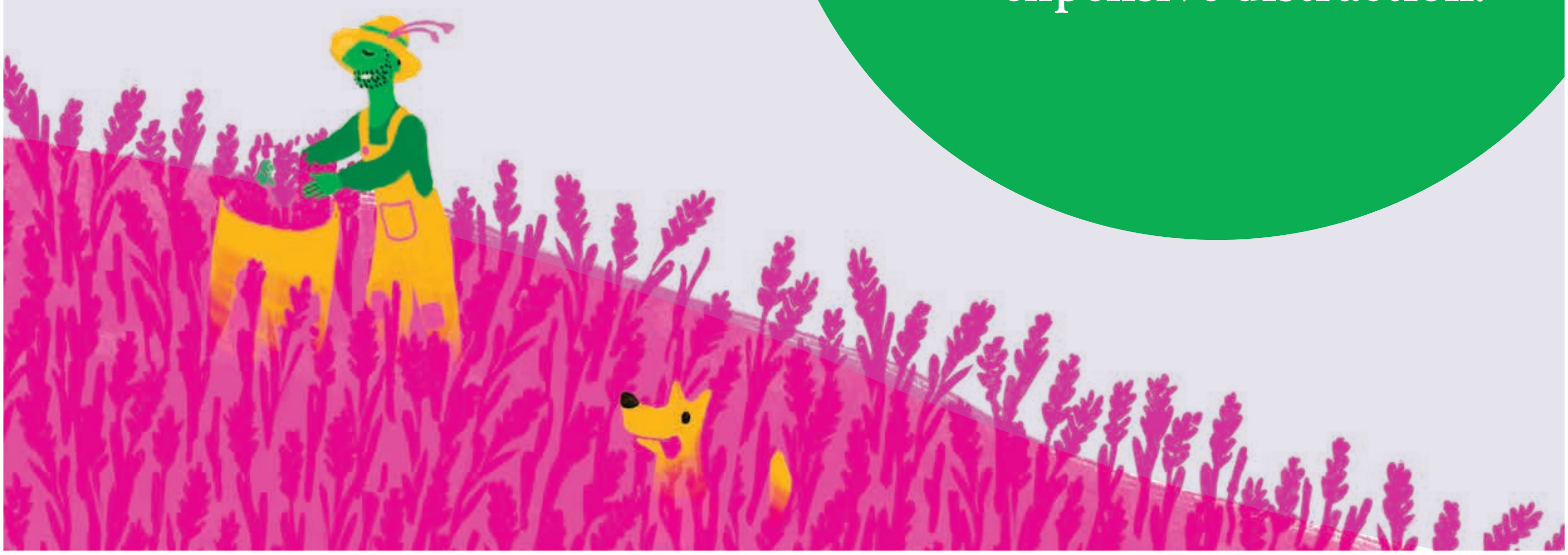
8. Gene editing is a risky and expensive distraction from proven successful solutions to food and farming problems

MYTH

Gene editing is necessary to grow food that is better for people and the environment, so not applying it would be morally reprehensible.

REALITY

We need to scale up proven successful solutions – conventional breeding and agroecology – from which genetic engineering is an expensive distraction.



Industry lobbyists claim that the use of gene editing is of “unprecedented importance” to deal with climate change and scarcity of natural resources such as arable land and water. They say it is necessary to develop crops that are pest- and disease-resistant and can adapt to difficult climatic conditions such as drought, heat, and salinity.[1,2]

According to Bayer, gene editing is “fundamental in achieving the goals of the EU Green Deal”[3] that aims to tackle both climate change and environmental degradation and make the EU economy sustainable. The company says that if the EU fails to “reverse legislation” that blocks gene editing, it could: “miss out on one of the most promising innovations of our lifetime to enable more sustainable resilient food systems”.[4]

Bayer says the EU could “miss out on one of the most promising innovations of our lifetime to enable more sustainable resilient food systems”.

The EU seed industry association, which Bayer is part of, says it is the EU's "prohibitive" GMO laws that prevent innovation "for a more sustainable agri-food system at the pace that is urgently needed".[1]

Such arguments create a context in which genetic engineering is viewed as the moral imperative – and rejection, or even just regulation, as morally reprehensible.

NEW TECHNIQUES, OLD CLAIMS

Claims that genetic engineering can help farmers to deal with adverse conditions and protect the environment are not new. First-generation transgenic GM crops were promoted on the basis of claims that they would be adapted to difficult climatic conditions, such as drought, and reduce pesticide use.[5]

These promises proved false. Regarding drought, a transgenic GM drought-tolerant maize from Monsanto was released in 2011, but the US Department of Agriculture (USDA) said it was no more effective than conventionally bred varieties.[6] Farmer adoption of varieties in which the drought tolerance was achieved via GM has "lagged behind" varieties in which it was achieved by conventional breeding.[7]

> Herbicide-tolerant GM crops are sold by agrichemical companies in tandem with their proprietary herbicides

