DANGER AHEAD

Why gene editing is not the answer to the EU's environmental challenges

GREENPEACE

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NEW GMO DANGER AHEAD

Why gene editing is not the answer to the EU's environmental challenges

In this briefing, Greenpeace warns that the use of so-called gene (or genome) editing techniques like CRISPR-Cas could not only exacerbate the negative effects of industrial farming on nature, animals and people, but it could effectively turn both nature and ourselves (through the food we eat) into a gigantic genetic engineering experiment with unknown, potentially irrevocable outcomes.

Gene editing is a set of new genetic engineering techniques that is both powerful and easy to use. It can be applied in medicine and in various industries, including agriculture, as much as by hobby scientists (biohackers) and the military.

This paper focuses on the environmental release of gene-edited organisms for agricultural purposes. In farming, the use of gene editing could extend far beyond the scope of old-style genetic modification (GM) technology. Potential applications are not limited to agricultural crops and farm animals, but extend to a wide range of wild species. Gene editing also makes it possible to transfer the genetic engineering process from controlled laboratory conditions to open fields and non-agricultural landscapes, essentially converting the environment into the laboratory.

Proponents of GM technology want the EU to give a pass to most gene-edited organisms by excluding them from Europe's regulations governing genetically modified organisms (GMOs). This would mean that farmers, retailers and consumers would no longer be able to reject GM products and opt for GM-free choices. It would leave the fate of our food and nature in the hands of a few corporations that have shown to have little regard for people's health and the environment.

However, new GMOs are indeed subject to existing EU GMO law pursuant to a July 2018 ruling by the European Court of Justice (ECJ). The EU Commission and Member States have a duty to fully apply and enforce EU GMO law, while fixing weaknesses in the areas of risk assessment, labeling and democratic oversight. The EU must make it a priority to adopt and implement policies that change the predominant chemical-based farming system towards ecological agriculture that works with, not against, nature.

DANGER AHEAD

GM CROPS ARE PART OF AN OUTDATED CHEMICAL FARMING MODEL

Today, genetically modified (GM) crops are mainly grown in North and South America. In the US and Brazil, around 95% of soybean, maize and rapeseed are genetically engineered.[1] These crops are produced by a handful of multinationals such as Bayer, Corteva, Syngenta and BASF, which dominate the global commercial seed market, and the GM seed market in particular.[2]

The vast majority of GM crops have been modified to withstand the spraying of weedkillers such as glyphosate, so farmers can spray the weedkiller ("herbicide") also during the growing season. Other crops have been engineered to produce their own pesticide (called "Bt toxin"). Many GM crops do both.[3]

Developed and marketed by agrichemical companies, these GM crops are part of a disastrous "chemical warfare" approach against weeds, pests and diseases, which has decimated wildlife, impoverished soils and led to the emergence of hard-to-control super weeds and super bugs. In the US, agricultural use of glyphosate rose 300-fold from 1974 to 2014.[4]

Despite the "collateral damage" they cause, GM crops are making good money for the companies selling them, and they even benefit from their failures. When unwanted plants and pests become resistant to the onslaught of particular weedkillers or Bt toxins, the companies will offer GM crops that tolerate more herbicides and produce more toxins. This allows a few corporations to hold farmers hostage to a failed technology, like hamsters in a treadmill.

In countries where GM crops are routinely grown, agrichemical corporations not only dictate farmers' choices, they also manage to set government policies. In the US and Brazil, for example, dangerous weedkillers that the EU has banned or restricted due to health and environmental concerns, continue to be allowed.[5]

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1 ISAAA, 2020, Brief 55-2019 - Executive Summary.

2 IHS Markit, 2020, Analysis of sales and profitability within the seed sector.

3 In 2019, 43% of the global GM crop area was planted to herbicide tolerant crops, and another 45% by crops that combined herbicide tolerance with insect resistance, according to ISAAA, 2020, Brief 55-2019 - Executive Summary.

4 Benbrook, C. M., 2016, Trends in glyphosate herbicide use in the United States and globally. Environmental Sciences Europe 28, 3.

