would develop seed varieties well adapted to local soil, climate conditions and local varieties. Multinationals focus on the main global agricultural species. Establishing a framework that allows SMEs to operate with NBTs, provided that the SMEs are not burdened with the regulatory cost, would be beneficial for maintaining competitiveness and diversity in the supply on the seed market.
As Europe wants to develop its production of grain legumes, considerable research is needed into these crops to improve yields and to reduce annual yield variation. Breeding programmes for small varieties such as clover, alfalfa, vetch, and even peas need to be improved if Europe wants to increase its protein crop production. The same applies to cover crops (mustard, radish, etc.).
The EU has an excellent reputation for its high-quality production of speciality crops. Innovation regarding crop varieties in such 'niche markets' is often dependent on investments from specialised breeding companies like SMEs. Accessibility of NBTs for these companies is essential to stay competitive and, for the respective crop production sectors, to keep up with market and societal demands
If regulated according to the GMO-directive, there are no opportunities for any businesses to market crops developed using the technology. A situation where NBTs are regulated as crops developed by traditional breeding methods, opens up major opportunities for SME/small scale operators to go into the market with NBT-products. The reason is that one or a few traits can be added to existing traditionally bred material without any new DNA inserted, which can be done quite easily at a low cost. The new situation will be that traditional breeding companies will be able to offer new varieties to all their customers as opposed to the situation we have had for many years where only huge companies can afford to use GM-technology.

*** 19. Do you see benefits/opportunities from patenting or accessing patented NGTs/NGT-products?**

- Yes
- (selected) No

* Please explain why not

Like Cogeca, Copa's position on patents on plants has been very clear for almost 30 years. Europe has the best innovative plant breeding sector in the world. The CPVR system has worked well for 50 years, creating a positive environment for breeding. It gives farmers access to an excellent and diverse range of plant varieties. Breeders in Europe currently create around 3,000 varieties a year which shows just how well the system is working. Without this system, 90% of the varieties would disappear in the next 10 years to the economic benefit of a few multinationals. For varieties obtained by mutagenesis, regardless of the breeding technique that the breeder has chosen to use, the only IP protection possible is the Community Plant Variety Right (CPVR).

o Mutating a gene does not create any novelty, since no new gene is inserted and because there is no significant change in the gene or the genome. The gene and genome remain intact, there has simply been a break in the gene allowing the cell to repair the damage itself – the gene remains still the same, it has merely been injured. This is supported by the fact that these events constantly occur in nature and have the exact same effect on gene expression as seen in induced mutation. It is therefore highly questionable that mutagenesis in plants meets the novelty criteria necessary for patentability. The methods for targeting mutagenesis might be subject to patents, but there is no innovation involved in using genes that have always existed.

o Mutagenesis is within the scope of essential biological processes. The mutant genes used in our crops (dwarf genes, ml-o, null-lox, etc.) can always be found in nature and, as a rule, come in two versions: a 'natural' and an 'induced' version. In other words, the result of a mutation is exactly the same, be it naturally occurring or the result of targeted mutagenesis. The mutation traits are therefore completely identical to 'native traits' - the process leading to the trait is not important. These traits are used in the breeding process in any other conventional breeding activity in which the pool of genes are subject to crossing and selection.

o The EPO argue that "mutagenesis as such is considered to be a technical process which results in a modification of the genome of the plant or animal. This applies to "traditional" methods like irradiation or chemical mutagenesis, but even more so to molecular methods like Zinc Finger Nucleases, CRISPR, TALEN, ODM (oligonucleotide-directed mutagenesis) etc., which require man-made molecules for targeted mutagenesis". Mutagenesis might involve a technical process, but that in itself does not make the resulting trait patentable if the trait in the plant does not meet the novelty criteria. Using genes that have existed for thousands of years does not fulfil the novelty criteria. One could say that the result of mutagenesis is not an inventive step because the gene and the gene function already exist and the trait developed is discovered and not invented, the outcome of the mutation being obvious.

o The EPO argue that "whether a specific mutation indeed would occur as the result of spontaneous mutagenesis is entirely speculative". That is simply not true. All genes are essentially a result of mutations and every gene evolves as a result of mutations. The mutation rate in a growing crop with hundreds of thousands of individuals over consecutive seasons make it entirely speculative that a mutation in given genes should NOT occur.

o With genetic modification, in contrast, foreign DNA is introduced at new positions in the genome. Here, it is a matter of creating something innovative and novel that is different from all essentially biological processes and different from any native trait. In this particular case, patentability is highly appropriate and relevant.

Patents on products, traits or genes derived from genetic engineering breeding techniques should only apply to products that contain DNA that cannot be found in nature or cannot be obtained through conventional breeding methods or mutagenesis techniques.

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D - Information on potential challenges and concerns on NGTs/NGT-products

* **20. Could NGTs/NGT-products raise challenges/concerns for your sector/field of interest?**

- (•) Yes
- ( ) No

* Please describe and provide concrete examples/data

Like Cogeca, Copa is concerned about the possibility of intra-EU trade barriers due to an adoption of NBT-based crops, a consequence of the poor harmonisation of EU legislation worldwide and among Member States. Like Cogeca, Copa sees a risk of distortion of competition, higher business concentration and loss of genetic sovereignty and diversity.
There is a risk of distortion of competition if EU regulation doesn't apply to imported products in the same way (how to control importation when detection is impossible?). Distortion of competition is already taking place since imported products are usually not subjected to the same production constraints as they are in the EU, but the situation could be more critical with NGT products.
Risk of higher concentration of businesses in the sector, which could affect the relationship between breeders and farmers. If NGT development can not be pursued by cooperatives but only by multinational corporations. For example, for Sexing Technologies or Zoetis in the livestock sector, there is a risk of loss of genetic sovereignty.

There is a risk for our genomic selection system for international breeds such as Holstein if genome edited animals are imported without traceability: their progeny will introduce a bias in the reference population, resulting in a loss of genetic progress.
Each NBT should be analysed and discussed by experts on a case-by-case basis and according to strict scientific criteria. The decision on evaluating them and ascertaining the correct regulatory approach should also be proportionate to the risks. NBTs are constantly evolving and developing. Copa therefore reserves the right to express their possible positions on these new techniques on a case-by-case basis.
Introducing NBTs into the agricultural sector should be done such that freedom of choice is maintained. This can be achieved by providing and maintaining transparency regarding the seed varieties on a voluntary basis.

* Are these challenges/concerns specific to NGTs/NGT-products?

- ( ) Yes
- (•) No

* Please explain why not

Some of them exist also for GMOs.

* **21. Could NGTs/NGT-products raise challenges/concerns for society in general such as for the environment, human, animal and plant health, consumers, animal welfare, as well as social and economic challenges?**

- ( ) Yes
- (•) No

* Please explain why not

For the crop sector, as far as applications of NBTs are concerned, there is no reason to expect that NBTs that produce organisms that cannot be distinguished from those obtained by conventional breeding or natural processes would have any other impact than those latter organisms. The adaptation of new or existing seed varieties to climate change, to resist important pests and diseases , to secure yield and to maintain or improve product quality are essential to both farmers and consumers.
It is rather the opposite: effectively excluding the application of NBTs in the sense above (through regulation of products as GMOs) will deprive European farmers, as well as EU-citizens and the European society in general, from the potential benefits of those products (which in turn will raise challenges/concerns for society). In a situation where NGTs are not regulated as GMO, it is still so that new seed varieties need to be tested and approved regarding DUS in order to be sold on the market.
It is obvious that specific traits give rise to concerns in society in general. Regarding the crop sector, some European citizens are unwilling to accept GMOs with herbicide tolerance. However, this does not mean that herbicide tolerance per se is a trait with negative consequences regarding aspects such as the environment or human or plant health. If well managed, it is a trait that can be highly beneficial to the farmer as it allows for a more flexible and targeted weed management. It also promotes low-till farming practices, with benefits for the soil environment.
In the livestock sector, the presumed lack of social acceptance is of huge concern. However, this purported low social acceptance has not been substantiated by any opinion poll to date. It mainly hinges upon the low acceptance for GMOs. They still support research on Genome Editing to assess the safety (off targeting, mosaics) and efficiency (feasibility, costs compared to traditional breeding…) of this technology. As far as examples go, there are only a few known major genes of interest (from ~150 major genes identified in cattle, 90% are genetic defects!), mainly for coat color, milk proteins, muscularity, hornlessness, heat resistance (short hair)… Some mutations have been described that decrease vulnerability to tuberculosis and paratuberculosis. Most traits of interest in cattle are quantitative (QTL) and governed each by ~ 300 genes (causative mutation usually unknown).

*** 22. Do you see particular challenges for SMEs/small scale operators to access markets with their NGTs /NGT-products?**

- (●) Yes
- ( ) No

* Please explain and provide concrete examples and data

European farmers have serious concerns about their access to innovation in seed breeding. If the EU were to regulate all products that result from NBTs as it regulates GMOs, NBTs would cease to develop in Europe, as small and medium-sized enterprises in the sector would not be able to shoulder the costs of the requirements set out under Directive 2001/18/EC. This could lead to a higher concentration of businesses in the seed, which could affect the relationship between breeders and farmers. Similarly, it is vital for public research institutes to continue to be able to access NBTs. It is vital for farmers to have quite a wide choice of seed variety suppliers. If the seed market is concentrated between a few operators it could conduce to higher prices for varieties and lower yields as crops will not be well adapted to local conditions for all European regions.

*** 23. Do you see challenges/concerns from patenting or accessing patented NGTs/NGT-products?**

- (●) Yes
- ( ) No

* Please describe and provide concrete examples/data

Copa does support the view that the patentability of plant traits poses major risks to European agriculture. Patenting plant traits will hinder innovation. Breeders are increasingly limiting their starting material to self-owned varieties, yet even this does not fully guarantee that no patents are infringed. Additionally, as more money is needed to cover patent attorneys, legal fees and transaction costs, such as license fees, less funding is available for R&D.
Patenting plant traits directly jeopardises many SMEs that are active in plant breeding, as they generally do not avail themselves of the necessary resources to build up their own patent portfolio or to monitor patents from third parties to ascertain whether certain materials are protected. Many SMEs are likely to be forced out of business, leading to further consolidation and/or reduced innovation in plant breeding. This would lead to the market being much more dependent on larger seed companies.
Patenting plant traits will reduce the freedom of choice for farmers, the industry, trade, and consumers. It may be a while before this effect is palpable, as developing varieties takes considerable time. The repercussions of cancelling breeding programmes or breeders going out of business will therefore only be felt years down the line, yet this remains an unavoidable consequence of current patenting practices for genetic traits.
Patenting plant traits could once again threaten agricultural biodiversity by limiting the number of breeders and breeding programmes. Seeing as the variety of biological starting material is reduced, the gene pool will become progressively more limited, thus increasing the vulnerability of crops to plagues and diseases.
We believe that patent law is an inappropriate instrument for agriculture and for selecting plant varieties because it stymies the work of farmers and breeders. Establishing the farmers and breeders' privilege in line with the CPVO was an important step forward that boosted the plant variety sector. For all of the aforementioned reasons, Copa call on you to ensure that genetic resources remain freely available in the future and that the work carried out by farmers and breeders will not be hindered. Patenting the animals / mutation makes no sense. Indeed, genetics exist within a mutual framework and the breeders and farmers are free and want to remain free to produce their next generation. Patenting a genome edited bull would imply that heifers produced by this bull would be subject to royalties when calving…
We remain concerned about the potential negative effect of patents on their day-to-day work regarding free access to plant breeding genetic material and royalty payments.
a)Blocking effect on breeding: When a breeder wants to use a variety for further cross-breeding and to create a new variety, either he has to do away with the patented trait of the plant or he needs to get a license from the patent holder. With more patent varieties, there may be multiple patented traits which would need to be bred out or which would require a license. This would inevitably block further breeding and progress in new variety breeding.
Furthermore, patents make it possible for patent holders to exercise economic greed through their ownership of the patent rather than working in the general interest towards bringing about improved new varieties. Farmers need access to the best seed varieties at all times and are concerned about the hindrances to progress in breeding that the blocking effect of possible patents may cause. Therefore, farmers are of the view that a breeders' exemption that allows breeders to freely use any variety that contains a patented element for further breeding must be implemented in patent laws all over Europe.
b)Royalty payments: Patents also affect farmers from the point of view of royalty payments. If the patent brings a value to the farmer, it is legitimate to charge royalties for that benefit. However, if this is not the case, it is not acceptable for farmers to pay extra royalties.
For the above reasons, we are of the view that in addition to the Commission notice and the rule change by the EPO, there is still more to do.
It is essential that any possible plant patents are subject to EU laws on plant variety protection in order to secure farmer access to the best performing varieties. It is also essential that farmers cannot in any way violate possible patents when using certified seed.
Moreover, patenting the technology may also give rise to issues, depending on the licencing strategy (high costs, exclusivity…), in particular for SMEs.

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E - Safety of NGTs/NGT-products

*** 24. What is your view on the safety of NGTs/NGT-products? Please substantiate your reply**

Radiation or chemical treatments have been commonly used to create random mutations in a large number of seedlings, followed by selection and multiplication of desirable individuals. In this respect, NBTs allow us to target and monitor changes in the genome much better. In plants,
as safe as plant products already produced by methods considered having a history of safe use. The techniques and their resulting products are not expected to be less safe than other plant breeding techniques.

*** 25. Do you have specific safety considerations on NGTs/NGT-products?**

- (●) Yes
- ( ) No

* Please explain

According to the Danish Council on Ethics [SEM(19)5061rev.1, page 24]: “in the 20 years of cultivating herbicide- and insect-resistant plants, there have been no reports of harm to human beings or nature resulting from the use of genetic modification in itself”.

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F - Ethical aspects of NGTs/NGT-products

*** 26. What is your view on ethical aspects related to NGTs/NGT-products? Please substantiate your reply**

See useful paper: GMO and ethics in a new area, Danish Council on Ethics statement, see SEM(19)5061rev
http://www.etiskraad.dk/~/media/Etisk-Raad/en/Publications
/DCE_Statement_on_GMO_and_ethics_in_a_new_era_2019.pdf?la=da
Many factors have changed since the GMO Directive was introduced 30 years ago.
Several sustainability problems have become more urgent.
If temperature rises are not contained, the consequences for future generations will be unpredictable. This should weigh heavily in an ethical assessment.
Plant breeding innovation alone cannot solve the climate challenge, but the situation today is so serious that all measures should be employed unless there are substantial arguments not to do so. Accelerated variety development would be a strength in a situation with rapid climate change.
There has been substantial concern over the years regarding the products of gene technologies, voiced by certain activist groups and often also reflected in public opinion. For ethical reasons, it is important that these concerns are taken into account. However, there are also several other ethical concerns, in particular related to the policy approach towards the products of gene technologies in Europe.
First, it is problematic that science is often overlooked when it comes to making decisions for authorising the products. We appreciate the importance of aligning political decisions with the needs and expectations of all societal actors, and therefore regret that scientific advice is often overlooked when it comes to plant breeding innovations. This will impede any efforts to develop responsible governance of innovations using these techniques, particularly since many stakeholder groups do support the evidence provided by scientists. It is highly problematic from an ethical perspective to overlook scientific probabilities/facts and instead base decisions on opinions based on different agendas.
It is also highly ethically questionable that farmers who want access to improved seeds are denied this.
It is also ethically questionable from the point of view of equal access to technology. Should the products of NBT be subject to the provisions of the GMO legislation, this would result in SMEs/small scale operators being excluded from using the technology for the European market, and thus work actively against a particular segment on the market.
It is ethically problematic to not take advantage of latest technologies when these offer good benefits. There is a cost associated also with refraining from using beneficial applications.

