Is the Irish political stance towards genetically modified crop cultivation shifting?

Abstract

Historically, Ireland has maintained a firm stance against genetically modified (GM) crop cultivation, resulting in an outright ban. Through examining recent Irish political debates this staunch opposition to GM crops may be slowly shifting. A pivotal moment occurred on March 9th 2022 when scientific expertise was incorporated into the political discussion. Their input highlighted recent advancements in GM technology, assessing the potential benefits and risks of adopting GM crops. The discussion reflected a societal shift in perspectives from concerns of "playing God" to new apprehensions of Ireland's agricultural competitiveness on a global scale. Numerous factors may contribute to the evolving political openness toward GM crop adoption. This paper identifies four primary drivers that underpin this shifting perspective. First, our imperative to mitigate the effects of climate change, prompting consideration of GM crops as a potential solution. Second, political post-pandemic willingness towards innovative science. Third, the recent advancements in GM agricultural research. Finally, the economic significance of GM crop cultivation and the impact on Irish farmers if this innovation is not utilised. As the agricultural industry evolves to adapt to changing circumstances, this paper underscores the importance of a nuanced approach that balances public perception, scientific evidence, and economic imperatives in shaping future policy decisions.

Layman's Summary

Ireland's agricultural industry has always taken pride in its natural and high-quality methods of production. This has led politicians to safeguard the industry's competitiveness on the global stage, which included a ban on cultivating genetically modified (GM) crops. However, in recent years politicians are showing a slow shift in their perspectives towards this ban. On March 9th 2022 scientific experts were invited to the Irish parliament to discuss the recent advancements, potential benefits, and risks of using GM technology in farming.

Traditional genetic engineering involved the insertion of a gene from one organism to another. In the pharmaceutical sector this was used successfully to insert the human gene for insulin into E.coli bacteria, providing a safe and efficient source of insulin to treat diabetes worldwide. However, when it came to using GMOs in farming, concerns arose surrounding the effects it may have on biodiversity and the perception that GM crops were inherently altered and unnatural. Recent advancements in genetic engineering technology now allow for small precise changes to be made to the genetic code, akin to the small mutational differences which make each of us unique.

The potential of GM crops has expanded, which will be crucial to tackle the increasingly extreme weather events resulting from climate change. These crops can withstand harsh conditions such as drought or heavy rains, as well as resist infections. As our climate warms, it creates the perfect hot and humid environment that allow plant diseases to thrive.

Currently, farmers must rely on chemical pesticides and herbicides. Whilst these chemicals may help save the harvest, they go on to harm aquatic wildlife and our available drinking water. Developing crops which are inherently disease resistant reduces the impact of farming on biodiversity.

The recent pandemic prompted politicians to trust in scientific expertise, seeking guidance on preventing virus spread and developing vaccines. This growing political willingness to discuss with scientists now extends to other issues, such as GM crop cultivation. Irish plant scientists, including Dr Thomas McLoughlin have long expressed their frustration at the Irish government for their limited understanding of GM crop cultivation in Ireland. The tide changed during the March 9th debate, when he, along with other experts were invited to discuss the possibility of incorporating GM crop cultivation in Ireland.

During the debate, a new concern emerged: the fear that Ireland's agricultural sector would lag behind countries who have adopted GM crops. Despite the ban, GMOs are entering Irish food chains through imported animal feed, and the continued ban may prove futile for protecting Irish consumers. The economic benefits of GMOs can no longer be dismissed, and if Irish farmers are prohibited from utilizing this tool, they risk losing out.

Introduction

Despite the ban on GM crop cultivation in Ireland, recent parliamentary discussions suggest a potential shift in viewpoints. Out of the 655 Oireachtas[1] debates that mentioned GM organisms, the first to incorporate a scientific perspective occurred on March 9th, 2022. During this discussion, the Committee on Agriculture, Food, and the Marine consulted several experts, officials from the Department of the Environment, Climate, and Communications, and representatives from Teagasc, the state agency responsible for researching, advising, and educating in agricultural development. The committee examined recent advancements in GM technology, such as CRISPR-Cas9 gene editing, and considered the potential benefits and risks of incorporating GM crops in future agriculture. While concerns about "playing God" and losing Ireland's reputation as a natural food producer were once prominent, the discussion acknowledged the new fear that Ireland's agricultural industry could fall behind other countries that have adopted GM crop cultivation. Summed up by Senator Paul Daly, who questioned the experts, "In the countries that have accepted CRISPR, how far behind the curve are we?" Fears surrounding genetically modified organisms (GMO) implementation have shifted, fear of their implementation has been replaced by economic fears of being left behind.