The claim of reduced pesticide use also proved to be false Herbicide-tolerant GM crops are sold by agrichemical companies in tandem with their proprietary herbicides. They have increased the use of chemical weedkillers, including products containing the "probable carcinogen" glyphosate.[8,9]

Insecticide-producing GM crops (so-called Bt crops) rapidly lost effectiveness against targeted pests, fell victim to Bt toxin-resistant and secondary pests, and are now used in combination with chemical insecticides.[10,11,12,13,14,15,16,17,18] These include highly toxic neonicotinoid insecticidal seed treatments, the use of which has risen in parallel with Bt crops in the USA.[16]

GENE EDITING APPROACHES TO PEST CONTROL SET TO FAIL

Agricultural biotech companies are promoting the newer techniques of gene editing as a way to manage insect pests that would reduce the need for chemical insecticides. Proposed approaches include altering plant composition in order to repel pests.[19]

However, these approaches may meet the same fate as older-style GM crops – as pests can rapidly evolve resistance to environmental stresses, whether they consist of sprayed-on chemical pesticides, built-in pesticides like Bt toxins, or plants genetically engineered to repel pests.

In the UK, Rothamsted Research's so-called "whiffy wheat" trial, in which wheat was genetically engineered to release an aphid-repelling chemical found in mint, failed after £2.6 million of public money was spent on the project. The aphids rapidly got used to the smell.[20]

Ironically, previous government-funded research undertaken by Rothamsted and others demonstrated that aphid levels can be kept below economically significant levels by maintaining diverse field margins and hedgerows.[21] This innovative research was based on an understanding of agroecology. But seemingly, it has been ignored by GM researchers and their institutions.

CONVENTIONAL BREEDING AND GOOD FARMING PRACTICES WORK BETTER TO FIGHT PLANT DISEASES

Seed industry associations say that gene editing is a way to fight plant diseases while reducing pesticide use. One promotional video claims that wheat can be gene edited to make it resistant to rust and powdery mildew diseases.[22]

> The key to controlling both crop diseases and insect pests lies in prevention through good farming practices

However, powdery mildew-resistant wheat has already been developed through conventional breeding, helped by marker assisted selection.[23] Progress has been made in gene mapping for powdery mildew resistance in wheat, to help breeders who want to use these techniques.[24]

Rust-resistant wheat varieties have also been developed via conventional breeding.[25,26,27] According to the International Maize and Wheat Improvement Center (CIMMYT), its "rust-resistant varieties now cover more than 90% of the wheat farming area in Kenya and Ethiopia".[28]

Attempts to achieve disease resistance through gene editing are unlikely to match these conventional breeding successes. Disease-causing microorganisms, like insect pests, have great genetic diversity and thus adaptability, so they can easily "break" a resistance based on changes in one or a few genes.

Moreover, the key to controlling both crop diseases and insect pests lies in prevention through good farming practices such as crop rotation,[29] which is often ignored in monocrop, industrialised agriculture.

GENE EDITING CANNOT CONFER DESIRABLE COMPLEX TRAITS

Conventional breeding continues to outstrip GM in developing crops with durable resistance to pests and diseases, drought tolerance, enhanced nutritional quality, and tolerance to salinity.[30,31,32,33] This is because these are genetically complex traits, meaning that they are the product of many genes working together in a precisely regulated way. Such traits will be extremely difficult or impossible to achieve by manipulating one or a few genes, which is all that gene editing and genetic modification in general can achieve, even using multiplex approaches.

> Genetically complex traits will be extremely difficult or impossible to achieve by manipulating one or a few genes

GM has largely succeeded only in producing crops with genetically simple traits such as herbicide tolerance or the ability to express an insecticide. Gene editing is set to continue on the same path. The gene-edited crops commercialisation pipeline is mainly characterised by genetically simple traits, such as or herbicide tolerance, or modified composition to increase product shelf life or provide raw materials for processing industries.[34] These traits do not improve the sustainability or climate resilience of agriculture, but allow developers to continue to sell GM seeds with agrochemicals and help industry to optimize its manufacturing processes.

It is not surprising, then, that thus far the only gene-edited crops that have made it to market are Calyxt's soybean and Cibus' SU Canola. The soybean has an altered fat profile to avoid creating unhealthy trans fats when cooking food at high temperatures.[35] The canola has been engineered to enable increased herbicide use without killing the crop – the opposite to the claimed reductions in pesticide use from gene-editing technology.

GENE EDITING CAN BRING ADDITIONAL RISKS

Gene editing plants for disease resistance brings other risks, too, some of which have already come to light. Attempts to use CRISPR gene editing to produce virus-resistant cassava plants failed, and in the process broke their already-existing natural resistance to a different, more widespread virus.