*** 27. Do you have specific ethical considerations on NGTs/NGT-products?**

- [x] Yes
- [ ] No

* Please explain

Gene editing technologies offer enormous potential for scientific advancement in fields such as medicine and agriculture, but their use also raises serious ethical and public policy concerns. Ethical consideration needs to be given to all applications of gene editing, including the non- human applications. We do not have any specific ethical considerations, since concerns are the same as with traditional selection.
NBTs are merely techniques. We believe that each NBT should be analysed and discussed by experts on a case-by-case basis and according to strict scientific criteria. The decision on evaluating them and ascertaining the correct regulatory approach should also be proportionate to the risks. NBTs are constantly evolving and developing. We therefore reserve the right to express their possible positions on these new techniques on a case-by-case basis. We call on you to fully take into account the 2012 Member State Expert Group conclusion that the legal definition of GMOs does not apply to most NBTs and that these techniques should be exempted from the rules of Directive 2001/18/EC.
Many NBTs, with mutagenesis techniques as a good example, generate mutations that are indistinguishable from those arising spontaneously in nature or through some forms of conventional breeding. Given that the communication of the European Commission has been postponed several times, we call on you to accelerate the process to clarify the legal status of NBTs; indeed, the status of mutagenesis techniques is a prime example of why this process needs to be sped up.
The focus should rather be on the products obtained by NGTs . See http://www.hautconseildesbiotechnologies.fr/fr/avis/avis-sur-nouvelles-techniques-dobtention-plantes-new-plant-breeding-techniques-npbt
We believe that patent law is an inappropriate instrument for agriculture and for selecting plant varieties because it stymies the work of farmers and breeders. Establishing the farmers and breeders' privilege in line with the CPVO was an important step forward that boosted the plant variety sector. For all of the aforementioned reasons, we call on you to ensure that genetic resources remain freely available in the future and that the work carried out by farmers and breeders will not be hindered. NBTs - and access to plant varieties obtained herewith - is a key instrument, as stressed above.

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G - Consumers' right for information/freedom of choice

*** 28. What is your view on the labelling of NGT-products? Please substantiate your reply**

Products obtained through new mutagenesis techniques should be labelled using existing labelling schemes. It is only appropriate to label products if they are distinguishable from those produced obtained through conventional breeding. Otherwise, such labels would be misleading to the consumer and therefore violate the Food Information to Consumers Regulation. In addition, if there is no difference in the labelled product, it would not be possible to enforce the labelling.

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H - Final question

* **29. Do you have other comments you would like to make?**

- (selected) Yes
- No

Please provide your comments here

In order to address the challenges presented by climate change, tackle plant diseases and protect biodiversity, a clear solution for new breeding techniques needs to be developed at European level. This is essential to avoid jeopardising the results achieved so far in the current agricultural model, which is increasingly oriented towards efficiency and sustainability.
The European Court of Justice's ruling on 25th July 2018 in case C-528/16 leads to uncertainty for European farmers. It entails a risk that research and innovation activities may be relocated outside the EU, severely hampering progress in plant breeding, depriving European farmers of the progress resulting from the use of these techniques, and negatively affecting the competitiveness of European agriculture as well as growth and employment in the EU's rural areas.
Modern mutagenesis techniques are already being used in some non-EU countries, but the products obtained using these techniques are not considered as genetically modified organisms (GMOs) and are thus not labelled as such in these countries. Besides the issue of import controls, importing agricultural products currently involves a real risk as it is impossible to guarantee their compliance with European rules. The EU may also have to do without the use of genetic material from third countries in order to improve plant varieties, including material for conventional cross-breeding techniques.
In addition, the requirements for the authorisation of GMOs in the EU and the high costs involved in the authorisation procedure prevent the European agricultural sector from benefiting from the scientific progress linked to the use of new mutagenesis techniques for breeding plant varieties. This leads to the EU being put at a competitive disadvantage compared with other regions which have a more innovation-friendly legal framework.
European farmers and agri-cooperatives need to have access to technological advancements in order to overcome a number of challenges, such as remaining competitive, adapting to and mitigating climate change, and providing an adequate supply of high-quality food. Guaranteeing legal certainty and establishing an efficient European single market for plant varieties are a basis for investments in the development of new seed varieties and are therefore of paramount importance for the future of European agriculture.
Ultimately, the objective must be to allow European farmers to take advantage of the sustainable opportunities opened up by innovation in biotechnology. Such innovation could help to enhance the uniqueness of the European agricultural model. Each NBT should be analysed and discussed by experts on a case-by-case basis and according to strict scientific criteria. The decision on evaluating them and ascertaining the correct regulatory approach should also be proportionate to the risks. See http://www.hautconseildesbiotechnologies.fr/fr/avis/avis-sur-nouvelles-techniques-dobtention-plantes-new-plant-breeding-techniques-npbt

We have called on the European Commission and Member States to fully take into account the findings of the Member States' expert group in 2012, which state that the legal definition of GMOs does not apply to most modern plant breeding techniques and that these techniques should be exempted from the provisions of Directive 2001/18/EC. Similarly, the conclusions of Advocate General Michal Bobek, presented on 18th January 2018, which also support this approach, should be taken on board. Since the European Commission's communication on this matter has been postponed on several occasions,
we have called on the European institutions to accelerate the process to clarify the legal status of NBTs. Indeed, the status of mutagenesis techniques is a prime example of why this process needs to be sped up. Modern mutagenesis techniques are an important part of new plant breeding techniques.
Their use is necessary in order to overcome certain challenges linked to climate change, to meet society's expectations concerning the reduction in the use of PPPs, and to ensure that the EU is not left behind in the globalisation of world trade.
In addition, we would like to mention the opinion of the German Bioeconomy Council (see SEM(19)1401(rev. 1)
https://biooekonomierat.de/en/publications/?tx_rsmpublications_pi1%5Bpublication%5D=129&tx_rsmpublications_pi1%5Baction%5D=show&tx_rsmpublications_pi1%5Bcontroller%5D=Publication&cHash=4a06627d0a672591d38af91661a8a288

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Contact

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Sustainability with climate focus

2019-12-02

Hans Berggren, CEO
Sveriges Stärkelseproducenter (SSF)

Lyckeby

Sveriges Stärkelseproducenter (SSF)

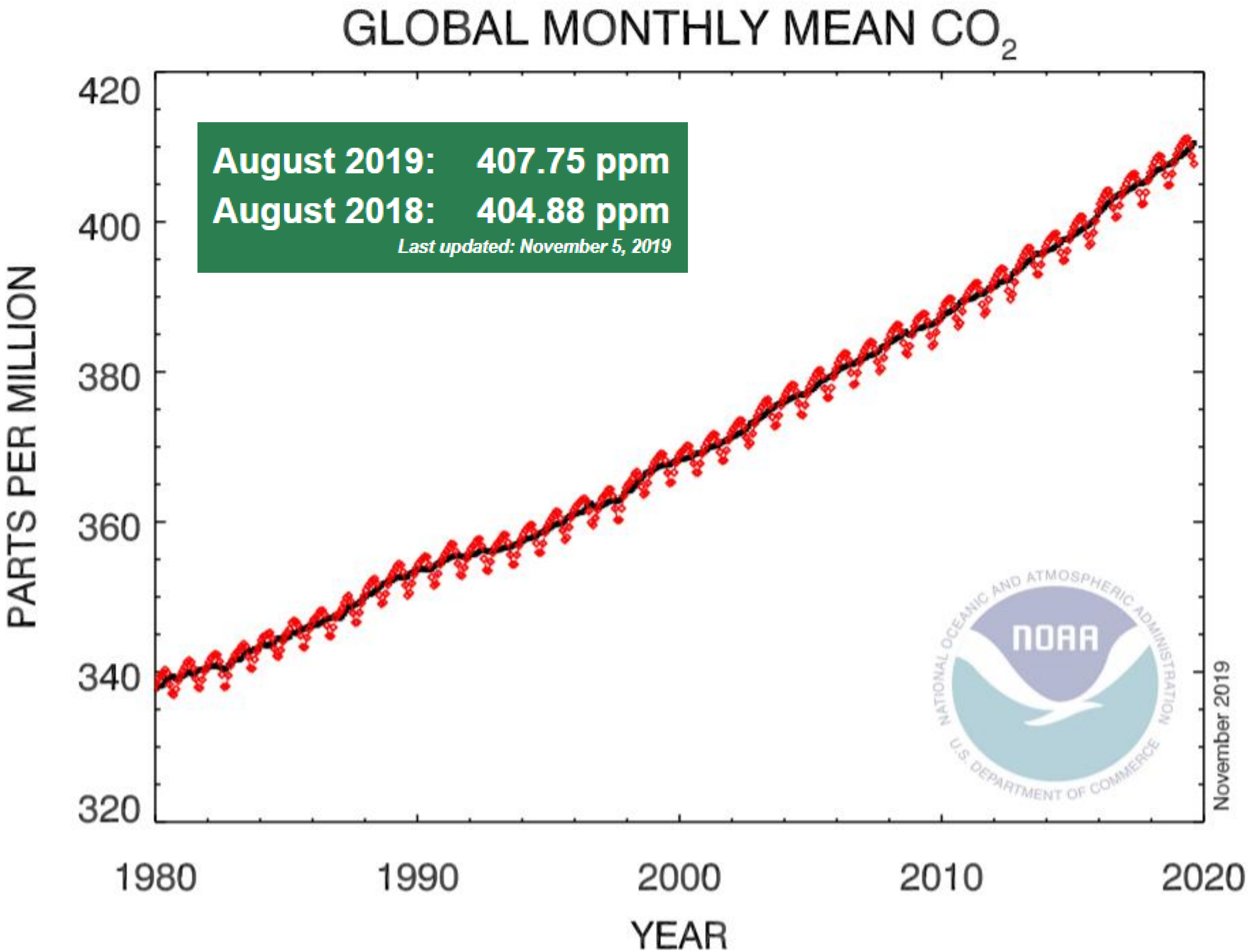
- Swedish Starch Producers Association
- Founded 1927
- Owned by 600 potato growers in southeast of Sweden
- 400 employees in Sweden + 300 employees abroad
- Represented in +50 countries
- Revenue 190 M€

Content

- What causes rising CO_2 content in the atmosphere?

- What can be done in Lyckeby?
  - **To reduce our footprint – topic of today**
  - To utilize starch replacing fossil material – topic of another day

- Need for political support

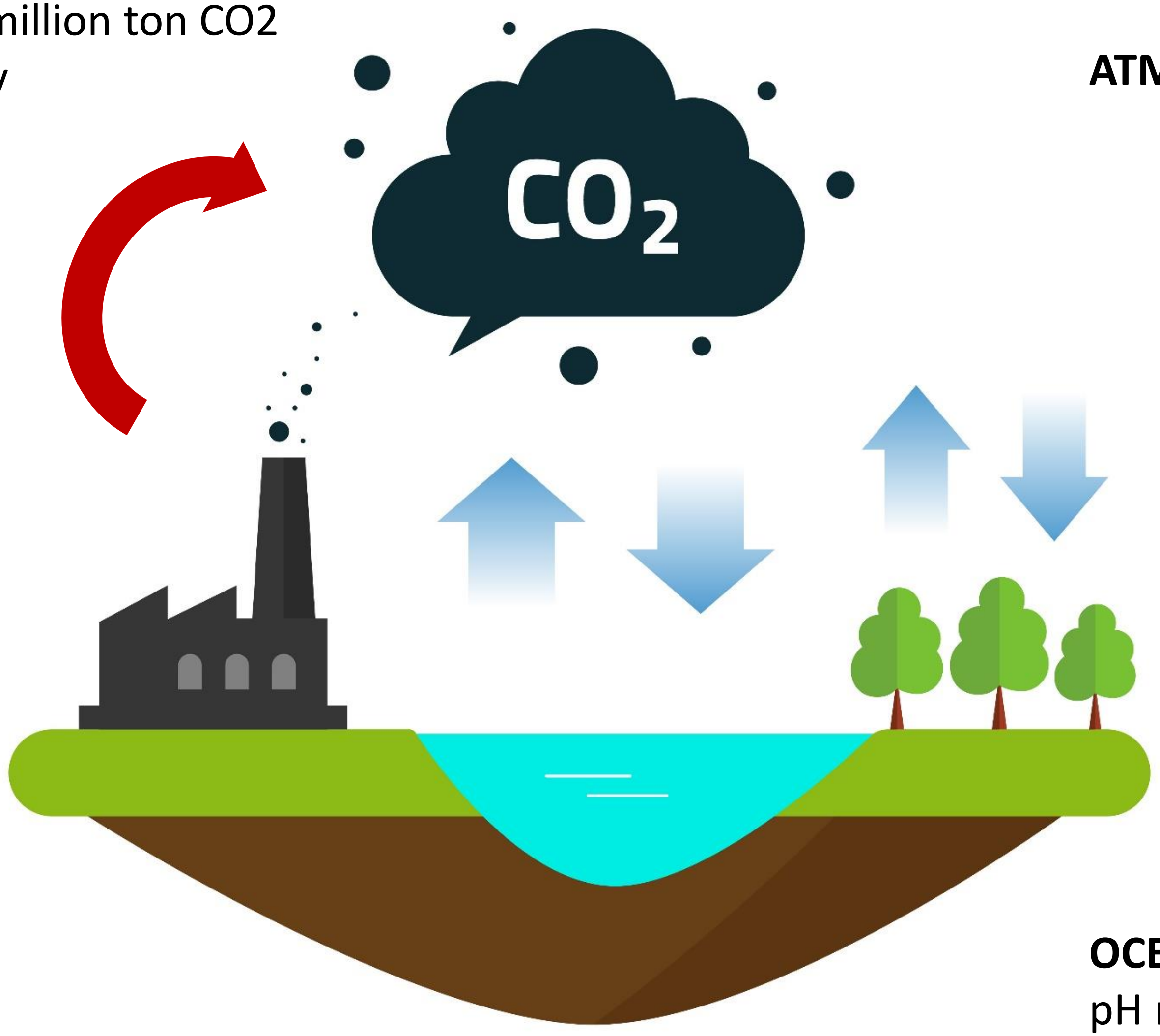


GLOBAL MONTHLY MEAN CO_2
August 2019: 407.75 ppm
August 2018: 404.88 ppm
Last updated: November 5, 2019
PARTS PER MILLION
420
400
380
360
340
320
1980
1990
2000
2010
2020
YEAR
November 2019