This shift in political willingness to re-evaluate Ireland's stance on agricultural GMOs has occurred relatively recently. As late as July 2018, Directive 2015/412 was passed by the Minister for Climate Action and Environment, Denis Naughten, to reinforce the ban against GMOs. Naughten stated that it was crucial for Ireland to maintain its GMO cultivation-free status, which is a significant part of the country's reputation as a sustainable and environmentally conscious food producer. Of the 655 Oireachtas debates which featured

[1] The Irish parliament consisting of the President of Ireland, the Lower House of the Dáil and the Upper house of the Seanad.

GMOs in their discussion, only 22% took place since 2010, within the last decade. Considering the recent expansion of GMO research perhaps the laws surround GMO legislation should be reconsidered. However, scientific advancement alone would not be enough to cause politicians to rethink their strong stance against GMO cultivation.

The risks associated with the cultivation of GMO crops have heavily influenced political policy. The early adoption of GMOs in the pharmaceutical industry was positively viewed by consumers as the direct benefits of GMOs were tangible to them (Marris, 2001). For example, the use of microbes to produce human insulin easily in a fermentation tank, rather than extracted from pig pancreases (Hanlon & Sewalt, 2021). However, extrapolating that success to the agricultural industry was met with vehement opposition. Conservationists feared that GMOs would have a negative impact on biodiversity. For instance, an herbicide-resistant GMO runs the risk of becoming an invasive species. The NGO group Greenpeace continues to argue against GMOs on this basis. In 2021, Kevin Stairs, a representative from Greenpeace, stated, "The EU has a responsibility to protect the rights of farmers to choose what they plant and for people to choose what they eat, and to protect the environment and biodiversity from potential harm from new GMOs." Farmers also feared the risk of GM crops contaminating other crops in their vicinity. As many Irish products were labelled as GMO-free abroad, introducing GMOs would significantly embarrass and harm the Irish agricultural industry. After Deputy Denis Naughten reiterated the ban against GM crop cultivation in Ireland, this policy was used to market Irish food abroad as GMO-free. Later that year, Glanbia launched their "Truly Grass Fed" cheese brand in the US, advertising itself as cheese from non-GMO, growth hormone-free, and antibiotic-free cows. As many rural areas in Ireland rely on a successful agricultural business, risking the perceived quality of Irish goods by introducing GMOs would be a politically unwise stance to take, thus influencing political policy.

Some risks are more abstract than others. When the public lacks scientific understanding of a subject, they tend to rely on their instincts. Regarding GMOs, people's intuitive response is that they are inherently unnatural and can illicit feelings of disgust (Blancke et al., 2015; Best, 2006). In the early 2000s, the rising Green Movement aimed to detach human interference from nature to allow it to thrive. Since GMOs were considered inherently unnatural, they were not viewed as a possible solution for environmental restoration and instead, as an obstacle to that goal (Scott, 2000). GMOs posed a risk to the environment by introducing further unnatural, human interference.

In addition, European society was highly opposed to consuming GM crops and feared the risk they posed by contaminating the food chain. Early political debates centred around the need for GM crops to be specifically labelled to regulate their sale in the European market (Herrick, 2005). This opposition may stem from our natural feelings of disgust to unknown food (Kelly, 2011). With GMOs, the perceived essence of the organism has been contaminated by altering its DNA. A lack of understanding about the genetics of GMOs led to heightened levels of fear and mistrust of the unknown. Surveys conducted on 1,200 Americans from 2001-2004 asked for their opinions on GM food (Hallman et al., 2004). While many expressed interest in the topic and how it would affect their health, they also held misconceptions about it. In 2003, 57% of respondents thought that ordinary tomatoes did not contain genes, while GM tomatoes did. Also, 60% of respondents in 2003 believed

that inserting a catfish gene into a tomato plant would give the tomato a fishy flavour (Hallman et al., 2004). These responses speak to the failure of the scientific community to properly explain their own findings, many respondents also desired more information about GM food.