5 Examples are atrazine and paraquat.

BOX 1

WHAT ARE GMOS AND HOW ARE THEY MADE?

Proponents of gene editing in agriculture pretend that gene editing is not genetic modification but "plant breeding innovation".[6] But gene-edited organisms are genetically modified organisms (GMOs), both legally and technically.

According to EU law, a GMO is 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".[7]

The vast majority of GMOs that are in the marketplace today are **transgenic organisms,** meaning they contain genes derived from another species or 'foreign' genes. When the gene derives from a crossable (i.e. sexually compatible) species, these GMOs are called **cisgenic or intragenic organisms.**

During the genetic engineering process, the genes are isolated and inserted into the host's cells along with promoters (i.e. segments of DNA that activate genes). In plants, this is usually done with the help of a plant microbe, *Agrobacterium tumefaciens,* or a so-called 'gene gun'. Subsequently, the cells with the modified DNA are grown into full plants using a process called 'tissue culture', that involves the use of a medium composed of hormones and nutrients, among other things.

Gene editing is mostly used to alter an organism's own genome so that the final product claims to not contain any 'foreign' genes. The most prominent technique is CRISPR-Cas. Others are called TALENs, Zinc Finger Nucleases (ZFN), Oligonucleotide Directed Mutagenesis (ODM) and Base Editing.

The 'editing' usually consists in the cutting of DNA by proteins, called nucleases, at a chosen site in the genome of a living cell. The nuclease, sometimes called 'gene scissors', will find the chosen site with the help of a stretch of RNA that serves as a 'guide'. The cell then repairs the cut, which more often than not results in the knockout (silencing) of the affected gene. [8] [9]

In plants, a common way to introduce the 'gene scissors' and 'guide' is to have them produced by the cell itself, based on a DNA sequence that is introduced into the cell via old-style means of delivery, i.e. soil bacterium *Agrobacterium tumefaciens* or 'gene gun'. Once the cell is turned into a full plant, the (intermediate) result is a transgenic organism, which requires several generations of back-crossing to eliminate the 'foreign' DNA. [10]

6 Euroseeds, Plant Breeding Innovation.

7 EU Directive 2001/18/EC.

8 ODM works differently. Instead of cutting the DNA, a short piece of single-stranded DNA or RNA, called oligonucleotide, is used as a template for the cell's own DNA repair.

9 Base Editing, a modification of CRISPR-Cas, also works differently. It makes specific changes to the DNA (replacing letter T with C and G with A) instead of cutting it.

10 The US military's advanced technology arm, DARPA, is studying how the CRISPR-Cas machinery can be delivered to agricultural crops by virus-carrying insects.

EUROPEANS DO NOT WANT GM FOOD

EU consumers are uncomfortable with GM food.[11] So the EU has brought in legislation that requires risk assessment, traceability and labelling of GMOs.[12] Hardly any GM crops enter into our food simply because most people would not buy food that carries a GMO label. **However, there are massive loopholes in the existing regulations. As a result, the EU is a big market for GM crops grown elsewhere.**

Just one GM crop – a pesticide (Bt)-producing maize variety – is grown in the EU, and that only on a very small area.[13] Eighteen of 27 EU countries have banned the cultivation of this GM maize, along with that of other GM crops that the EU could authorise in the near future.[14]

But the EU imports large amounts of herbicide-tolerant and pesticide-producing GM crops, all of which go into animal feed. This is due to a gap in the EU's labelling regulations, which means that milk, eggs and meat from animals reared on GM feed do not have to be labelled. Most consumers are unaware of this and may choose to avoid such food if they had the opportunity. EU countries such as Germany, Austria and Slovenia have introduced voluntary 'GMO-free' labelling, and the range of 'GMO-free' animal products is steadily increasing.[15]

The EU authorisation of GMOs for import or cultivation in the EU is based on a cursory risk assessment by the European Food Safety Authority (EFSA).[16] Usually, less than half of EU countries back the decisions, and their support has been declining over recent years.[17] The European Parliament routinely votes to reject the authorisations.[18] The final call is however for the European Commission, which consistently allows GM crops for import despite the lack of political support.[19]

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11 Eurobarometer, 2010, Biotechnology.