The Carbon Cycle

FOSSIL FUEL
+ 100 million ton CO2
per day

ATMOSPHERE CARBON



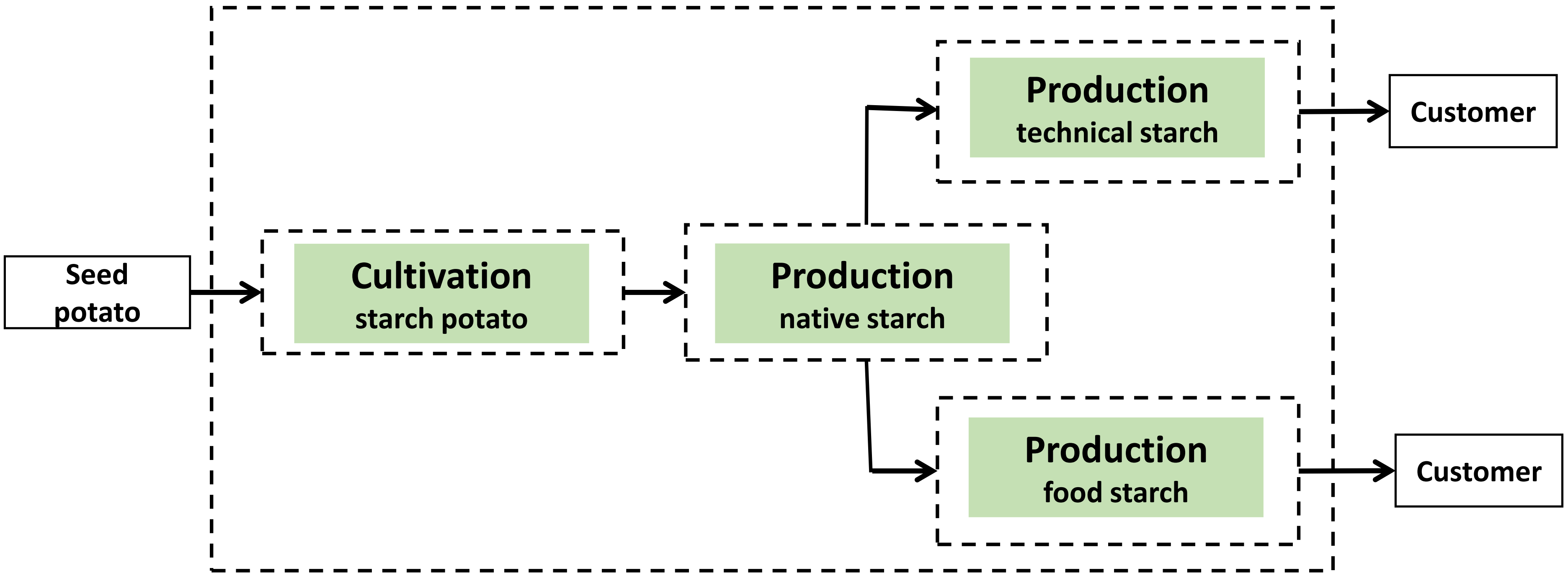
BIOSPHERRE CARBON
Biomass

OCEAN CARBON
pH reduction

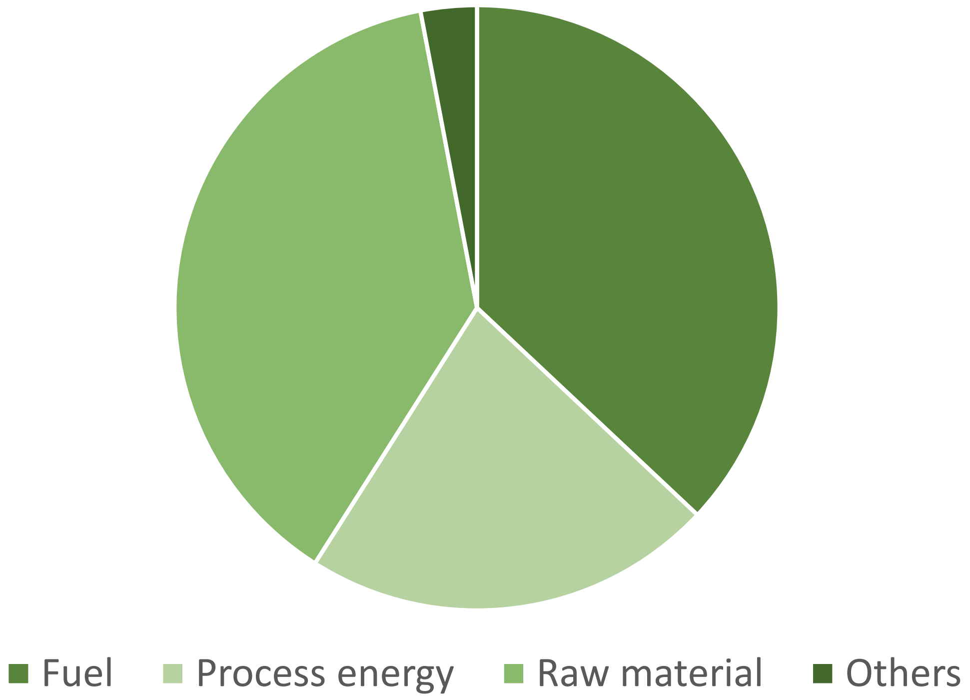
What can Lyckeby do?

Climate impact assessment with lifecycle perspective

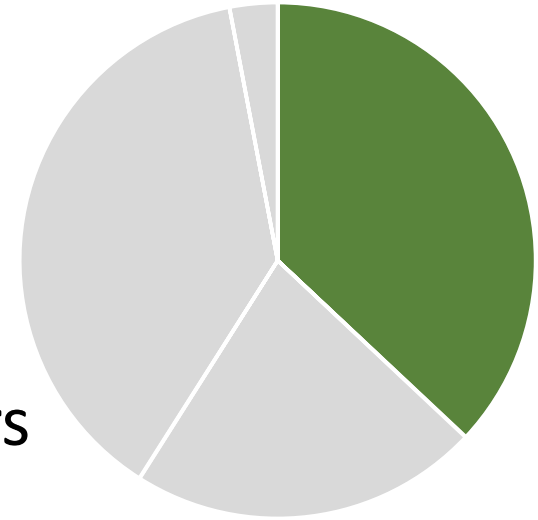
4 connected systems from cultivation to transport to customer



Distribution of total climate impact from our starch operations (%)



Fuel

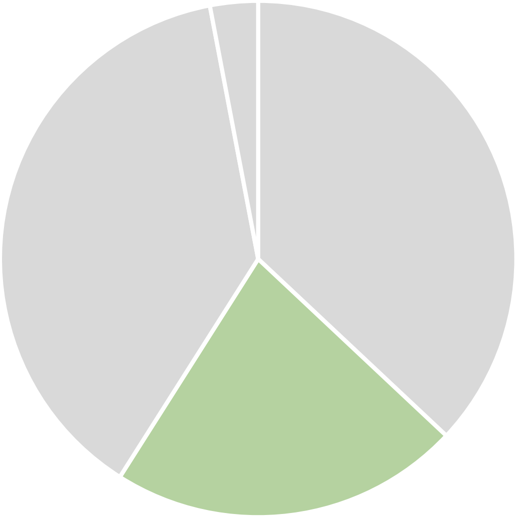


- Cultivation process, transport of potatoes and transport to customers

- Possible actions
  - → Reduce driving through better cultivation technology
  - → Reduce driving through better logistics
  - → Replace fossil fuel by electric power
  - → Replace fossil fuel through successively substitution
  - → Replace fossil fuel with HVO in own agreements

Lyckeby

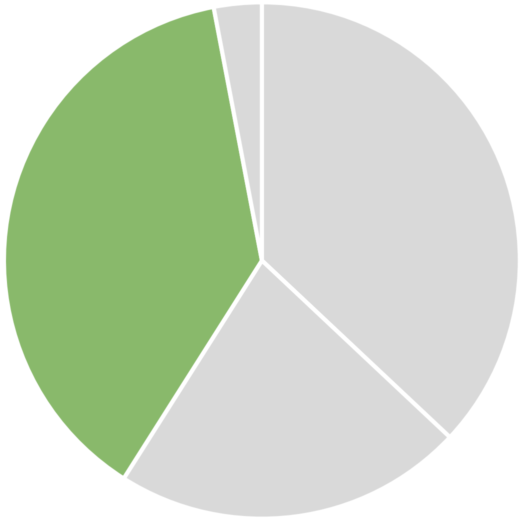
Process energy



- Production of native starch and refining of modified starch

- Possible actions
  → Reduce trough optimized processes
  → Conversion of steam boilers to electricity
  → Conversion of steam boilers to renewable energy
  → Increase proportion of clean label starch

Raw material



- Commercial fertilizers, plant protection, process chemicals
- Possible actions
  - → Reduce through optimal cultivation
  - → Reduce through optimal process
  - → Eliminate with modern plant breeding technologies
  - → Renewable energy for production of raw material

Site Directed Mutagenesis for Sustainable Starch Production

Lyckeby

Sustainable production

Vision
"The green starch factory"

Today:

Chemical modification

Similar technology for 80 years

Future:

Clean label starch – product of tomorrow

Clean label technology for eqvivalent products

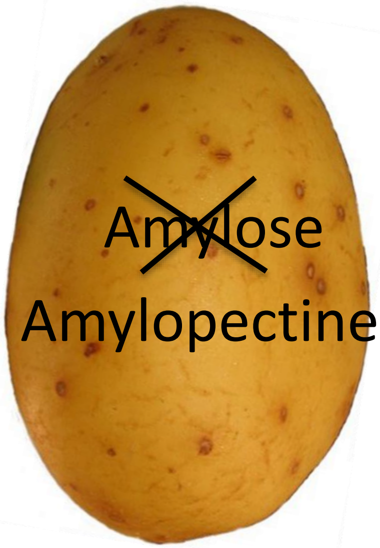
Lyckeby

Using NBT we have managed to solve storage stability.

Research project in collaboration with SLU

Lyckeby

Site directed mutagenesis for improved sustainability



Site-directed mutagenesis CRISPR-Cas9

New variety:

Amylopectine starch

- ✓ Natural storage stability
- ✓ No need of chemical modification

Reduction of process chemicals: **4-5000 MT/year**

Reduction of energy consumption: **0,5 GWh/year**

- Project started 2014
- 2019 → field production
- 2022 industrial production of new, climate friendly, starch products

Late blight resistant potato

- The use of plant protection products against leaf mold is extensive in potato cultivation
- By creating varieties that are naturally resistant to the fungus, we can reduce the use of plant protection by up to 75%
- At the same time, the use of fuel is reduced
- Breeding work is in progress, the first varieties will be evaluated in 2020

Lyckeby

Need of political support

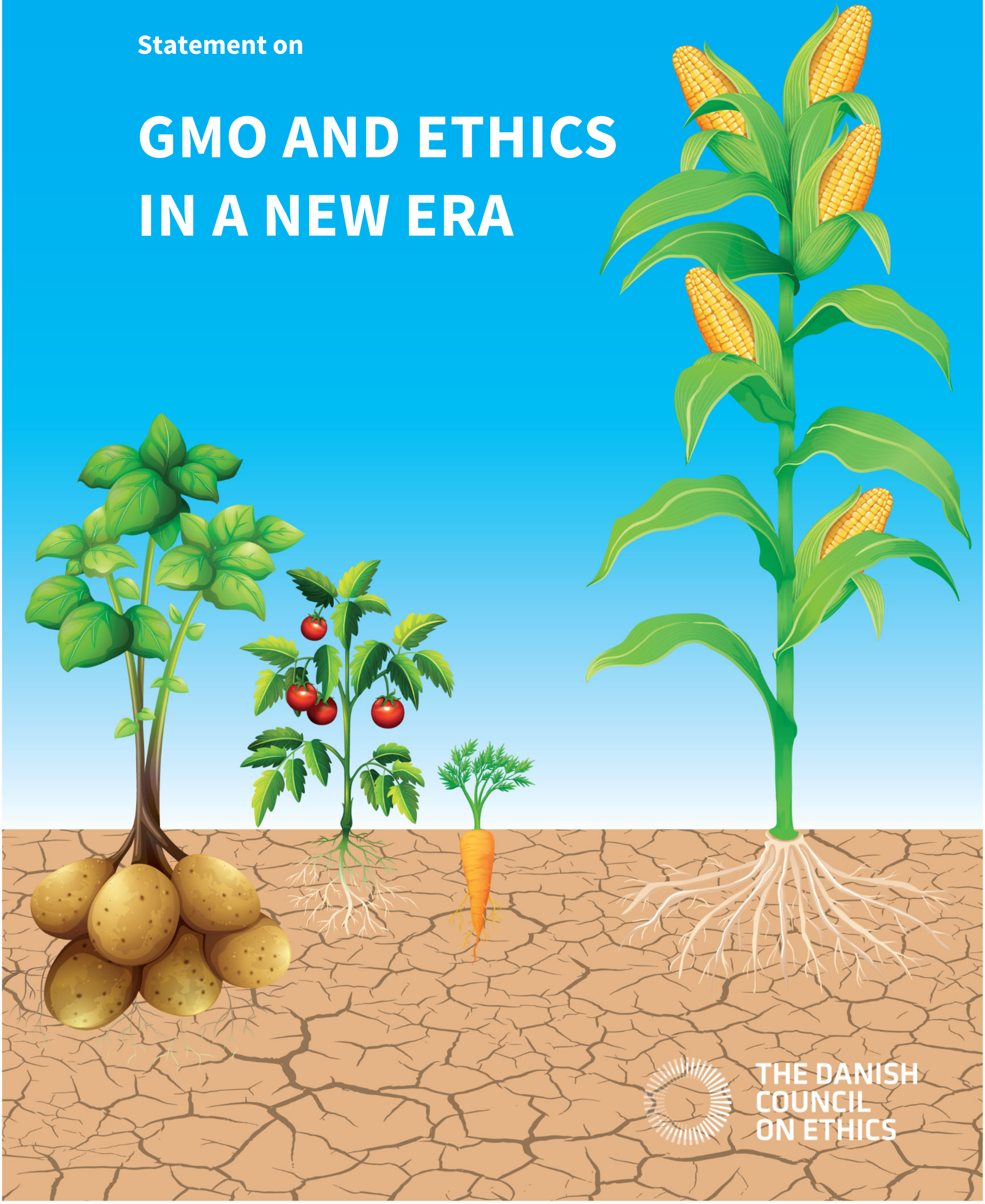
- Further policy decisions are needed to increase the availability of renewable energy sources
- Modern plant breeding is stopped by EU legislation, we need a change of the GMO-legislation

Lyckeby

Thank you!

Statement on

GMO AND ETHICS IN A NEW ERA



THE DANISH COUNCIL ON ETHICS

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GMO AND ETHICS IN A NEW ERA

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PREFACE

This statement has been prepared by a working group established by the Danish Council on Ethics in the winter of 2018-2019.

The Council would like to thank the following experts for having contributed to the working group:

Mickey Gjerris, Associate Professor of Bioethics at the University of Copenhagen;
Rikke Bagger Jørgensen, Senior Researcher Emeritus at the Department of Environmental Engineering, Technical University of Denmark;
Klemens Kappel, Professor of Philosophy at the University of Copenhagen;
Jørgen E. Olesen, Professor at the Department of Agroecology, Aarhus University and
Michael Broberg Palmgren, Professor of Plant Physiology at the Department of Plant and Environmental Sciences, University of Copenhagen.