Before delving further, it is important to define GMO crops for the purposes of this paper. While one may assume they understand what a GMO is—an organism whose genetic code has been altered by a scientist—different stakeholders use various definitions according to their backgrounds in the subject. During the political debate on March 9th 2022, two scientists from different organisations presented two separate definitions. Mr. Eoin Deegan, the Principal Officer of the environment policy division in the Department of the Environment, Climate, and Communications, defined GMOs as "any organism whose genetic material has been modified using genetic engineering or transgenic technology, such as by inserting genetic material from another living organism or through gene editing." Meanwhile, Dr. Barbara Doyle Prestwich, Head of University College Cork's Plant Science Department, attempted to distinguish New Genomic Techniques such as CRISPR-Cas9 from traditional GMOs by stating that "while additional sequences can be introduced, there is also CRISPR whereby a change is made, and the change is not any different from one that might occur in nature or one that could be induced through X-ray mutagenesis, which are not labelled under the directive as GMO techniques."

These conflicting explanations do not provide a definitive background to describe a GMO. Thus, it is essential to clarify the definition of GMOs compared to New Genomic Techniques to prevent further confusion. The definition from the European Commission study on New Genomic Techniques (October 2021) concluded that New Genomic Techniques are "techniques capable of changing the genetic material of an organism and that have emerged or have been developed since 2001," an important date to keep in mind as it marks the adoption of EU legislation on GMOs. In 2001, Directive 2001/18/EC of the European Parliament defined GMOs 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." Natural recombination refers to the genetic reshuffling of genes that occurs during sexual reproduction. Since both these definitions seem to describe the same process of unnatural genetic material editing with the defining difference being the date of discovery, for the purposes of this paper, I will consider New Genomic Technology and Genetically Modified Organisms to be the same.

Whilst the European Directive of 2001 largely prohibited the use of genetic modification techniques due to the risks they posed, the study European Commission study on New Genomic Techniques (October 2021), had a positive conclusion. The latter recognised the potential of these techniques to help the EU reach the goals of its ‘farm to fork’ initiative. It also recognised the limitations in the current policy regarding genetic modification of crops, which does not keep pace with scientific development in this area. Yet current policy remains a reflection of previous perceptions of the risks GMOs posed.

Two Europeans studies commissioned 20 years apart make opposing conclusions. Since the early 2000s political debates have shifted in perspectives towards GMOs. Many reasons are behind this frameshift. There are four which I have identified, but I am aware this is not an

exhaustive list. First, the changing attitudes resulting from our increased understanding of climate change. Globally, we have all felt its effects and every effort must be taken to mitigate its consequences. One of our mitigation options is GMO crop cultivation, we can no longer ignore the potential benefits they can provide to the environment. Second, our post-pandemic world view, the pandemic had far-reaching affects at all levels of society, changing the way the world thinks. Third, the new genomic technologies that have developed since the early 2000s in this field. We have vastly improved our understanding of GMOs and now have decades of research on the effects of GMO cultivation on the environment, mitigating some of the previously perceived risks. Lastly, the economic benefits of GMO introduction should no longer be dismissed. Furthermore, as Dr Thomas McLoughlin so finely put it in the Seanad's political debate March 2022, "The train has left the station." We must face our reality; GMOs are entering our food supply chain and to continue to hinder Irish farmers from GM crop cultivation negatively affects our agricultural industry as they try to compete against farmers across the globe.

The Age of New Genomic Technology

As previously discussed, genetic research has undergone rapid advancements in recent years, leading to more precise techniques that enhance researchers' ability to make specific, small-scale alterations to the genetic code. When the EU Directive against the cultivation of GMO crops was initially enacted in 2001, most genetic modification methods focused on the insertion of genes from one organism into another. However, certain genetic modification methods applicable in the medical field, such as in vitro fertilization, were not included in the directive. Likewise, natural genetic modification processes like horizontal gene transfer, which occurs between bacteria and is commonly utilized in industrial fermentation (Bron et al., 2019, Wang et al., 2023), were also excluded. Horizontal gene transfer involves the transfer of genetic information between distantly related organisms. Another excluded technique was polyploidy induction, which doubles the number of chromosomes in an organism. While this can occur naturally due to incomplete separation of cells during meiosis, it is deliberately utilized in the flower industry, particularly with orchids, to produce larger, more resilient flowers with improved pathogen resistance (Vilcherrez-Atoche et al., 2022). As these techniques were deemed to be naturally occurring without adverse effects on the environment, they received approval for use in industry.