12 European Commission, GMO legislation.

13 ISAAA, 2020, Brief 55-2019 - Executive Summary.

14 European Commission, Restrictions of geographical scope of GMO applications/authorisations.

15 European Non-GMO Industry Association (ENGA), The Non-GMO sector in Europe.

16 EFSA considers that it makes no difference whether a crop tolerates several herbicides or produces several toxins. It only assesses individual traits, not their combined effect.

17 Purnhagen, K. & Wesseler, J. 2020, EU Regulation of New Plant Breeding Technologies and Their Possible Economic Implications for the EU and Beyond.

18 Metz, Tilly & Evi, Eleonora, 2020, Stop the import of GM crops destroying nature.

19 Three authorisations for cultivation are pending, including the renewal of the EU's only GM maize and approval of two further GM maize varieties. EU member states voted on these already in 2017, and the decision is now with the Commission.

NEW GMO ON THE HORIZON

The same corporations who brought us old-style GMO (or GMO 1.0) are now promoting a new generation of GMOs for use in agriculture, which they plan to develop using so-called "gene editing" techniques such as CRISPR-Cas (also termed new GMO or GMO 2.0). (See Box 1)

Gene editing is very powerful, allowing to genetically engineer a wide range of species across different kingdoms. It is also cheaper and easier to do than old-style genetic engineering, so nothing appears to be off limits. Whilst most scientists will be cautious about applications in humans (i.e. for gene therapy), there is a genuine "gene rush" ongoing to engineer agricultural crops and farm animals as well as wild species including algae, bacteria, insects and mammals.

Gene editing is also highly "weaponisable",[20] an aspect that has drawn much funding from the US defence department[21] and the Chinese people's army[22]. **In 2016, a US intelligence report listed gene editing as a potential "weapon of mass destruction and proliferation."[23]**

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20 DiEuliis, D. & Giordano, J. 2018, Gene editing using CRISPR/Cas9: implications for dual-use and biosecurity. Protein Cell, 9.

21 Kupferschmidt, K. 2018, Crop-protecting insects could be turned into bioweapons, critics warn Science (news).

22 Kania, E. B. & VornDick, W. 2019, Weaponizing Biotech: How China's Military Is Preparing for a 'New Domain of Warfare' Defense One.

23 Regalado, A. 2016, Top U.S. Intelligence Official Calls Gene Editing a WMD Threat, MIT Technology Review.

GENE DRIVES

BOX 2

CRISPR-CAS GENE DRIVES – NATURE GENETICALLY ENGINEERING ITSELF

A particularly worrying application of gene editing are genetically engineered "gene drives". Whilst today's GM organisms tend to be agricultural crops that are meant to stay put on fields, gene drive organisms are meant to "drive" a certain GM trait through entire populations of wildlife species.

A specific application of gene drives, so-called "suppression drives", are designed to eradicate populations. This has been shown to work in the laboratory for a mosquito species and for mice.[24] Patent applications typically cover insects that carry diseases (such as Malaria-carrying mosquitoes) or are regarded as crop pests (such as the olive fly), and plants regarded as agricultural weeds (although the application in plants is less advanced at this point).

This technology, aptly termed "extinction on demand"[25], goes against any efforts to stop the galloping loss of nature. **Scientists warn that it is practically impossible to predict how a gene drive would work outside the laboratory, therefore a robust risk assessment cannot be done at this stage.[26] Greenpeace and others have called for a global moratorium on gene drives.[27] The European Parliament has backed this call.[28]**

Despite the "gene rush" that got hold of public and private laboratories, very few farming applications have made it to the market. This is regardless of regulations and likely linked to technical hurdles, patent issues and consumer rejection. In the US, although many gene-edited organisms were released from regulation, only two gene-edited are grown commercially, a herbicide-tolerant oilseed rape (Cibus' SU Canola) and soybean with an altered fatty acid composition (Calyxt's High Oleic Soybean). A gene-edited hornless cow was put on hold after US authorities found it to be in fact transgenic, despite claims by the developers that it was free from foreign genes[29] – its genome inadvertently contained bacterial DNA that conferred antibiotic resistance.[30]

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24 ENSSER et al, 2019, Gene drives. A report on their science, applications, social aspects, ethics and regulations.