The experiment also resulted in the propagation of mutated viruses that, if they had escaped the laboratory, could have led to “the development of a truly pathogenic novel virus”, according to the researchers.[36] The lead researcher questioned on Twitter whether this was a “risk” worth taking in fields. Meanwhile, non-GM programmes for breeding and supplying virus-resistant cassava have proven successful over many years, but struggle for funding.[33]

Currently, so-called gene drives, a particular application of gene-editing technology, are being promoted as a way to eradicate insect pests.[19] But the risks posed by gene drives are unpredictable and the impacts potentially severe.[37]

SYSTEMS, NOT JUST GENES

When it comes to solving challenges of pests, diseases, or climate change, it is crucial to look at whole farming systems rather than employing a reductionist approach that only looks at genes, especially genetic engineering approaches that only manipulate one or a few genes. As well as robust crops providing stable yields under adverse conditions, we need resilient farming systems that cope with a variety of environmental stresses. Such systems include soil building with organic matter to retain moisture and planting a diversity of crops to prevent pest and disease problems.

> Agroecology projects in the Global South and other developing regions have produced dramatic increases in yields and food security

Successful systems approaches include :

• The organic system. In the longest-running trial comparing organic and conventional grain cropping systems (including GM crops), the Rodale Institute Farming Systems Trial, researchers found that organic systems produce yields that are competitive with conventional systems after a 5-year transition period. Yields in the organic systems were up to 40% higher in times of drought. The trial also found that organic systems use 45% less energy and release 40% fewer carbon emissions. Crop rotations were used instead of pesticides to control pests.[38]

• The System of Rice Intensification (SRI). SRI is an agroecological method of increasing the productivity of rice by changing the management of plants, soil, water, and nutrients. The benefits of SRI include yield increases of 20–100%, up to a 90% reduction in the amount of seed required, and water savings of up to 50%.[39]

• Agroecology projects in the Global South and other developing regions. These projects have produced dramatic increases in yields and food security.[40,41,42,43,44,45]

OVER 400 INTERNATIONAL SCIENTISTS SAY AGROECOLOGY IS THE WAY FORWARD

In 2008 a ground-breaking study on the future of farming was published. Sponsored by the World Bank and the United Nations and conducted by over 400 international scientists, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) did not endorse GM crops as a solution to world hunger.

The report noted that yields of GM crops were "highly variable".
It added that safety questions remained over GM crops and that the patents attached to them could undermine seed saving and food security in developing countries. The report concluded that the key to food security lies in agroecology.[46]

EXPENSIVE DISTRACTION

GM approaches have been shown to be an expensive distraction from already-available approaches to solving challenges of climate change, pests, and diseases. These approaches, based on the science of agroecology, are also the most sustainable way to end our dependency on chemical pesticides.

> The need to reduce pesticide use is pressing, but this goal will not be achieved by looking to companies that sell these products

The need to reduce pesticide use is pressing, but this goal will not be achieved by looking to companies that sell these products. In fact, the agricultural biotech companies promoting gene editing (for example, Corteva, Bayer, Syngenta, and BASF) are also agrochemical companies and their business model is built on selling seeds in a package with pesticides and other chemical inputs.

Resources should instead be directed towards making proven-successful agroecological methods more widely available to farmers.

In a time of climate and ecological breakdown, this – not risky genetic engineering technologies owned and promoted by agrichemical companies – is the moral imperative.

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CONCLUSION

The evidence presented in this report shows that gene editing is imprecise and that its outcomes are uncontrollable. Numerous types of unintended mutations have been shown to arise from gene editing, including large deletions, rearrangements and insertions at on-target and off-target sites of the genome. These will cause altered gene function, leading to compositional changes in plants that could result in toxicity or allergenicity. Gene editing in animals has also been shown to have unpredictable and potentially dangerous outcomes.

In gene editing, unlike with transgenic technology, traditional mutagenesis or conventional breeding, any region of the genome can be targeted. In addition, given that gene editing will be used simultaneously or sequentially to target one or more genes, the risks will be compounded with each step.

Inadequate screening by developers could result in harmful traits persisting in products reaching the marketplace. In order to protect health and environment, all types of unintended effects of gene-editing techniques should be taken into account in a detailed process- and product-based risk assessment, as some scientists recommend.

Given the uncertainties and risks attached to gene editing, it is unacceptable to weaken the regulations governing these genetic manipulation techniques. Rather, the existing protocols for GMO risk assessment should be extended and strengthened to take account of gene editing's particular risks.

In particular, broadening the risk assessment to include new molecular analysis tools ("omics") would help to identify important unintended changes in transgenic and gene-edited GM crops.

Given that gene editing can only manipulate a limited number of genes, it will fail to deliver on desirable complex genetic traits such as drought tolerance, pest resistance and disease resistance, which involve multiple gene families working together.

Furthermore, ownership and control of gene-editing technology is in the hands of a very few large corporations, which means that it will not democratize agriculture but will instead lead to further consolidation of the seed industry and threaten food and seed sovereignty.

In the interests of public health, the environment, and a resilient food system, gene editing must remain under the current EU GMO regulations. Furthermore, risk assessment guidance should be tightened to take into account the particular risks posed by this technology.

The climate and sustainability crises demand that we implement proven-successful agroecological solutions to the problems in our food and farming systems, rather than pursuing risky and expensive gene editing approaches.

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