Our understanding of natural biological systems has since advanced. The CRISPR-Cas system, discovered in prokaryotes in 2007, serves as an adaptive immune mechanism against invading viruses attempting to incorporate their DNA into prokaryotic cells. CRISPR identifies foreign viral DNA and, with the assistance of the Cas9 protein, removes it from the prokaryotic genome (Mojica & Rodriguez-Valera, 2016). This method of genetic modification occurs naturally. Hence, it is understandable why many scientists are frustrated with current EU laws which focus on the regulation of unnatural processes. During the Seanad Debate, Dr. Barbara Doyle Prestwich sought to differentiate the new CRISPR techniques from older methods that required the insertion of foreign genes into an organism. CRISPR may only require a single nucleotide change in the DNA to achieve the desired functional alteration in plants. Thus, it is far less invasive than previous genetic modification techniques, and natural mutation could achieve the same result.

With the emergence of new genomic technology, we can now recognize the inconsistency of mutagenic breeding techniques. This approach, developed in the 1930s, involves exposing plant seeds to ionizing radiation, which induces various genetic changes in their DNA code. The seeds are then grown, and those displaying enhanced traits of interest are selected for further breeding (Stadler, 1930). Although these organisms were only classified as GMOs in 2018, they remain exempt from the EU's GMO directive due to their long history of safe use. The argument behind this exemption is that random mutations occur naturally, such as through exposure to UV radiation. In contrast, targeted mutagenesis using CRISPR continues to be labelled as "unnatural," despite its existence in nature. A study on plant mutagenesis tools categorizes traditional mutagenic techniques involving ionizing radiation such as X-rays, gamma rays, neutrons, and high-energy ion beams as conventional methods, while describing CRISPR/Cas-based tools as targeted mutagenesis techniques (Shelake et al., 2019). The underlying biology of gene editing is fundamentally the same as that of mutagenic techniques: small changes are made to the genetic code, and the resulting plants are cultivated for human consumption. However, the crucial distinction between mutagenesis and specific gene editing using CRISPR is that we have knowledge of the genetic changes introduced by CRISPR, whereas mutagenesis can lead to thousands of untargeted alterations in the DNA code. CRISPR may only introduce one specific targeted DNA edit (Schulman et al., 2020). As Dr. Frank O'Mara highlighted in the Seanad Debate, "A key problem with mutagenesis is that the process is purely random and induces thousands of other unwanted genetic changes in the variety, which are not required. In contrast, gene editing is a precision breeding technique which makes it possible to enhance the performance of an organism via a targeted approach that changes a single gene at a time." He emphasized the similarity between CRISPR's targeted mutagenesis, and the random mutagenesis currently employed, although both can yield the same plant product. However, CRISPR-directed mutagenesis is precise and fast, significantly reducing the time required to produce new crop varieties (Yang et al., 2017). The rapid production of new crop variants is necessary to protect them against the emergence of fungal pathogens, as these pathogens quickly develop resistance to crop fungicides (Hahn, 2014).

Advancements in the development of GM crops have continued since their inception. The first approved GMO crop emerged in 1994 after evaluation by the US FDA, which deemed it as safe as traditionally bred tomato plants. At the time, concerns arose regarding potential risks to biodiversity and the contamination of other crops in the surrounding areas where these crops were cultivated. However, substantial progress has been made in addressing these concerns. Nearly 30 years of evaluation have provided insights into the environmental impact of growing GMOs. A field trial conducted in Ireland examined the growth of genetically modified blight-resistant potatoes and found no adverse effects on biodiversity (Mullins, 2019). A research paper exploring the potential benefits of GM crop cultivation revealed that 68% of survey participants believed GM crops could reduce the environmental footprint of agriculture by reducing water and nutrient inputs while increasing crop yields per hectare. Although a smaller percentage (39%) believed GM crops could enhance biodiversity, the well-established benefits of reduced chemical usage on fields are noteworthy (Lassoued et al., 2019).