25 The Economist, 2018, Extinction on demand. The promise and peril of gene drives.

26 ENSSER et al, 2019, op cit.

27 Greenpeace, 2020, Letter to Commissioners Sinkevičius and Kyriakides on gene drives.

28 European Parliament, 2020, Resolution on COP15 to the Convention on Biological Diversity.

29 Maxmen, A. 2020, Gene-edited animals face US regulatory crackdown, Nature (news).

30 Regalado, A. 2019, Gene-edited cattle have a major screwup in their DNA, MIT Technology Review.

BOX 3

GENETIC "EDITS" OFTEN INTRODUCE ERRORS

Gene editing is prone to unintended outcomes that can pose a serious risk to the environment and consumers. Some of these are identical to old-style GM while others are new.

Firstly, old and new GMOs have more in common than proponents would make us believe. Of the three main steps involved in gene editing – gene delivery, editing, and whole plant regeneration with the help of tissue culture – the first and last essentially remain the same.

These steps can lead to the integration of unwanted DNA sequences originating from the DNA-transferring bacterium or from cell culture - a problem that occurs in gene editing as in old-style genetic engineering.[31]

Secondly, gene editing has its own, specific problems. For example, the cutting often happens not only at the targeted site, but also in other places in the DNA, causing off-target effects. In addition, the subsequent repair can lead to deletions and rearrangements, not only around the DNA cuts but also further down in the DNA, affecting the functions of multiple genes. This has mostly been documented in mammals but there is no reason why it would not also happen in plants. These "genetic errors" can affect the biochemical pathways in plants and potentially lead to the production of novel toxins or allergens, or different levels of existing toxins and allergens.[32]

The degree to which off-target effects occur varies according to the tools (CRISPR-Cas or other), the targeted sites and the organisms. Developers use computer algorithms to predict the location of off-target effects but success has been limited. More often than not, genetic errors pass unnoticed in gene-edited organisms because developers are not looking for them.[33] Thus, it is often reported that the desired change has been achieved, but there is little consideration of what genetic errors might also have been created.

There is no reason to believe that gene-edited GM organisms are any less risky than first generation GMOs, and that they can be subject to less regulatory scrutiny.

GENE EDITING

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31 Latham, J. 2019, Gene-Editing Unintentionally Adds Bovine DNA, Goat DNA, and Bacterial DNA, Mouse Researchers Find.

32 Kawall, K., Cotter, J. & Then, C. 2020, Broadening the GMO risk assessment in the EU for genome editing technologies in agriculture. Environmental Sciences Europe 32, 106.

33 Idem.

GM SEED PRODUCERS WANT TO SEE NEW GMO EXCLUDED FROM EU GMO LAW

Companies like Bayer, Corteva and Syngenta argue that Europe must follow the example of countries already hooked on GM technology and exempt new GMO from its GMO regulations. They claim that gene editing can produce organisms that are just the same as conventionally bred ones, and that these organisms have no place under EU GMO law.

But this is wrong. The process by which gene-edited GM organisms are produced (see Boxes 1 and 3) makes it is highly unlikely they could also be naturally developed.

Firstly, the genetic changes caused by "gene scissors" are fundamentally different from those triggered by toxic chemicals, ionising radiation or sunlight. Gene editing can effect identical changes across all or multiple gene copies, for example. It can also bypass mechanisms that normally shield certain regions of the genome from mutations, making the whole genome accessible to genetic modification.[34] Secondly, two out of three steps in the genetic engineering process remain the same with gene editing as with old-style GM (as outlined in Box 3).