Participating from the Danish Council on Ethics were Anne-Marie Axø Gerdes, Henrik Nannestad Jørgensen and Morten Bangsgaard (chair of the working group).

The Council would also like to thank Andreas Christiansen, Postdoc from the Department of Media, Cognition and Communication, University of Copenhagen for having prepared the background paper on ethical restrictions on GMO (*Danish title: Baggrundsnotat om restriktioner på GMO*) and the paper on whether GMO opposition is based on the perception that naturalness is good in itself (Danish title: *Skyldes GMO-modstand at naturlighed opfattes som godt i sig selv?)* We are also grateful to Torben Chrintz, Scientific Adviser at the think tank Concito; June Rebekka Bresson from Noah, Friends of the Earth; and Arne Holst-Jensen, member of the Norwegian Biotechnology Advisory Board and Senior Scientist at the Norwegian Veterinary Institute for their presentations at the Council meetings.

Morten Andreasen and Anne Lykkeskov have prepared the statement in the Council's secretariat.

The statement has been transacted by the Council on three meetings in October 2018 and January and February 2019.

Anne-Marie Axø Gerdes
Chairperson of the Danish Council on Ethics

Christa Kjøller
Head of Secretariat

STATEMENT ON GMO AND ETHICS IN A NEW ERA

Many factors have changed since genetically modified organisms made their entry in Europe more than 30 years ago, and the Danish Council on Ethics therefore finds that the time has come for a renewed debate on GMO. New types could potentially play a positive role in achieving several of the UN's Sustainable Development Goals from 2015. In this statement, the question of whether GMO's technology could and should be used to develop plants with traits beneficial to achieving the goal of taking urgent action to combat climate change is used as an example of the potentials of GMOs'. Other examples could be the goals to end hunger, to promote sustainable use of ecosystems and to achieve food security and ensure sustainable consumption and production patterns. The Council provides recommendations on the question of whether it would be ethically problematic to reject GMOs with beneficial traits provided they are not assessed as posing a higher risk to humans or the environment than similar varieties developed by conventional methods. The Council's opinion moreover implicates recommendations for a change of the EU's authorisation system for GMOs and other plants with new traits

1. Introduction

The public opposition that has been levelled against genetically modified organisms (GMOs), and especially GM plants, since their introduction in Europe more than 30 years ago[1], has largely been based on arguments of ethics. Genetic modification was looked upon as a particularly invasive technology that would change nature in unprecedented ways. Since no experience had been gained with such invasive changes before, people were afraid of the risks in the form of unintended events that could arise in the short and long term.

Several things have changed in these 30 years, however, and the Danish Council on Ethics therefore finds it relevant to call for a renewed debate on the ethical implications of genetically modified plants:

- **The techniques have improved**, and especially the CRISPR technology, developed in 2012, has made it far more simple to quickly and more accurately alter genes without inserting genetic material from other species. In addition, it is possible to make small changes like turning genes on and off[2]

[1] Genetic modification of crop plants was developed in the 1970s, and since the 1980s, the technology has been used to add novel traits to plants, see National Academies of Sciences, Engineering, and Medicine. 2016. *Genetically Engineered Crops: Experiences and Prospects*. Washington, DC: The National Academies Press, 5

[2] A change could cover one or more of the following features of a gene: the gene's code (the bases of the DNA), its functional product (amino acids and/or protein folding structure), or its activity level (from completely turned off to hyperactive)

- We now have more than 20 years of research into **risks** which shows that there is no scientific evidence that GMO in itself entails a greater risk than conventional plant breeding technologies[3],[4]

- **Benefits to societies:** Some developers, e.g. universities and small seed breeders, have started developing GMOs which are of relevance to the handling of serious societal problems, including the climate challenge and the biodiversity challenge

It seems today that not all GMOs should be assessed in the same way from an ethical point of view. There is nothing to suggest that gene modification per se has any bearing on how risky new plants are. This makes it relevant to question if the EU's Deliberate Release Directive[5] is up-to-date given that it requires all genetically modified organisms to be subjected to the same comprehensive and costly authorisation procedure before being released for cultivation in the EU. It also raises the question of whether it is ethically problematic if the legislation obstructs the development and marketing of GMOs, e.g. those with positive effects, if they are not deemed more risky than similar conventional varieties.

The EU defines a GMO as: an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination.
Both plants and animals can be GMOs, but this statement focuses solely on genetically modified plants.

In the following we use the climate challenge as an example of a serious threat to which GMO could contribute positively. The same principled considerations could be applied to the use of GMOs in other areas. Climate change is an acute threat to the foundations of life for human beings now and in the future, and the window for action in relation to avoiding temperature increases of more than 1.5°C above pre-industrial levels is quite narrow. It is obvious that neither GMO nor any other single solution will be enough to solve the problem of climate change. More and more, however, indicates that we are in a situation where we cannot afford to turn down any measure that can contribute to mitigating or limiting the impacts of climate change, unless there are good reasons for doing so. The Council therefore finds that the time has come for a renewed debate on GMO.

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[3] National Academies of Sciences, Engineering, and Medicine. 2016
[4] EU Commission. 2010. A decade of EU-funded GMO research (2001-2010), 16
[5] Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC

2. Why are fast changes to the plants we eat necessary?

In October 2018, the Intergovernmental Panel on Climate Change, IPCC issued their report6 on the measures needed to limit global warming to 1.5°C above pre-industrial levels – the target set by the global leaders in Paris in 2015.7 The report concluded that this can still be achieved but that it will, among other measures, require unprecedented transitions in the use of global land areas. Large areas should be converted into permanent vegetal cover, e.g. planted or self-sown forest and other natural habitats, thus reducing the area for agricultural production immensely. Since the industrialisation, CO_2 emissions from human activities have already caused the temperature to increase by 1oC, causing the changes we are already experiencing in the form of extreme weather events, melting ice in the Arctic Region, rising sea levels, etc.

The Paris Agreement 2015

At Paris COP21 in December 2015, 196 member states of the UN ratified the UN Framework Convention on Climate Change (UNFCCC), which is a legally binding climate agreement known as the Paris Agreement.

The Paris Agreement's long-term goal is to keep the increase in global temperature to below 2°C – and to work towards limiting the increase to 1.5°C above pre-industrial levels.

The IPCC report on global warming of maximum 1.5°C

After the Paris Agreement was ratified in 2015, the member states asked the Intergovernmental Panel on Climate Change (IPCC) to prepare a report by 2018, detailing the possibilities of achieving the goal of keeping global warming at 1.5°C above pre-industrial levels.

The 91 experts responsible for the report make it clear that if the goal is to be achieved, CO_2 emissions must reach net zero around 2050. But it is not enough: CO_2 must be removed from the atmosphere as well. One approach could be to plant more forest in very large areas, combining it with so-called BioEnergy Carbon Capture and Storage (BECCS) where the wood is combusted at power plants and the CO_2 is captured and pumped into the underground. Another approach could be to develop even more high-yielding crops for biomass production, for example via CRISPR technology and in conjunction with BECCS. It is, however, debated whether this technology would work adequately.

[6] IPCC. 2018. *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for Policymakers*

[7] UN. 2015. The Paris Agreement, see: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

If temperature rises are not to accelerate, it is not enough to reduce future greenhouse gas emissions; we will also need to remove CO_2 from the atmosphere. Since trees and other plants absorb CO_2, a central approach would be to increase the areas of natural habitats on a large scale, including self-sown and planted forest.[8] The protection of a number of habitats, such as peat bogs, rain forest and seagrass beds, could have a positive effect in terms of limiting climate changes by absorbing and storing carbon, thus reducing the amount of carbon dioxide in the atmosphere.[9] The global area utilized for the cultivation of food would thus need to be reduced significantly.[10] This is an enormous challenge, which only grows bigger as the global population will increases from 7.5 billion in 2017 to 11.2 billion in 2100 according to the UN estimate.[11] We will need to feed a rapidly growing global population while reducing agricultural land considerably. It must be achieved concurrently with climate changes that are challenging agricultural production in many places, causing droughts and seawater floods which make cultivation of the soil no longer tenable.

One of the conditions for being able to produce more food in a smaller area and under more extreme weather conditions caused by climate change, is the ability to develop very efficient and **higher yielding plants** that can yield more in a smaller area. It will also be beneficial to develop plants that are better at **binding CO_2** in the soil or can do with less fertilisation or ploughing since both of these activities increase the emission of CO_2 from fossil fuels **(climate mitigation)**. In addition, we must develop plants that can adapt to the climate changes we are already experiencing, even in Denmark, and which will only become more common in the future, e.g. by being able to adjust to major variations in precipitation, etc. **(climate adaptation)**. It may be possible to develop such types of plants via conventional processing techniques, but with the CRISPR technology such varieties can in many cases be developed quicker and more accurately.

2.1 Conventional breeding

Throughout the thousands of years where humans have cultivated land, farmers have selected the best specimens among their harvested crops and have crossed them with each other to combine the best traits. Thus, the natural genetic variations in plants have been the basis of the alterations in traits – and thus the genetic composition – of

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[8] IPCC. 2018*, s 22*
[9] Barfod, A et al. 2019. Vi kan stadig nå at bremse klimakrisen, men uddør en art, er den væk for altid. [There is still time to slow down the climate crisis, but once a species is extinct, it is gone forever] *Politiken,* 24 February.
[10] IPCC reports that the area no longer to be used for agricultural production is the size of the USA (10 million km^2), adding that energy crops will need to be planted in an area the size of Australia (up to 7 million km^2)
[11] UN. 2017. World population prospects. 2017 revised

the crop plants. Developing new plan varieties through crossbreeding takes a long time, normally 12-16 years.

The development of new, more valuable plant varieties is called plant breeding. A distinction is traditionally made between *conventional* and *biotechnological* plant breeding. However, this is somewhat misleading as conventional plant breeding also makes use of biotechnology, e.g. so-called DNA marker assisted selection (MAS), chromosome doubling, etc.

The traditional mutagenesis techniques, which are still being used, were developed in the 1940s in response to the challenge that it was often impossible to find the genetic variant in the species itself that would enable the needed progress through traditional plant processing. Scientists began altering the genome of living organisms by introducing mutations, for example by irradiating them with a radioactive source or exposing them to mutagenic chemicals.[12] Both spontaneous and induced mutations increase the genetic variation that the plant breeder bases his work on. In both cases, the results are random mutations, meaning that it is not possible to control where they occur. Induced mutagenesis is thus an "inaccurate genetic modification".

The vast majority of mutations are either neutral or undesireable, both for the plant's ability to survive in nature and as a crop plant. Once an attractive trait/mutation is identified, several rounds of *backcrossing* are therefore necessary, crossing the mutant plant with high-yielding varieties and selecting the offspring that has retained the attractive trait and, as far as possible, has not inherited any of the bad mutations. This technique is usually time-consuming, and there is no guarantee that all bad mutations are removed. The types of genetic modification that does not introduce genes from other species are collectively referred to as **mutagenesis**.

2.2 Gene technology and CRISPR

When gene technology entered the scene, it was revolutionary in enabling a more targeted alteration of plant genes. For example, it became possible to introduce genes from other plants of the same or closely related species – so-called **cisgenesis** – thus reducing or eliminating the subsequent plant breeding processes. And it became possible to introduce DNA from organisms with whome the plant cannot reproduce in nature – so-called **transgenesis**.

The first gene modification techniques were inaccurate and time-consuming, so initially the progress was much slower than expected. However, in recent years,

[12] van Harten AM. (1998) *Mutation Breeding: Theory and Practical Applications,* 353 pp. Cambridge: Cambridge University Press.

technological advances have been fast and comprehensive. Especially the **CRISPR** technology, developed in 2012, has made it far simpler, quicker and more accurate to alter genes without inserting genetic material from other species. The **CRISPR** technology can be aplied to all the three types of modifications, but it enables a more accurate modification than the previous techniques. Many people therefore use the term 'gene editing' or, when the changes do not introduce external genetic material into the plant but merely knocks out selected genes, the term 'precision mutagenesis' about changes produced by CRISPR.[13]

3. European opposition to GMO

When the general public became aware that scientists were working on changing what was considered the "basic ingredients" of organisms, the genes, it caused widespread concern. In particular, the thought of inserting genes from completely different organisms into plants was troubling. Did scientists want to redesign nature entirely, and would they ever be able to grasp what the long-term consequences of what they had started would be?

It was also feared that GM foods would be dangerous to consume and that the edited plants would spread uncontrollably in nature. However, in 2016 an extensive US review of 20 years of GMO research was published. It documented that the existing GM plants had neither caused health damage to the livestock they had been fed to, nor to the people who had consumed them.[14] Other major studies have show similar results: the application of genetic modification does not in itself involve higher risks than, for example, conventional plant breeding technologies.[15] It has been argued by GMO opponents that feeding animals with GM food has caused diseases such as infertility, tumours and premature death. In none of the cases, however, did the documentation presented by the opponents live up to the requirements for scientific studies.[16]

Nonetheless, it should be noted that the existing risk assessments are based on only a few types of GMOs. The fact that no risks have been shown in these particular types is therefore no guarantee that no risks will be found in other types of GMO in the future. For example, the problem of spreading (invasiveness) depends on which traits are being edited or inserted. So far, we have almost exclusively seen types of traits that are

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[13] Danish Agricultural Agency. 2018. *Hvad kan de nye planteforædlingsteknikker bruges til og hvordan skal de reguleres? [What is the potential of the new plant breeding techniques, and how should they be regulated?]*

[14] National Academies of Sciences, Engineering, and Medicine. 2016. *Genetically Engineered Crops: Experiences and Prospects*. Washington, DC: The National Academies Press,

[15] EU Commission. 2010. A decade of EU-funded GMO research (2001-2010), 16

[16] American Association for the Advancement of Science. 2012. *Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods*

advantageous only in the cultivated ecosystem where, for example, herbicides are applied. Such alterations would not do well outside the fields. But other traits such as salt and drought tolerance might grant the plant an advantage in the wild and thereby increase it's potential to spread.

Therefore, the risk assessments completed so far show that *not all* GMOs pose a risk to human beings or to nature – i.e. there is no basis to reject all GMOs as risky. However, the studies cannot be used to argue that *no* GMOs are risky. It is conceivable that at some point in time GMOs will be developed with different traits that will pose a risk to humans or to nature. Similarly, it is conceivable that in the future new varieties developed by means of conventional technologies could turn out to be risky.[17] This indicates a need to establish an authorisation system that does not treat all GMOs as risky and all other new varieties as not risky. A system that to a higher degree looks at the type of alteration that has been introduced as the basis of deciding which varieties needs to be subjected to risk assess.

The public opposition to GMO, especially in Europe, has not diminished over time. Whereas the acceptance of gene technology to develop new treatments for diseases in humans has risen since first introduced, the same cannot be said for applying gene technology to plants. There are several reasons for this tendency, which we will return to.