Evolving Climate Action

Within the March 2022 Seanad debate a key focus was that the EU would not be able to reach its New Green Deal goals without the use of GMO technology. As part of the farm-to-fork strategy they set legally binding targets to reduce crop chemical inputs, such as pesticides, by 50% and reduce nutrient inputs, such as fertilisers by 20% by 2030. This commitment is in part to halt their impact on human health and to prevent further biodiversity loss in Europe caused by the build-up of pesticide residues in the environment. Pesticide use in agricultural areas has led to a decline in pollinators, 10% of bee and butterfly species in Europe are on the verge of extinction, with a further 33% of them in decline. As 75% of global food crops are reliant on pollinators, their decline has significant repercussions on our food supply. Reducing their use will be dependent on creating new crop varieties which are better adapted to changing environmental extremes such as flood and drought conditions, as well fortitude against invasive insect or fungal species. Using traditional breeding program methods, it takes an average of 10 years to create new cereal varieties and 13 years to develop new potato varieties, placing these crops, if they were successful, far outside the Green New Deal's time frame.

Over the last 20 years climate change has dominated our social consciousness as one of the greatest challenges of our generation. An opinion poll of 10 European countries in 2005 and again in 2007 found that participants considered it 'very likely' that they would be personally affected by climate change. Rising from 36% to 55% in the two surveys (Capstick et al., 2015). Over the years the urgency to address climate change has grown stronger. However, the agreed method to tackle this issue has shifted overtime. In the early 2000 much focus was placed on the individual to take personal responsibility in fighting climate change. Opinion polls between 2005 and 2010 showed a decline in favouring new technologies to combat climate change, with much more emphasis placed on changes in the lifestyles of individuals to help mitigate its effects (von Borgstede et al., 2013). Furthermore, there was a lack of political drive to promote innovation-based solutions to climate change. For a politician it is riskier to try and implement new policies to keep up with radical innovations than it is to promote an individual-based approach to tackling climate change (Howlett, 2014). Up until the 2010s there was a political resistance against drastic efforts to mitigate climate change for fear of risking their political standing, a solution like GMO introduction would be far too controversial for a politician to suggest, furthermore, there is no public drive for their introduction. Outside of the individual-based approach, another popular focus was the rewilding of our natural landscapes.

Environmental remediation focuses on repairing the nature we have damaged through thousands of years of farming and the past 200 years of industrialisation. Projects such as rewilding Europe work on natural ways to mitigate human influences on the environment and return Europe to its pre-farming landscape. The success of rewilding projects is difficult to define, and it will take years to see their true outcome. Some of these projects have faced backlash as the validity of returning extinct species to an environment that has been changed is not a proven science, it is possible animals will be introduced only for them to go extinct in the area again (Perino et al., 2019). The land has changed and will never return to a pre-anthropogenic state. Humans have made profound changes on the Irish landscape since woodland clearances first began on the island (between *c.* 2400–2100 B.C.) (Overland

& O'Connell, 2008). Efforts to restore native forest are hindered by pathogenic tree fungi. Rising rates of temperature and humidity in Ireland create the perfect climate for pathogenic fungi to thrive (Garrett et al., 2006). The common ash is one of the most important native trees in Ireland covering approximately 13% of Irish forest area, it is now under threat by the fungus *H. fraxineus* (Soldi et al., 2022). One proposed method to counter this pathogenic threat was referenced in the Seanad debate. Using CRISPR-Cas9 to introduce resistance into native Irish trees, the hope is to reinvigorate the tree population and provide rewilding projects a useful tool to restore the native landscape. In recognition of the possibility that we may never restore what has been lost through natural means, perhaps innovation with CRISPR is the way forward to mend past damage.

Nowadays, there is greater acceptance towards more interfering methods of climate remediation. For example, solar radiation modification was recently investigated by the United Nations Environment Programme after they faced increased demand for its implementation. Previously, the method was dismissed as too invasive and risky. Solar radiation modification, or solar geoengineering involves the reflecting of sunlight back into outer space to reduce human caused climate change. Models have now been developed to explore this model more thoroughly (MacMartin et al., 2022). The UN released a report detailing the technology and its risks in late Feb 2023. The use of genetic modification would also fall into a similar category of an interfering method of climate remediation and may now face a much warmer reception.