If gene editing were to be excluded from EU GMO rules, a new generation of GMOs, including products from GM farm animals, could end up on our fields and plates, and in nature, untested and unlabelled. Farmers, whether conventional or organic, could no longer avoid planting GM crops. Consumers could not avoid buying GM food, since the EU's GMO labelling rules would no longer apply. EU governments could not impose national bans on the cultivation of GM crops. **The companies could turn our landscapes into a massive field trial with unknown consequences for our food and ecosystems.**

Fortunately, new GMOs are covered by the EU GMO Directive, pursuant to a landmark ruling of the European Court of Justice (ECJ) of July 2018. According to the Court, the exclusion of new GMOs would reduce the scope of the directive in a way that "would compromise the objective of protection pursued by the directive and would fail to respect the precautionary principle which it seeks to implement" (para 53 of the ruling). Since that ruling, the EU has the duty to implement and enforce EU GMO legislation and the precautionary principle for all GMOs, including new GMOs.

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34 Kawall, 2019, New possibilities on the horizon: Genome editing makes the whole genome accessible for changes. Frontiers in Plant Science 2019, 10.

BROKEN PROMISES AND POOR TRACK RECORD

GMO proponents are saying that new GMO is necessary to make EU farming more environmentally friendly and allow it to withstand the ravages of climate breakdown.[35]

However, the same claims have been made before – about old-style GM crops. Experience shows that these promises failed to deliver. [36]

There is another reason to doubt these claims: the same corporations that are promoting gene editing as a safe and reliable method of "breeding" have hidden the nefarious effects of their pesticide products for decades. They pretend these products are safe even after the EU has banned these chemicals due to the dangers they cause to people and the environment. For example, Bayer still stands by its bee-harming neonicotinoid pesticides and Corteva by its brain-damaging insecticide chlorpyrifos. Syngenta sees no reason to stop the production of weedkillers paraquat and atrazine. Bayer also continues to claim that its glyphosate products are safe even after US courts ruled in three different cases that they caused cancer.[37]

Clearly, these companies have little concern for people's health or the environment. They may back down on individual products – usually after the patent runs out – but continue to defend the dead-end chemical farming model as such, despite its failures.

Given the companies' poor track record, nobody should believe that any of their products will be safe "by design". So long as these corporations are wedded to the 20th century's chemical farming model, we should not expect any better from new GMO than we have seen with old-style GMO. So long as they profit from environmental degradation, they cannot be the ones telling us how to end it.

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35 Euroseeds, 2018, Position: Plant Breeding Innovation.

36 Greenpeace International, 2015, Twenty Years of Failure.

37 US Right To Know (USRTK), Monsanto Roundup & Dicamba Trial Tracker.

THE EU MUST STAY AWAY FROM NEW GM TECHNOLOGY

EU politicians must resist the pressure of agrichemical corporations. Their decisions must serve people not corporations. They should:

FULLY APPLY EXISTING EU LAWS

— Apply zero tolerance to unauthorised imports of GMOs, including new GMO;

— Develop technical methods to identify non-authorised new GMO products;

— Ensure that GMO safety evaluation is based on the latest science, taking into account all possible pathways of harm;

— Work towards a global moratorium on the release of genetically engineered gene drives.

TIGHTEN EU LAWS

— Reform the EU GMO authorisation process so that decisions can no longer be taken by the Commission alone, without the backing of a qualified majority of EU member states;

— Ensure full accountability of EU decisions – all documents must be made public, votes of each member state known and exchanges with member states released in line with the European Ombudsman recommendations;[38]

— Close the gap in the EU's GMO labelling regulations so that products derived from animals fed with GM feed are clearly labelled.

DEVISE OBJECTIVES AND TOOLS TO ACHIEVE ECOLOGICAL FARMING

— Reduce meat and dairy production and consumption, so that EU farmers grow food for people not farm animals;

— Set an objective of GMO-free farming – no GMO cultivation and no GMO imports from other parts of the world;

— Set an objective of pesticide-free farming – no use of synthetic pesticides in the EU and no import of products treated with them;

— Invest public money in research into and training on ecological breeding and farming, rather than GM technology.

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38 European Ombudsman, 2019, Recommendation of the European Ombudsman in case 2142/2018/TE.

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