The strongest opposition is in Europe, and until 2017, only one single crop has been authorised for cultivation in the EU. It is a type of maize (MON810), which is grown in approximately 100,000 hectares every year in a number of southern European countries.[18]

In the rest of the world GMO is gaining ground. So far, four types of crops (soya beans, maize, cotton and oilseed) and two types of traits (herbicide tolerance and insect resistance) have been dominant. Among them, GMOs with either of these two traits made up 99% of the GMO-covered area in 2017.[19] The GMO crop that is used most widely in the world is RoundupReady soya that, by means of genetic modification, has been made resistant to the herbicide glyphosate, which is the active substance in Roundup from Monsanto, a multinational seed and chemical company. The resistance

[17] The Lenape potato is an example of conventional breeding leading to serious and unintended effects, see Zitnak A and Johnston GR. 1970. Glycoalkaloid content of B5141-6 potatoes. *American Potato Journal*, Vol 47, no 7: 256–260

[18] Danish Agricultural Agency. 2018. *Hvad kan de nye planteforædlingsteknikker bruges til og hvordan skal de reguleres? [What can the new plant breeding techniques be used for, and how should they be regulated?]*

[19] ISAAA. 2017. *Global Status of Commercialized Biotech/GM Crops in 2017: Biotech Crop Adoption Surges as Economic Benefits Accumulate in 22 Years*. ISAAA Brief 53, 105

implies that the genetically modified soya is not affected when farmers spray it with Roundup whereas other plants, weeds, etc. are killed.

Bt cotton is an example of an insect-resistant crop that carries a gene from a bacterium that makes the plant produce Bt toxin. Bt toxin is harmful to certain insect pests, which are thus controlled without the farmer having to use pesticides. This is an advantage because it avoids the spread of toxins that would affect several organisms in and outside the field and not just those insects that damage the crops.[20]

There are, however, also problems associated with these uses of GMO. There have been reports of insects and weed plants that have developed resistance to a herbicide, likely as a result of local excessive use of that particular substance.[21]

What many of the reported problems generally have in common is that they are not the result of genetic modification in the sense that they will be present in any genetically modified organism. The problems concerns only *certain GMOs*, more specifically those that are dominant today which have been developed for a certain type of farming characterised by monoculture. The widespread use of GMO plants with, for example, Roundup-tolerant traits has even given rise to monocultures of plants with this transgene.

This has made many critics not impressed by this type of GMO. They consider it a problem that the varieties have been developed by the agrochemical industry, which appeals to large-scale farming, monoculture and a high requirement of external resources and where the sale of seed corn is linked to the sale of chemicals, which essentially is not sustainable. The fact that these GMO varieties are covered by patents, while Europe has had no tradition for patenting new varieties, has also led to widespread criticism. Because of the patenting system, farmers who would wish to set aside seed corn for next year's sowing, cannot do so because they are forced to buy the seeds from the seed company. This can be a problem for farmers in developing countries in particular.

The fact that GMO with these two traits are so dominant has made many critics regard GMO as inseparable from the use of pesticides, dependence on multinational seed and chemical companies, less diverse cultivation systems and patenting. All of this had

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[20] ISAAA. 2017. *Global Status of Commercialized Biotech/GM Crops in 2017: Biotech Crop Adoption Surges as Economic Benefits Accumulate in 22 Years*. ISAAA Brief No. 53. ISAAA: Ithaca, NY, p 3
[21] National Academies of Sciences, Engineering, and Medicine. 2016, 144

made it difficult for Europeans to consider GMO as progress, and the opposition has been consistently strong throughout all these years.

4. CRISPR as a tool to introduce positive climate traits

In recent years, quite a lot of research has been carried out by universities and smaller manufacturers to develop genetically modified plant varieties with entirely different traits than the two mentioned above. They for example develop plants that are more resistant to disease, that are healthier to eat, that can keep for longer (so reducing food waste), etc.[22]

In addition, varieties with beneficial climate traits are developed, including:

- Varieties that are **high-yielding** and thus area-efficient while being able to survive with **less fertilisation, spraying or ploughing** (e.g. *de novo* domesticated tomato) or **store more CO_2** in the roots (e.g. perennial grains) **(climate mitigation)**,

- Varieties that can adapt to the climate changes, e.g. by being **drought resistant or salt tolerant (climate adaptation)**.

Both conventional and organic production still have far to go before they meet the need for making plant production better adapted to a changing climate. Conventional production is high-yielding, but is a burden to the climate and the environment. Organic production is in many cases better for the environment[23], but produces a lower yield per hectare or per animal. It therefore requires a larger area that could have been used for natural habitats, e.g. forest. Both production types could turn out to suffer substantial reductions in yield if climate-resilient varieties are not developed. Gene technology is one of many means that appears capable of offering solutions.[24]

A new field of research departs from the fact that many of the traits required to achieve the above-mentioned goals are already present in the plants' wild relatives from which the commercial variants were once developed. Or in wild plant species that so far have not been developed for modern food production. This has inspired researchers to start with these wild species and refine them rather than continue breeding on the present crops. Only this time make the improvements in a more

[22] Norwegian Biotechnology Advisory Board 2018. *Genteknologiloven – invitasjon til offentlig debatt. Sammendrag [Gene technology legislation – invitation to public debate. Summary].*
[23] However, a knowledge synthesis from 2015 has indicated that the nitrogen load from organic pig farms was significantly higher compared to conventional pig farms.
http://icrofs.dk/fileadmin/icrofs/Diverse_materialer_til_download/Vidensynte_WEB_2015__Fuld_laengde_400_sider.pdf
[24] Other methods include contemporary MAS and changed agricultural practices – e.g. crop rotation practices, choice of crops, two varieties per season, etc.

targeted way through so-called *de novo* domestication.[25,26] This process is based on mutating so-called domestication genes in the not yet cultivated plant[27,28].

A domestication gene is a gene that, once mutated, results in a plant with desirable traits for human use of the plant. The result of the mutation is often the destruction of the gene or its delicate regulation. This leads to the loss of a trait that is important to the wild plant but might be undesirable from a cultivation perspective. For example, wild rice drops its ripe seeds in the blowing wind while cultivated rice has been bred to avoid this. Whereas this is a loss for the wild plant because it makes it difficult for it to spread, it is an advantage for farmers who want to harvest the rice. We know of many domestication genes today, although the number of domestication genes is still debated.[29]Research published in the autumn of 2018 has shown that wild tomatoes can be *de novo* domesticated by introducing only six mutations. This allows wild or semi-cultivated crops which already possess the desirable positive traits to be *de novo* domesticated, in principle, by mutating genes that show similarities with domestication genes in close relatives. For example, it is doubtful whether transgenesis or mutation technologies can be used to tweak a given plant to store more CO_2 in its roots. But if a wild plant is known to have this trait already, it should, in principle, be possible to use mutation technology to domesticate the plant while preserving its ability to store CO_2 in its roots. However, the increased carbon capture in the roots will ultimately require improved photosynthesis for the plant to maintain its yield.

Domestication genes
Recent years' sequencing of the plant genome has led researchers to identify the genes – so-called domestication genes – that make the plants commercially attractive, e.g. in terms of fruit size and fruit yield, shelf life and form.

The background paper describes an example of such a *de novo* domesticated variety developed by means of the CRISPR technology. This is the result of entirely new

[25] Østerberg JT, Xiang W, Olsen LI, Edenbrandt AK, Vedel SE, Christiansen A, Landes X, Andersen MM, Pagh P, Sandøe P, Nielsen J, Christensen SB, Thorsen BJ, Kappel K, Gamborg C, Palmgren M. (2017) Accelerating the domestication of new crops: Feasibility and approaches. *Trends in Plant Science*. 22(5):373-384.
[26] Zsögön A, Cermak T, Voytas D, Peres LE. (2017). Genome editing as a tool to achieve the crop ideotype and de novo domestication of wild relatives: Case study in tomato*. Plant Science.* 256:120-130.
[27] Doebley JF, Gaut BS, Smith BD. (2006) The molecular genetics of crop domestication. *Cell*. 127(7):1309-21.
[28] Comai L. (2018). The taming of the shrub. *Nature Plant*s. 4(10):742-743
[29] Torkamaneh D, Laroche J, Rajcan I, Belzile F. (2018). Identification of candidate domestication-related genes with a systematic survey of loss-of-function mutations. *Plant Journal*. 96(6):1218-1227.

research[30,31] and involves studies where wild tomato yielded more, larger and more resilient fruits (the fruits of wild tomatoes are rather small, so they are low-yielding) merely as a result of a few and minimal CRISPR-induced mutations in the plant's DNA. The wild tomato itself has a number of the traits that are desired and are difficult to breed in modern tomato varieties:

- Resilience to drought, which could limit the need for irrigation and increase yields in periods of drought
- Resilience to pests, which could limit the need for pesticides
- A high content of lycopene, which is considered to have positive health effects
- Salt tolerance, corresponding to tolerance to water shortage, as salt extracts water from the plant[32]

CRISPR technology is thus used to perform precision mutagenesis, i.e. 'internal' editing of the plant's genes, but carried out with higher accuracy compared to traditional mutagenesis. Genes from other organisms are not added.

The other example concerns work done to modify the wild grass *Thinopyrum intermedium* (or *Intermediate wheatgrass*) where conventional plant breeding has so far been a very slow process, and where the CRISPR technology is thought to be able to accelerate the breeding process. This is another variety that has a lower yield than its developed modern varieties, but on the other hand has several climate-friendly features, first and foremost because it is a perennial and has a large root system (up to 3 m deep). It can be 'cut' like lawn grass, which means no harvesting of the roots and no ploughing. This offers several advantages to farmers, the environment and the climate:[33]

- the plant can survive long periods with limited precipitation and is thus better adapted to weather fluctuations caused by global warming
- the plant is better at absorbing nutrients, which limits the requirements for fertilisation and reduces nutrient leaching

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[30] Li T, Yang X, Yu Y, Si X, Zhai X, Zhang H, Dong W, Gao C, Xu C. (2018). Domestication of wild tomato is accelerated by genome editing. *Nature Biotechnology*. doi: 10.1038/nbt.4273

[31] Zsögön at al. 2018. De novo domestication of wild tomato using genome editing. *Nature Biotechnology* 1. October, doi:10.1038/nbt.4272

[32] Zsögön at al. 2018

[33] Lubofsky, E. 2016. The promise of perennials: Working through the challenges of perennial grain crop development. *CSA News* Vol. 61 No. 11, p. 4-7

- the plant binds more carbon in the soil, which is good for the climate
- it becomes harder for weed plants to take hold, which reduces the need for herbicides or manual weeding
- farmers can avoid many rounds in the fields whether it is fertilising, spraying, ploughing, harrowing, etc., which emit CO_2 and are time-consuming
- the soil quality is improved because the roots reduce erosion and add carbon and structure, and because the soil is not compressed by the frequent passage of machinery

With the first mapping of the *T. intermedium* genome in 2018[34] and knowledge of the wheatgrass' domestication genes, a much more targeted breeding process looks achievable. It can prove difficult and time-consuming to use conventional breeding means to develop a variety with all the traits that makes it both commercially useful and climate-friendly. Crossbreeding of *T. intermedium* with other wheat variants such as spelt has been tried in various forms, but those variants that gained a remarkably better yield lost their perennial qualities. This is yet another example where it is conceivable that the CRISPR technology could be used to domesticate the crop through targeted mutations in domestication genes, and without losing good genes in the crossing process. It might be easier to breed already perennial grass into a perennial grain than turning a modern annual grain, such as wheat, into a perennial.

Even with the use of CRISPR technology, it is not certain that we can produce varieties that are at the same time climate- and environment-friendly, high-yielding and commercially attractive. But no matter the technology, we should be able to make progress. As indicated above, the use of CRISPR technology to perform precision mutagenesis, will likely allow progress to be made far quicker than the use of traditional technologies.

Because of CRISPR, even small research environments and companies can now get much more involved in gene technological processing with the potential of making food production significantly more adapted to the climate. The problem in terms of developing GMO that benefits society is, however, that, in Europe, universities and small-scale manufacturers cannot get their plants authorised for deliberate release

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[34] Kantarski, T, Larson, S, Zhang, X et al. 2017. Development of the first consensus genetic map of intermediate wheatgrass (Thinopyrum intermedium) using genotyping-by-sequencing. *Theoretical and Applied Genetics,* Vol 130, no 1: 137-150

into the environment because they cannot afford to go through the comprehensive safety assessments required by EU legislation.

5. EU GMO legislation and the mutagenesis exemption

In 2001, the public opposition in the EU against GMO resulted in the adoption of the so-called Deliberate Release Directive,[35] which establishes that genetically modified organisms must undergo an authorisation procedure before they can be released for cultivation in the EU. Thus, they must satisfy multiple requirements that new varieties created through other means must not. Among other things, the manufacturer must carry out extensive assessments of risks to human health and the environment posed by the deliberate release of the specific GMO.

Since the conduct of these risk assessments is a major economic expenditure, it is a paradox that only the multinational seed companies can afford risk assessing their GMOs. Researchers at universities and small companies are in reality prevented from seeking authorisation of their plaints in the EU due to the cost of conducting these risk assessments.

Lately, another paradox of the legislation has been discussed. In the directive, new varieties whose genes have been edited through irradiation or chemical treatment have been exempted from the authorisation procedure through the directive's so-called mutagenesis exemption. The reason is that they ”have conventionally been used in a number of applications and have a long safety record.”[36]

This seems to indicate that organisms developed by mutagenesis are not considered risky. In response to this, researchers have pointed out that the type of genetic changes involved in employing CRISPR technology e.g. to introduce domestication genes as described above are much more limited and controlled than mutations introduced by traditional mutagenesis. In other words, you cannot credibly claim that the uncertainty associated with the use of CRISPR makes the technology more risky than the practices we are already using and have used without any significant problems for centuries – on the contrary, the uncertainty seems to be far smaller. This will be elaborated on in the background paper (available only in Danish on the website of the Danish Council on Ethics).

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[35] Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC

[36] Ibid, whereas-clause 17

The European Court of Justice was requested to decide on these considerations, and it delivered its judgment on 25 July 2018. To many people's surprise, the court upheld that only organisms obtained by traditional mutagenesis should be exempt from the directive's requirement for safety approval. The grounds cited by the court was that "the development of those new techniques/methods makes it possible to produce genetically modified varieties at a rate and in quantities quite unlike those resulting from the application of conventional methods of random mutagenesis." [37]

Whereas opponents of GMO were generally satisfied with the judgment, the research communities have demanded that the legislation be changed. They want the legislation to no longer be based on *which technique* has been used to develop the plant, but to focus instead on *which traits* have been added to the plant.[38] It are good reasons to continue risk assessing organisms that have been added certain traits – for example, traits with particular risks of undesirable effects on the environment and health – before we start using them. But other types of changes that add traits that we know carry no increased risks should not be subjected to such extensive risk assessment requirements.[39]

6. Ethics: Is genetic modification of plants wrong in itself – wrong in every case?

Today, we face a challenge where both sides of the debate claim that ethical concerns support their views: The opponents make the claim that it is ethically problematic to make such fundamental changes to nature as is done by gene technology, and that it is wrong to expose human beings and the nature to the risks of GMO cultivation. Advocates stress that if a technology can help to solve very serious problems that could potentially cost human lives, and if no special risks have been identified from its use, it would be wrong not to make use of the technology.