Not only are more drastic methods being considered, but increasingly pressure is placed on governments and organisations rather than the individual to tackle climate change. Evidence shows that when faced with a choice, individuals are unlikely to choose solutions to mitigate the effects of climate change. A study of citizen engagement in sustainability solutions concluded, that often citizen engagement hinders sustainability outcomes. For example, in a case where a sea wall was needed to prevent flooding of sea front properties, half of the stakeholders argued for the sea wall as their property was flooded and half argued against as it would ruin their sea view (Wamsler et al., 2020). In contrast, a case which used techniques to genetically alter algae to produce biofuels, and did not affect individuals specifically, was positively viewed as a method to help the transition towards renewable energy production. Research and innovation which contributes towards drastic sustainable solutions for societal problems are now more acceptable, socially responsible, and thus should be encouraged (Bauer & Bogner, 2020).

However, many of the arguments against GMOs remain present. The use of GMOs in the agricultural sector is countered by pushes for organic farming methods which, in contrast, have minimal ethical considerations attached to them. Greenpeace remains one of the most stringent opposers of GMO introduction. The Irish Green Party's manifesto for 2030 includes a line stating they are "Keeping Ireland GMO free at this time." Their agricultural policy's focuses on promoting organic farming. However, the efficacy of organic farming methods in terms of mitigating agricultural effects on the environment is not clear. A US study which compared organic, conventional and GMO farming found that there was no basis for organic farming being better for the environment than other farming practices (Ehn & Ryder Fox, 2019).

Another major fear is the potential that GMOs would become an invasive species as their improved adaptability to the environment would outcompete native species. However, this argument was countered in the March 2022 Seanad Debate by pointing out the proliferation of non-GMO invasive species in Ireland such as Japanese Knotweed which was first introduced as an ornamental plant. Ornamental plants which were intentionally introduced in Ireland represent 67% of all invasive species, we risk more from people's gardens than we do from GMOs. Scientists have considered this risk and propose methods of ensuring biocontainment by preventing crossbreeding to reduce the spread of GMOs. For example, by making the second generation of seeds sterile or dependent on a chemical input for fertilisation (Clark & Maselko, 2020). Furthermore, plants which have been modified through long standing mutagenesis techniques have not developed into invasive species.

Further arguments are made that we need not rely on GMO crop cultivation, as other methods are available. For addressing plant pathogens in Irish forests, we can rely on methods to limit the spread of disease. For example, to prevent native ash dieback by ensuring trees are not imported from diseased regions and the felling of infected trees. However, in British forests, safety felling of infected trees is the costliest impact of the disease (Hill et al., 2019). It is also a reactive response rather than one which is proactive and prevents further infection from occurring.

Our Post-Pandemic World View

The pandemic affected lives around the world, impacting our politics and the way we work and educate ourselves, as well as taking a large hit on our financial markets and agricultural industries. It has greatly impacted the way people view science as everyone was forced to educate themselves in virology to help mitigate the spread of covid.

The agricultural industry experienced significant repercussions due to the pandemic (Siche, 2020). Stringent movement restrictions presented challenges in securing the assistance of migrant workers for harvest activities. In April 2020, Keelings, an Irish strawberry fruit company, faced criticism for transporting fruit pickers from overseas amid the pandemic. Although the workers were subjected to a 14-day period of limited mobility and the company asserted that without the aid of foreign labour, the crop would have perished, a social media outcry ensued, calling for a boycott of the company. In addition to the shortage of workers, farmers confronted disruptions in their supply chains. At the outset of the pandemic, international trade suffered adverse consequences. The initial governmental responses had detrimental effects on our food supply chains (Štreimikienė et al., 2022). The panic-driven surge in food demand was subsequently offset by reduced consumer spending habits. This market fluctuation introduced considerable uncertainty for farmers. The pandemic underscored the importance of agrobiodiversity in guaranteeing a varied local food supply (Zimmerer & de Haan, 2020). It served as a clear indication that resilient and innovative farming practices are necessary to safeguard our future food security. Moreover, it emphasized the significance of heeding the perspectives of both farmers and scientists to establish redundancies within our food supply system (Gunther, 2020). Therefore, incorporating genetic modification techniques to enhance diversity in our food supply would prove advantageous for both farmers and consumers.