From an ethical point of view, it is relevant to distinguish between whether something such as a technology is *wrong or problematic in itself*, regardless of its application. Some of the criticism raised against GMO has been characterized by deeming *all* applications of gene technology with plants as wrong. Other critics find that the use of

[37] Judgment of the court, case C-528/16, 25 July 2018

[38] It is important here to distinguish between a purely physical change, e.g. if it involves a major insertion or a replacement of a single base pair on one side, and the functional (phenotypic) change (the trait being added) on the other. For example if the trait is well known and already present in the concerned food product plant, or if it concerns a completely novel trait that has been obtained from another species or produced synthetically.

[39] The European Societies of Plant Biology. 2018. *Regulating genome edited organisms as GMO's has negative consequences for agriculture, the society and economy*

gene technology on plants is wrong, but that in some situations other concerns still make it ethically acceptable to apply the technology.

Another approach could be to consider gene technology as being wrong or problematic when used in certain ways that *lead to wrong outcomes*. In much the same way that most people would not consider knives to be problematic in themselves, but obviously considers it wrong if a knife is used to stab another person. This type of GMO criticism would not object to GMO applications that can serve societal objectives, e.g. by helping to fight climate change, or for purposes that are not risky. While applications that, for example, are risky because they have undesirable effects on the environment or the health of humans and animals would be considered wrong – because they are risky, not because they are the result of gene technology.

Much of the criticism directed at GMOs – e.g. that they promote the use of pesticides, are subjects to patenting, are developed by multinational companies or planted in areas where rain forest used to grow – is not criticism of GMO as such, but of the conditions that surround certain applications of certain GMOs. In other words, these problems concern *certain particular* GMOs. The problem arises when these considerations are used to argue against *all* GMOs.

This is problematic because a GMO might very well be developed at a university, have no patent, not require the destruction of rainforest, not be pesticide-resistant, etc. The criticized properties are not the result of genetic modification in the sense that all GMOs would possess them. Consequently, this criticism cannot justify a general opposition to GMO. Instead they can be used as arguments for the far less extensive claim that some GMOs are problematic, e.g. those that are tolerant to pesticides. What makes them problematic, then, is their ability to tolerate pesticides. Since not all GMOs tolerate pesticides, this is not an argument that can be used against GMOs in general; it is irrelevant for GMOs that do not tolerate pesticides.

In the following, we will focus on the general arguments against GMOs, i.e. arguments that are often put forward as reasons to reject the use of GMO as such because genetic modification of plants is considered problematic in itself. We shall, however, also consider the ‘opposing’ argument that, morally, we ought to use the types of GMOs that could be beneficial, e.g. by advancing the UN global goals, if there are no strong arguments not to use them. The three arguments thus are: 1) Genetic modification of plants is wrong because it is particularly risky, 2) Genetic modification of plants is valuable if it can help achieve the UN Global Goals, and 3) Genetic modification is wrong because it is unnatural.

6.1 Genetic modification of plants is wrong because it is particularly risky

A majority of Europeans consider it unsafe to consume GMO (59%) and say GMO is harmful to the environment (53%).[40] If it is a characteristic of all genetically modified plants that they are risky in this way, GMO development should always be considered wrong. However, the known uses of GMO have so far not been shown to cause harm to human beings or the nature that was a result of the genetic modification. Of course, this does not mean that in the future,no GMOs that could turn out to be harmful to consume or could spread uncontrollably in nature will be developed. Some will also argue that long-term effects of the GMOs which have already been risk assessed might still emerge at a later point in time, while others will claim that 20 years is long enough to safely say that there is no evidence to consider all genetically modified plants as risky – although they will admit that there could still be reasons to risk assess some types of GMO before use. The most frequent arguments for and against are:

6.1.1. Gene modification is particularly risky

The fact that no risks have been observed for genetically modified plants so far does not mean that problems will not emerge in the long term. Changing the genes of plants with gene technology is hazardous in ways that breeding using other processing techniques are not. And if, along the way, diseases in humans or damage to the ecosystems occur that researchers did not anticipate, it will be too late to reverse the development.

It is an inherent quality of the technology that it moves into territory beyond the comprehension of human beings. We should therefore avoid using it in plant breeding based on the so-called *precautionary principle*. The interpretation of this principle is often that if there is reasonable suspicion that an activity could seriously harm human beings or the environment, measures against it must not be delayed on the sole ground that there is scientific uncertainty when it comes to the risks of a technology.[41]

6.1.2. Gene technology should not (always) be considered risky

As mentioned earlier, 20 years of GMO risk assessments have not established that GMO is risky in general. Obviously, it cannot be guaranteed that no damage will emerge in future if other types of changes are made than those we have experience in today. But this is also the case if other changes are introduced using irradiation or chemistry for example.

It seems groundless today to continue claiming that there is scientific uncertainty as to whether genetic modification in itself entails particularly high risks. It is the type of

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[40] European Commission. 2010. *Biotechnology report – Special Eurobarometer*

[41] Peter Pagh in the Danish encyclopaedia ‘Gyldendals Store Danske’ (http://denstoredanske.dk/Samfund,_jura_og_politik/Jura/Landboret_og_milj%C3%B8ret/forsigtigheds princip

modification – the trait added – that determines the risk, not the technology used to obtain it. Equal things should be judged equally, and a given change introduced with CRISPR technology is no more risky than the same change introduced with irradiation or chemistry (the use of which even produce unintended mutations with unknown consequences). The question of whether to carry out risk assessments before the introduction of a new variety should therefore depend on the trait being added, not the technology used to achieve it.

6.2 Genetic modification of plants is valuable if it can help achieve e.g. the UN Global Goals

The focus of GMO discussions often concerns avoiding negative traits (such as unnaturalness), or undesirable consequences (such as health risks or undesirable effects on nature).

Those who find that genetic modification is an inherently risky or unnatural technology and therefore problematic to apply, may still consider whether beneficial effects of using GMO could, in some situations, outweigh these concerns. Positive impacts on the climate or sustainability in general could represent such beneficial qualities. If genetic modification could contribute considerably to mitigating the sustainability problems that in many areas, including the climate area, are serious, this could in some perceptions outweigh the problems that follow from the lack of naturalness.

Another approach could be to weigh the overall consequences of introducing GMO by comparing the consequences of using a given GMO with the consequences of not using it. If the consequences for sustainability (and thus for the conditions of human life) of using a given GMO are better compared to not using it, then we ought to use it.

Whether – and if so to what extent – positive features such as sustainability should be included in the assessment of given GMOs is debated, the arguments for and against often being:

6.2.1. Positive consequences for the climate and sustainability should be included in the assessment of a GMO

If the global temperature increase is to be kept below 1.5°C above pre-industrial levels, we will need to produce much more food in a much smaller area and with fewer resources. Used in the right way, genetic modification could contribute to this although, obviously, the technology cannot single-handedly solve the problems of reducing the agricultural CO_2 impact and the challenge of feeding a rapidly growing global population. However, the current situation is so severe that we cannot refrain from using *all* available means to ensure food production in the future. It is not a question of whether to use gene technology *or* rather introduce dietary changes; in the current situation, we need to use all means available if there are not very good reasons not to do so. Similarly, if a given GMO can help solve other serious problems, it should be brought to use.

6.2.2. Positive contributions to sustainability cannot outweigh the problems of GMO:
It is true that in many areas it is a problem that our way of living is not sustainable, meaning that for example climate changes are threatening the conditions for human life and the nature. There could, therefore, be situations where it would be necessary to accept solutions that are otherwise considered problematic as the lesser evil. But using such a fundamentally unnatural technology like genetic modification entails problems that are so serious that, in the bigger picture, they cannot be outweighed by the modest contribution to climate change mitigation offered by some GMOs. It is untrustworthy to rely on gene technology to make an important contribution to the climate and sustainability when 30 years with GMO have given no convincing results to that effect. Other means, such as changing consumption patterns towards more plant-based diet will contribute far more to sustainability compared to genetic modification of plants. There is a tendency to pin unrealistic hopes on technology to solve all problems so that we will not have to give up a lifestyle that we have become accustomed to, which is based on a non-sustainable high consumption. It clouds the acknowledgement that we need to make fundamental changes to the way we live and to get used to a much lower and more sustainable consumption.

6.3 Genetic modification of plants is wrong because it is unnatural

A survey shows that 70% of the European public consider GM food as unnatural.[42] Other surveys indicate that many people link the perception that something is unnatural to the belief that it is wrong.[43] This type of opposition can be substantiated in the belief that nature and naturalness possesses a value that makes it problematic for humans to interfere with it. There are differing understandings of what it is precisely that human beings should not interfere with. One view is that human beings human beings violate nature if they seek to control nature and exploit it for their own purposes in any way. Another and more moderate view is that certain processes in nature should be allowed to take place without human intervention. Therefore, a forest planted by humans can still be considered natural if the plants are then allowed to develop without human interference. In this understanding, then, it should not

[42] European Commission. 2010. *Biotechnology report – Special Eurobarometer*
[43] Scott S, Inbar Y, Wirz C, Brossard D and Rozin P. 2018. An Overview of Attitudes Toward Genetically Engineered Food. *Annual Review of Nutrition* no 38: 459-79

necessarily be considered unnatural if plants were modified through conventional breeding because the changes brought about would be considered similar to the changes nature itself could have created. In this view, what humans ought to abstain from would therefore be to completely deviate from natural processes, e.g. by inserting genes from different species into an organism.[44]

Although this argument has a wide appeal, it is difficult to pin down exactly why it is considered wrong to change nature or radically break with its normal evolution (see Annex on natural food products – available in Danish only on the website of the Danish Council on Ethics). The reason for this is that human beings change nature every day, e.g. through treatment of diseases or plant and animal breeding without it being considered as wrong. This raises the question why genetically modifying plants it is considered unnatural in a way that is seen as wrong while other unnatural acts are not considered wrong. Below we summarise some of the key arguments, which state that it is wrong to radically change nature, followed by a number of counter arguments, which state that it is not in itself wrong to do so.

6.3.1 It is not wrong to change nature even though nature is valuable in itself
We constantly change nature, for example through conventional breeding. And if clearly natural things such as cancerous tumours or tsunamis are seen as negative, while clearly unnatural things like appendectomies or computers are seen as positive, it becomes clear that naturalness cannot be used as a measure for whether things are good or bad. At the same time, it is not clear how to understand 'the natural' let alone draw a clear line and say that what lies beyond it is 'too unnatural'. For example, it is not necessarily the case that changes induced by means of gene technology are extremely comprehensive, or that the same change could never spontaneously emerge in nature. While CRISPR technology can be used to make major changes, it can also be used to make changes equivalent to those obtained by conventional breeding (mutagenesis), or changes that can occur spontaneously in nature.

But the fact that nature has inherent value does not mean that human beings should never make changes to it. It is a fact of life that we exploit nature, but we must of course at the same time take good care of it. So impacting nature to the extent that the livelihood of current and future human beings is put at risk, e.g. by causing temperature rises above 1.5°C above pre-industrial levels, or to caouse species extinction at the current speed of the biodiversity crisis, is morally problematic to a serious degree.

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[44] An account of a gradualistic perception of naturalness can be found in: Sandin, Per. 2017. How to Label 'Natural' Foods: a Matter of Complexity. *Food Ethics*, Volume 1, Issue 2, pp 97–107

6.3.3. Changing nature is at odds with the inherent value that nature posses
Humans should do more to adjust their way of living to the given nature rather than constantly trying to transform it to match their desires and treat nature merely as a resource. It is inherently wrong to constantly attempt to subordinate nature and change it, and it is this conduct that has brought us to where we are today with a climate crisis and other sustainability crises. It is true that human beings cannot avoid changing nature and exploiting it to survive, but the more we depart from the natural and the more high-technological tools we develop, the more problematic it is.

Gene technology is wrong because it is more unnatural than conventional breeding and thus a further step in the wrong direction. When it comes to the climate crisis and the other manmade crises, gene technology is part of the problem rather than part of the solution. The only way forward is for human beings to commit to the fact that we are part of nature, not its masters. We should find a way to live with it rather than increasingly change the natural balances with the serious consequences that we witness today.

The Act on the Danish Council on Ethics provides that “Respect for nature and the environment is based on the premise that nature and the environment are inherently valuable.” The members of the Council adhere to this at an overall level. However, this does not reflect a commitment on the part of the individual members to specific philosophical approaches.

7. The Council's recommendations

7.1 It is ethically problematic to reject GMO varieties if they can help alleviate or solve significant problems and there are no good arguments for rejecting them

Some members (Morten Bangsgaard, Anne-Marie Axø Gerdes, Kirsten Halsnæs, Mia Amalie Holstein, Poul Jaszczak, Henrik Gade Jensen, Bolette Marie Kjær Jørgensen, Henrik Nannestad Jørgensen, Rune Engelbreth Larsen, Eva Secher Mathiasen, Rico Mathiesen, Jacob Giehm Mikkelsen, Lise von Seelen, Karen Stæhr and Signild Vallgårda) find that there are today several examples of GMOs that show promising signs of alleviating or solving significant problems, and we have here shown two.

The members find that an authorisation system should be introduced that does not put obstacles in the way of GMOs based on the technology used to produce them (process requirement). Instead, the focus should be on the type of trait being added to a new variety. The requirement for risk assessment should therefore apply to varieties that are considered to pose an increased risk to human health or the environment (product requirement).

Many factors have changed since GMO was introduced more than 30 years ago: genetic modification technologies have improved and have become much more accurate. In the 20 years of cultivating herbicide- and insect-resistant plants, there have been no reports of harm to human beings or the nature resulting from the use of genetic modification in itself.

Meanwhile, in the 30 years that have passed, several sustainability problems have become more urgent. For example, global warming is threatening the life conditions of millions of people even in the short term, and if temperature rises are not contained, the consequences for our children and grandchildren will be unpredictable. This should weigh heavily in an ethical assessment. GMO alone cannot solve the climate challenge, but the situation today is so serious that all measures should be employed unless there are substantial arguments not to do so.

Here, we have described two types of GMOs: de novo domestication of wild tomato and intermedium wheatgrass with several beneficial climate features. We have found no compelling arguments against bringing them into use.

The wild tomato has been modified by CRISPR technology by 'turning off' genes in the plant without inserting any genes from other species (precision mutagenesis). The wheatgrass could be developed in the same way, but is not there yet.

Such changes are very close to the mutations that occur spontaneously in nature, which makes it difficult to see why they should be perceived as radically unnatural. They need not under controlled conditions collide with nature's inherent value or worsen the effects of the general, negative effects of humans in a geologic epoch that more and more researchers refer to as the Anthropocene. That is the era where humans influence nature more than the other way around – rather than the Holocene which is the official term for the period after the last ice age.

In principle, the changes could have been achieved with traditional mutagenesis techniques (although the changes made by these techniques would typically be more inaccurate and slow) and should therefore not be seen as more risky than the changes we already accept without demanding risk assessments because experience has shown that they are not risky. The fact that new varieties could be developed faster with CRISPR could potentially be problematic if their traits are not risk assessed. On the other hand, accelerated variety development could be considered a strength in a situation with rapid climate change where a need for short term development of new varieties may arise.

As mentioned, several other arguments often raised against GMOs are not relevant to the GMOs described in this statement: they are not developed or patented by multinational companies, they would presumably reduce rather than promote the use of pesticides, water and other natural resources, and they also have other beneficial environmental effects such as their ability to improve soil quality, limit erosion and add carbon and structure to the soil.

These examples refute the arguments that genetically modified plants in any form are more unnatural or more risky than plants developed by traditional means.

7.1.1 Absence of particular risks

Some of these members *(*Morten Bangsgaard, Anne-Marie Axø Gerdes, Mia Amalie Holstein, Poul Jaszczak, Henrik Gade Jensen, Bolette Marie Kjær Jørgensen, Henrik Nannestad Jørgensen, Rune Engelbreth Larsen, Eva Secher Mathiasen, Jacob Giehm Mikkelsen, Lise von Seelen, Karen Stæhr and Signild Vallgårda) *find* that the absence of particular risks is sufficient to allow the authorisation of new varieties.

7.1.2 Contribute to sustainable development

Other of these members (Kirsten Halsnæs, Rico Mathiesen) find that it ought to be an actual requirement when new GMOs are authorised that they are both deemed not to be risky and that they will contribute to sustainable development overall. They emphasise that GMO must be assessed in terms of their potential positive consequences for example in the form of increased access to food products, contribution to poverty reduction, health and other of the UN Global Goals, and in terms of a positive impact on the climate in the form of new crops with a high carbon-binding potential. The reason for this is that democratic societies should take into account when public opposition against a technology is persistent for such a long period as we have seen in the GMO area. The politicians should not ignore such opposition and ease the GMO requirements unless there are very good arguments to do so. In this situation, the absence of increased risk is not sufficient to derogate from the requirement for an extended risk assessment. In addition, it should be a requirement that the variety can contribute to sustainable development.[45] Such an authorisation requirement is found in the Norwegian gene technology act.[46]

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[45] See also Zetterberg, C and K Björnberg. 2017. Time for a New EU Regulatory Framework for GM Crops? *J Agric Environ Ethics* 30:325–347

[46] Lov om framstilling og bruk av genmodifiserte organismer m.m. (genteknologiloven) [Act on production and use of genetically modified organisms, etc. (the Gene Technology Act)] from 1993. Section 10 provides that "The deliberate release of genetically modified organisms can only be authorised when there is no risk of harmful effects on the environment and health. Furthermore, the assessment must attach

A large majority of the Council members thus find that not all GMOs should be prohibited solely because of the process, gene technology, used to produce them. Some GMO types are compatible with both the absence of particular risks and the contribution to sustainability and respect for nature's own processes. GMOs such as these should not be rejected or obstructed by subjecting them to risk assessment requirements that are not imposed on similar new varieties developed by conventional means.

Consequently, Denmark should work towards changing the authorisation procedures to a product-based system (looking at the organism's traits and risks regardless of creation method), thus moving away from a process-based system (looking at the method or technology used to modify the plant). It should be the end-product – a combination of trait, plant species and breeding area – which decides if a new variety should be subjected to a risk assessment process or if it can be introduced upon an administrative assessment.

Such a system can be designed in various ways, and different versions have emerged in the recent years. The authorisation system used in Canada is based on an assessment of the end-product. All so-called plants with novel traits must be authorised regardless of the technology used to produce them.[47] Norway has long had an authorisation system where requirements for societal benefits, sustainability and ethics are of key importance to the authorisation of GMOs. The Norwegian Biotechnology Advisory Board has just submitted a proposal for a new authorisation procedure for GMOs (plants and animals). It has three levels of authorisation requirement depending on the genetic modification being made.[48] Other proposals for changing the authorisation procedures have come from the Dutch government, which proposes to exempt plants obtained with so-called New Plant Breeding Techniques, including CRISPR, if they are considered at least as safe as plants obtained with traditional breeding.[49]

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particular importance to whether the deliberate release is beneficial to society and is suited to promote sustainable development"

[47] See the criteria here: http://www.inspection.gc.ca/plants/plants-with-novel-traits/eng/1300137887237/1300137939635

[48] Norwegian Biotechnology Advisory Board 2018. *Forslag til oppmykning av regelverket for utsetting av genmodifiserte organismer [Proposal for easing the regulations for the release of genetically modified organisms]*. Also see Bratlie, S. et al. 2019. A novel governance framework for GMO. *EMBO reports*

[49] The Netherlands Ministry of Infrastructure and the Environment. 2017. *Proposal for discussion on actions to improve the exemption mechanism for genetically modified plants under directive 2001-18-EC.* See also the proposal from Bioökonomierat, the German Bioeconomy Council. 2018. *Genome editing, Europe needs new genetic engineering legislation* - preliminary version

When assessing which new varieties to subject to risk assessment, the Danish Council on Ethics stresses that the main focus should be on the nature of the added change, not on the technique used to obtain it.

7.2 It is ethically problematic to use gene technology to change plants

One member (Herdis Hansen) finds that gene technology is the exponent of a way of thinking that fundamentally sees the goal of the human race as continuously extending their control over nature, enabling a far more extensive interference with nature's own processes, compared to conventional breeding.

This form of control of nature is wrong because it does not respect the inherent value of nature. The technology should therefore not be used, and politicians in Europe should listen to the national majorities and respect their wishes of avoiding genetically modified foods.

This member acknowledge that the climate changes are serious and that it is important to find ways of keeping the global temperature rise below 1.5°C over pre-industrial levels. However, this does not mean that genetic modification would be a suitable technology to achieve this goal.

Throughout history, human beings have continuously increased their control of nature, and we have reached a stage where it has been suggested to name our age the Anthropocene – the age where humans change nature more than the other way around. Climate change is only one of the results of this approach to nature and the disrespect for its balances. It is the incessant attempts of human beings to subordinate and change nature that have brought us where we are today. Gene technology is an expression of this approach to nature; it is more unnatural than conventional breeding, because it makes it possible to break with the processes that take place in nature. Using gene technology, humans can 'short-circuit' the evolutionary mechanisms, and introduce changes, that would not occur in nature without human interference. By moving further away from the natural processes, gene technology is taking one further step in the wrong direction.

Nature and ‘the natural’ have inherent value, and as human beings we should do more to adjust the way we live to the given nature rather than try to transform it again and again to match our desires.

Combating climate change requires a radically different perspective on nature and a much less materialistic way of life. It is necessary that we overcome the way of thinking that sees the 'good life' as dependent on a consumption, which is completely detached from what the natural foundation can sustain. The only solution is for us to start adjusting our way of life to the natural balances and to respect the limitations that is set by the natural foundation. A fundamentally unnatural technology such as genetic modification does not offer any solutions to these problems, because the technology itself is an expression of a way of thinking that wishes to exploit nature to meet our needs.

There are no easy solutions or technological fixes to solve the problem of climate change or any of the other complex crises that the UN climate goals address. Pretending that gene technology can offer such a technological fix runs the risk of shifting the focus away from the actual problems and delaying the realization that truly fundamental changes are needed.

Therefore, this member cannot support measures to ease the authorisation system for GMOs. A system that is based on product authorisation rather than process authorisation will inevitably lead to the release of several GMOs into nature on the basis of superficial risk assessments. This is not consistent with the precautionary principle and does not respect the major opposition to genetically modified food products from populations in the EU.

Bioökonomierat

BÖRMEMO 07 | 16.01.2019

Genome editing: Europe needs new genetic engineering legislation

Preliminary remarks

The European Court of Justice's long-awaited ruling of 25 July 2018 has provided clarity: The new technologies blanketed under the term "genome editing" are subject to EU Directive 2001/18/EC on the deliberate release of genetically modified organisms into the environment[1]. In all likelihood, this interpretation will also have to be extrapolated to other EU legal acts relating to GMO regulation[2]. Amongst other things, this will mean that, in future, all produce produced using the new technologies will have to pass through a very laborious and expensive licensing procedure before being released onto EU markets or into the environment.

However, genetic engineering has evolved dramatically since 2001. The technologies known as genome editing allow the genome to be modified much more quickly and cheaply and in a much more targeted way than was the case with the "old" genetic technology. For example, since it was first described in 2012, the CRISPR/Cas9 system has spread throughout the world within just a few years and is now being used in many different fields[3,4,5]. In the meantime, these new technologies have become part of the standard repertoire in research and university education and are also used by many industrial companies.

This situation now poses huge political challenges in Germany and the EU:

- On the one hand, we believe it would be irresponsible for the EU to create higher regulatory hurdles than the rest of the world, thereby permanently uncoupling it from a technological development that offers great potential in terms of sustainability and human welfare and that will therefore increasingly shape the global bioeconomy. Even if politicians wanted to, it will not be possible in the longer term to prevent the import of produce produced using genome editing – not least because it is impossible to detect the use of the technology in the final product.

Only differentiated regulation can do justice to the wide range of potential applications of genome editing.

- On the other hand, the answer cannot be to play down the risks associated with the rapid spread of these new technologies and opt for complete deregulation. Although there are many applications of genome editing that do not involve any greater ecological risk than traditional breeding methods or randomly occurring mutations, some applications can give rise to increased risks and therefore require stricter protective regulations.

A differentiated approach to the technology and its applications is therefore called for[6]. Current EU genetic engineering legislation is no longer able to respond adequately to these challenges. Many people instinctively feel that the new technology should be banned on ethical grounds or because of the risks associated with it. However, in reality this would not prevent the spread of genome editing in Europe but would mean that Europe would permanently lag behind the rest of the world, while at the same time having no say in the imperative global regulation of this "biological revolution". In order to change this situation, the Bioeconomy Council is calling for a prompt revision of EU legislation on genetic engineering to bring it in line with new technological developments and the latest scientific findings. This would also honour the original objective of the German Genetic Engineering Act, which was drafted at the beginning of the 1990s with the explicit purpose of promoting and enabling genetic engineering and with the intention of adapting the regulations to keep pace with technological progress.

The amended genetic engineering legislation should stipulate which applications of genome editing are essentially allowed, which are prohibited and which will only be allowed with a special permit. We must also be aware that some of the risks arising from the use of genome editing cannot sensibly be regulated by genetic engineering legislation but require amendments in other legal fields (for example patent law or agri-environmental law). And this is also necessary, because the extensive use of cross-referencing between various legal acts within EU genetic engineering legislation means that a marginal change in one legal act might automatically affect many others. Therefore, these policy fields must also be considered right from the start, in order to arrive at the best possible overall regulatory solution.

In order to promote a substantive debate about the future regulatory procedure for genome editing, the Bioeconomy Council offers the following guiding principles for discussion. Potential human applications are not addressed.

Risk-oriented licensing and approval procedures

Plants

- Breeding is based on crossing and selection. The basis for this is the present genetic diversity. In plant breeding, the mutation rate (mutagenesis) has been artificially increased for a long time now in order to expand genetic diversity, for example by using chemicals or irradiation[7]. This mutagenesis can now be done in a much more specific way with the aid of genome editing[8]. In terms of future regulation, the legislator could stipulate that no particular provisions would be required under genetic engineering legislation if only a few base pairs (e.g. less than 20; this being a scientifically contested limit[9]) were modified but, in this case, the plants could be released without requiring authorisation. The practice in Germany is to apply the tried and tested variety approval regulations instead. However, such a ruling would mean that the release of a herbicide-tolerant crop would not be subject to authorisation, if herbicide tolerance were achieved by means of a specific point mutation or modification of only a few base pairs[10]. Arable farming based on herbicide-tolerant crops is contentious from an ecological point of view. However, it is not primarily the modified crops that constitute a potential ecological risk but rather the herbicide that is used and/or the overall production system associated with it. To this extent, any regulation should not take place under genetic engineering legislation but in other specific areas of legislation (for example, plant protection legislation).

- Even in the amended legal framework, plants in which larger gene segments (e.g. more than 20 base pairs) are modified or gene sequences are transferred across species boundaries would still have to be evaluated and licensed under genetic engineering legislation. With the current procedure, it takes many years for a genetically modified variety to go through all the tests and be allowed onto the market[11]. We would have to weigh up whether the approval process could be accelerated or simplified for produce with more complex mutations that could also occur in nature (for example nematode-resistance in sugar beet), accompanied by particularly close scientific monitoring during the first few years of practical use.

Livestock

- There are also relevant applications for genome editing in livestock breeding, for example breeding hornless cattle[12] or specialised laboratory animals for medical research[13]. Unlike in plant breeding, ecological risks (outcrossing into wild species; retrieveability) are hardly relevant in this area. On the other hand, ethical aspects become more important. Over the last few years, the social debate about modern livestock production has shown that the public are critical of various aspects of livestock farming, e.g. farming methods, regional concentration and some developments in animal breeding. The Bioeconomy Council believes that a comprehensive livestock strategy is required, in order to arrive at a socially acceptable and sustainable model of livestock production. The Council recommends that guidelines be drawn up for future animal breeding (and hence also for the use of genome editing) and formalised as part of a comprehensive livestock strategy.

- At present, livestock strategies are predominantly being developed on a national level. That is presumably due to the fact that there are varying attitudes to the treatment of livestock in different parts of the EU. Since the Council believes that genetic engineering legislation should be established at EU level, in line with the EU competence rules, this law must essentially establish a minimum consensus on regulating the use of genetic engineering in animal breeding in the context of minimum harmonisation. To supplement this, the Member States could then be free to implement stricter regulations as part of their national livestock strategies, if they so wished.

Insects

- The genome of insects can also be modified using genome editing, for example to improve the options for biological plant protection, to increase pollination or to influence populations of disease-carrying insects. However, these potential benefits are offset by ecological risks, since there is no way of retrieving genetically modified insects. Particular care is required if organisms are modified to pass on their characteristics to nearly all next-generation descendants, thereby preferentially propagating these characteristics within the population ("gene drive"[14]).

- The Council recommends adopting a particularly high level of protection in this area and paying particular attention to the implementation of international transparency rules.

Fish and other aquatic organisms

- Even though fish and aquatic invertebrates can be regarded as livestock in a wider sense, they should nevertheless be covered by special regulations, since the ecological risks are disproportionately greater, due to their high potential for dispersion.

- The Council recommends that, as with insects, a high level of protection is required in this area and particular attention must be paid to the implementation of international transparency rules.

Microorganisms

- Microorganisms (bacteria, yeasts, fungi) and their products are used in the industrial sector, in medicine, agriculture, the food industry and in environmental technology. Mutagenesis through the use of chemicals or irradiation and subsequent screening for improved performance is an established and commonly used method. No provision is made for licensing procedures for the associated genetic modifications, since these are comparable to naturally occurring processes. Long-standing empirical knowledge in this area tells us that the risks are manifestly low.

- If genome editing is used to make comparable genetic modifications, we do not see any need to conduct a laborious licensing procedure under the Genetic Engineering Act. In particular, this should apply to applications, in which microorganisms are multiplied and used in closed bioreactors. However, if these microorganisms are released or used in foodstuffs or animal feed, the checks prescribed for conventionally produced microorganisms need to be applied.

- The use of genome editing that produces modifications that go beyond those of natural processes or of current mutagenic techniques should continue to be subject to the provisions of EU Genetic Engineering legislation.

Product labelling

Some applications of genome editing are detectable in the end product but some are not. For example, it is possible to detect the transfer of gene segments that are foreign to the species. In contrast, it is not easy to identify the technology used to effect point mutations or the specific incorporation or deletion of genes from the same species, for example, since these modifications could have been brought about in some other way (conventional mutagenesis and genome editing) or could even have occurred naturally[15].

- For this reason, the existing legal obligation to label genetically modified products can only be maintained if, in the future, the use of genome editing for point mutations or a few base pairs ceases to be classed as genetic engineering (see above: proposal for plants and microorganisms). However, if, in future, the legislator were to stipulate that modifications generated by genome editing technology (even if these are indistinguishable from natural or induced mutagenesis) fall under amended genetic engineering legislation, such produce should be excluded from any labelling obligation, as otherwise legal compliance could not be guaranteed in the trade of goods.

- If the labelling obligation were also to relate to such organisms, this could give rise to considerable problems in the movement of goods, for trading companies and the inspection authorities in the longer term, since it would not always be possible to identify the method used from the final produce. The more genome editing becomes established as a standard technology in international breeding, the more difficult it will become for European actors to legally check whether there is actually any genetically modified produce contained in imported goods – indeed, what gene sequences should they check for? The State faces the same problem if it wants to check legal compliance.

- This argues in favour of moving away from the general statutory labelling obligation for produce without foreign genes and opting for the voluntary declaration "Not genetically engineered". Companies who opt to label their produce in this way would then provide certificates throughout the goods chain to prove that no genetically modified organisms have been used in the manufacturing process (similar to the current regulation for the organic food sector). This would continue to safeguard consumers' freedom of choice.

Registration and monitoring

- Genome editing is not only used by established firms within the biotech sector and in academic research laboratories but also by many private individuals and start-ups. A "Do-it-yourself Biology"movement has emerged from the USA and its adherents conduct CRISPR experiments inter alia[16]. This does not necessarily take place in registered laboratories. The utensils and biochemicals required are freely available anywhere in the world for a few hundred dollars. Releasing the modified organisms is prohibited in Europe but is allowed in the USA for example, so long as it causes no damage to health or the environment. The US assumes that actors develop an adequate degree of self-control and that the fear of being sued for damages enforces sufficiently disciplined user behaviour.

- The Bioeconomy Council takes the view that EU genetic engineering legislation should require anyone who wants to use genome editing to record their use of the technology in an official register (see above for licensing requirements).

- Furthermore, the international community of nations should create a platform for exchanging experiences with different forms of regulation and monitoring of genome editing (see the proposals for a Global Genome Editing Observatory[17, 18]).

Research

Basic Research

- The Bioeconomy Council recommends the promotion of basic research in this important future-oriented field of science. State funding should also include training programmes and precompetitive development projects.

- State research funding should concentrate on areas that are of relatively little interest to the private commercial sector but of great interest to society as a whole.

Biodiversity research

- There are various hypotheses as to what effect genome editing will have upon biodiversity in agricultural landscapes[19, 20]. On the one hand, it creates better technological opportunities for increasing agrobiodiversity. On the other, use of the technology in free-market competition can result in the temporary proliferation of superior varieties in a particular region, thereby restricting diversity of varieties there. Equally, it is conceivable that this could have a positive as well as a negative impact on natural biodiversity. If genome editing is used to produce greater biodiversity and more sustainable cultivation (for example by reducing the use of pesticides), this would presumably benefit natural biodiversity. In contrast, if breeding via genome editing were used to promote or continue non-sustainable agricultural practices (e.g. overfertilisation and degradation of the soil), this would have a negative effect upon natural biodiversity.

- It is impossible to make an overall prediction of which effects will prevail, as this primarily depends upon external political and economic framework conditions. It would therefore not be expedient to initiate generally oriented preparatory research on this issue at this stage. Whether or not ex-ante assessments of the effects of genetically modified organisms on biodiversity are necessary can only be decided on a case-by-case basis, since this is not a question of the technology that is used but rather a question of the expected characteristics of the organisms. Should it prove impossible to answer these questions based on theories, models or empirical values, it might be sensible to conduct cultivation trials restricted to model regions, accompanied by close scientific monitoring.

- Independently of the question of whether genetically modified organisms are one day used in German agriculture or not, the Bioeconomy Council believes that it is necessary to set up a biodiversity monitoring programme. This is necessary to record the long-term changes in the biodiversity of our agricultural landscapes, so that they can be analysed in terms of possible causes and of controlling policy measures. The Council recommends that genome editing also be considered right from the start when designing the monitoring programme. The monitoring programme should be capable of identifying changes in the regional range of varieties and their impacts upon biodiversity in agricultural landscapes.

Research on rights of ownership and use plus economic consequences

- Genome editing techniques are the subject of patent applications and granted international patents, so that users must obtain licences and pay to use them commercially. It is debatable to what extent it is possible to patent gene sequences modified by genome editing or other techniques that produce a certain demonstrable useful feature in the organism. Official patenting practice has evolved in this direction over the last few years, while policy statements often support the basic principle of "you cannot patent nature".

- The clarification of such title issues is of fundamental importance for the development of market structures, for the emergence of innovations and the distribution of returns on innovation, for the State's ability to influence economic processes and lastly for social acceptance of new technologies. Controversial views and contradictory hypotheses abound in this area of debate; however, there has not yet been any systematic economic analysis of what regulatory options the policymakers might have or what the impact of the various options might be.

- Since genome editing is spreading rapidly and is becoming increasingly important for the global bioeconomy, the Bioeconomy Council believes that there is an urgent need to carry out a systematic economic analysis of the many unanswered questions relating to property rights, "open-source" data and technologies, economic structures and "global governance". In order to do this, it is necessary to form interdisciplinary scientific consortia at the interface between biotechnology, natural sciences, social sciences, cultural sciences, economic sciences and legal sciences, with a longer-term focus, to develop proposals for globally sustainable rules and regulations.

Social dialogue research

- The Bioeconomy Council recommends initiating new forms of social dialogue about genome editing. In contrast to many of the methods that have been employed so far, these should not be restricted to an exchange between organised interest groups. In particular, we recommend dialogue-oriented, deliberative processes [20], aimed at public participation and the public at large. These will help to identify the various patterns of perception and interpretation relating to social challenges and potential technological and social solutions and to understand divergent motivations in controversial debates, without at the same time calling for a consensus agreement. In order to be able to use these insights for policy and innovation strategies, various forms of procedure should be developed and trialled, supplemented by accompanying scientific research to determine the efficacy of the different methods[22, 23].

Endnotes

[1] ECJ. 2018. European Court of Justice. Press Release no. 111/18. Organisms obtained by mutagenesis are GMOs and are, in principle, subject to the obligations laid down by the GMO Directive. Available from: https://curia. europa.eu/jcms/ upload/docs/application/pdf/2018 07/ cp180111de.pdf [22.08.2018]

[2] Purnhagen, K.P., Kok, E., Kleter, G., Schebesta, H., Visser, R.G.F., Wesseler, J. 2018. EU court casts new plant breeding techniques into regulatory limbo, Nature Biotechnology, vol. 36, pp. 799–800.

[3] Wang, H., La Russa, M., Qi, L. S. 2016. CRISPR/Cas9 in genome editing and beyond. Annual Review of Biochemistry, 85, 227-264.

[4] Bortesi, L., Fischer, R. 2015. The CRISPR/Cas9 system for plant genome editing and beyond. Biotechnology Advances, 33(1), 41-52.

[5] Doudna, J. A., Charpentier, E. 2014. The new frontier of genome engineering with CRISPR-Cas9. Science, 346(6213), 1258096.

[6] *The following reports, which deal in detail with the various applications, opportunities and risks associated with genome editing and possible forms of future regulation are cited here by way of an example:*
- EASAC. 2017. European Acadamies Science Advisory Council.

Genome editing: scientific opportunities, public interests and policy options in the European Union. März 2017. Verfügbar unter http://www.easac.eu/fileadmin/PDF_s/reports_statements/Genome_Editing/EASAC_Report_31_on_Genome_Editing.pdf [22.08.2018]
- Leopoldina Nationale Akademie der Wissenschaften, acatech, Deutsche Forschungsgemeinschaft, Union der Deutschen Akademien der Wissenschaften. 2015. Chancen und Grenzen des genome editing. Stellungnahme. Verfügbar unter http://www.dfg.de/download/pdf/dfg_im_profil/reden_stellungnahmen/2015/stellungnahme_genome_editing_2015.pdf [22.08.2018]
- Shukla-Jones, A., Friedrichs, S. und Winickoff, D. 2018. Gene editing in an international context: Scientific, economic and social issues across sectors, OECD Science, Technology and Industry Working Papers, No. 2018/04, OECD Publishing. Paris. Verfügbar unter: http://dx.doi.org/10.1787/38a54acb-en [22.08.2018]
- VBIO. 2016. Verband Biologie, Biowissenschaften und Biomedizin in Deutschland. Genome Editing bei Pflanzen: Vorschlag für einen pragmatischen Umgang im aktuellen Rechtsrahmen. Impuls. September 2016. Verfügbar unter https://www.vbio.de/fileadmin/user_upload/verband/Positionen/160914_GE_Impuls.pdf [24.08.2018]

[7] Oladosu, Y., Rafii, M. Y., Abdullah, N., Hussin, G., Ramli, A., Rahim, H. A., et al. 2016. Principle and application of plant mutagenesis in crop improvement: a review. Biotechnology & Biotechnological Equipment, 30(1), 1-16.

[8] *Cited examples of crop improvement by genome editing without introducing foreign DNA are:*
- Nekrasov, V., Wang, C., Win, J., Lanz, C., Weigel, D., Kamoun, S. 2017. Rapid generation of a transgene-free powdery mildew resistant tomato by genome deletion. Scientific reports, 7(1), 482. Verfügbar unter https://www.nature.com/articles/s41598-017-00578-x?WT.feed_name=subjects_plant-biotechnology&error=cookies_not_supported [22.08.2018] *A mildew-resistant tomato was bred by mutagenesis. Such approaches could reduce the use of environmentally harmful pesticides.*
- Washington Post. 2018. The Future of Food – Scientists have found a fast an cheap way to edit your food´s DNA. 11. August 2018. Verfügbar unter https://www.washingtonpost.com/news/business/wp/2018/08/11/feature/the-future-of-food-scientists-have-found-a-fast-and-cheap-way-to-edit-your-edibles dna/?noredirect=on&utm_term=.feba97c5dc03 [22.08.2018] *This article describes the successful breeding of a soy bean with fewer unhealthy transfats.*
- Sánchez-León, S., GilHumanes, J., Ozuna, C. V., Giménez, M. J., Sousa, C., Voytas, D. F., Barro, F. 2018. Low-gluten, nontransgenic wheat engineered with CRISPR/Cas9. Plant Biotechnology Journal, 16(4), 902-910. Verfügbar unter https://www.ncbi.nlm.nih.gov/pubmed/28921815 [22.08.2018] *Since many different genes are responsible for gluten production in wheat, it has not been possible to breed gluten-free wheat using existing methods. However, genome editing makes such targeted breeding possible.*

[9] Lusser, M., Parisi, C., Plan, D., Rodríguez-Cerezo, E. 2011. New plant breeding techniques. Stateof-the-art and prospects for commercial development. JRC Scientific and Technical Reports/EUR 24760 EN.

[10] Lombardo, L., Coppola, G., Zelasco, S. 2016. New technologies for insect-resistant and herbicide-tolerant plants. Trends in Biotechnology, 34(1), 49-57.

[11] Smart, R., Blum, M., Wesseler, J. 2017. Trends in Genetically Engineered Crops' Approval Times in the United States and the European Union, Journal of Agricultural Economics 68: 182-198.

[12] Carlson, D. F., Lancto, C. A., Zang, B., Kim, E. S., Walton, M., Oldeschulte, D.C. et al. 2016. Production of hornless dairy cattle from genome-edited cell lines. Nature biotechnology, 34(5), 479.

[13] Yao, J., Huang, J., Zhao, J. 2016. Genome editing revolutionize the creation of genetically modified pigs for modeling human diseases. Human Genetics, 135(9), 1093-1105.

[14] Tagesspiegel. 2017. Genetisch veränderte Mücken sollen beim Kampf gegen Krankheiten helfen. Von Melanie Berger, 13.10.2017. Verfügbar unter https://www.tagesspiegel.de/wissen/forschung-zu-gene-drive-genetisch-veraenderte-muecken-sollen-beim-kampf-gegen-krankheiten-helfen/20448912.html [22.08.2018]

[15] Bundesministerium für Ernährung und Landwirtschaft. 2018. Fragen und Antworten: Neue Züchtungstechnologien. Verfügbar unter https://www.bmel.de/DE/Landwirtschaft/Pflanzenbau/Gentechnik/_Texte/FAQ-NeueZuechtungstechnologien.html [22.08.2018]

[16] New York Times. 2018. As D.I.Y. Gene Editing Gains Popularity, 'Someone Is Going to Get Hurt'. Verfügbar unter https://www.nytimes.com/2018/05/14/science/biohackers-gene-editing-virus.html [22.08.2018]

[17] Jasanoff, S., Hurlbut., J. B. 2018. A global observatory for gene editing. Nature, 555, 435-437.

[18] Hurlbut, J. B., Jasanoff, S., Saha, K., Ahmed, A., Appiah, A., Bartholet, E. et al. 2018. Building capacity for a global genome editing observatory: conceptual challenges. Trends in Biotechnology.

[19] Bundesamt für Naturschutz. 2017. Hintergrundpapier zu Neuen Techniken. Neue Verfahren in der Gentechnik: Chancen und Risiken aus Sicht des Naturschutzes. Verfügbar unter https://www.bfn.de/fileadmin/BfN/agrogentechnik/Dokumente/17-07-13_Hintergrundpapier_Neue_Techniken_end_online_barrierefrei.pdf [22.08.2018]

[20] Østerberg, J. T., Xiang, W., Olsen, L. I., Edenbrandt, A. K., Vedel, S. E., Christiansen, A. et al. 2017. Accelerating the domestication of new crops: feasibility and approaches. Trends in Plant Science, 22(5), 373-384.

[21] Deliberative processes rely on readily available information and good communications between all stakeholders and include debates, organised talks and public discussions.

[22] Shukla-Jones, A., S. Friedrichs and D. Winickoff. 2018. Gene editing in an international context: Scientific, economic and social issues across sectors", OECD Science, Technology and Industry Working Papers, 2018/04, OECD Publishing, Paris. S. 18 ff. Verfügbar unter http://dx.doi.org/10.1787/38a54acb-en [23.08.2018]

[23] van Mil, A., Henrietta Hopkins, Kinsella, S.. Potential uses for genetic technologies: dialogue and engagement research conducted on behalf of the Royal Society. Findings Report December 2017. Verfügbar unter https://royalsociety.org/~/media/policy/projects/gene-tech/genetic-technologies-public-dialogue-hvm-full-report.pdf

About this BÖRMEMO

BÖRMEMOS summarize the Council's appraisal of key aspects of the bioeconomy in a condensed form. They do not claim to provide a comprehensive study of these facts. Rather, they present a focused and generally comprehensible view of each area and its relationship to the bioeconomy. BÖRMEMOS undergo a peer review process. While this process is taking place, they are identified as preliminary. After assessment, they are incorporated in the items of the Council as a whole. They are part of a series of analyses published by the Bioeconomy Council.