The onset of the pandemic resulted in significant financial market volatility (Zhang et al., 2020). As millions of individuals worldwide lost their jobs in service industries, trust in the market declined. Regrettably, even after the conclusion of pandemic-related lockdowns, economic uncertainty persisted due to Russia's commencement of a full-scale invasion of Ukraine in 2022. Consequently, post-pandemic inflation escalated, leading to a sharp surge in oil, gas, and food prices. Prior to the onset of the conflict, European nations heavily relied on Russia for approximately 25% of their oil and 40% of their natural gas supplies (Mbah & Wasum, 2022). Dr. Thomas McLoughlin emphasized the need for GMO crop cultivation during the March 2022 Debate, stating, " we need to be using all the tools in the toolbox, but we also have to be very careful of what is happening because Ukraine and Russia produce a lot of wheat for the world market." By reducing dependence on overseas chemical inputs, GMOs would enhance financial stability within the markets. The pandemic and the war have highlighted the urgency of fostering self-sustainability.

In our post-pandemic world, politicians have significantly bolstered their trust in scientists, as they heavily relied on their guidance in combatting the spread of disease. The global emergency posed by Covid-19 necessitated comprehensive action, particularly in the scientific domain. The spotlight turned to scientific researchers as the public relied on them for practical guidance on adjusting their lifestyles and for optimistic prospects regarding innovative solutions such as vaccine development to overcome the pandemic. Politicians are now more inclined to seek the counsel of experts when confronted with unfamiliar situations. During the March 2022 Debate, Senator Victor Boyhan humbly acknowledged, "I do not think four doctors have ever appeared together before an Oireachtas agriculture committee." While it is unfortunate that experts were not heeded earlier, it demonstrates that Irish politicians are now taking positive steps forward.

Public trust in the scientific community also experienced improvement throughout the pandemic. Findings from a German survey indicate a substantial increase in trust in scientists after the onset of the pandemic, although it slightly declined over time, it remains higher than pre-pandemic levels (Bromme et al., 2022). In April 2020, over 80% of respondents agreed that science should inform policy-making. Two-thirds of respondents supported scientific debate and acknowledged that scientists may have disagreements regarding the most appropriate course of action, recognizing that the eventual correct course of action may prevail (Bromme et al., 2022). Hence, it is possible to present opposing views on GMO crop cultivation to the public, as it is not a straightforward, black-and-white argument. Nevertheless, people are now more inclined to seek direct input from scientists.

The Economic Benefits

Newly developed methods of genetic modification offer advantages in terms of speed and cost-effectiveness compared to previous approaches. These methods require less financial investment and can be conducted rapidly in small laboratories. Shifting perspectives on climate change have prompted a growing inclination towards the adoption of GMOs in agriculture, as we recognize the necessity for innovative technologies to achieve our climate objectives. These innovations have the potential to provide a significant boost to our economy.

One noteworthy concern associated with GMO technology was the potential monopolization by large industries and the subsequent patenting of natural resources. The fear of multinational companies misappropriating GMOs and privatizing life was voiced by Deputy Matt Carthy during the Seanad Debate, citing instances of "Farmers penalized for seed leakages." Companies like Monsanto, who made substantial investments to bring GMO seeds to market, rigorously protected their products by filing patents and pursuing legal action against farmers they believed had violated their contracts. Monsanto filed 147 patent violation cases against farmers from 1997 to 2018, with only 9 going to trial, the rest were settled outside of court, resulting in Monsanto's favour in every case (Schapiro, 2018). Monsanto's patent rights extended to any seed containing the patented trait, meaning that if farmers bred the seeds for the next season, the offspring would still fall under Monsanto's patent. Monsanto can continue these practices because their seeds consistently produce the most resilient crops, thus farmers continue to buy them. On average, GM crops reduce pesticide usage by 37%, increase crop yields by 22%, and boost farmers' profits by 22% (Klümper & Qaim, 2014). However, Monsanto's monopoly on the market would be significantly reduced if the laws pertaining to GMOs were changed to allow small laboratories and start-ups to create competitive strains.

The use of GM crops in an area affects the local chemical pesticide market, leading to decreased pesticide prices. This provides additional benefits for all farmers, including those not utilizing GM seeds. GM crops enhance farming efficiency, increase farmer incomes in developing countries, and reduce the need for pesticides. Despite the scientific advancements in GM crop development, the current state of biosafety regulations hinders smaller companies, which struggle financially to bring GM crops to market, fostering a self-sustaining monopoly that drives up GM seed prices (Lee & Giesbrecht, 2021). According to Dr. Barbara Doyle during the Seanad debate, "Applying to get a product onto the market can cost up to €20 million. As universities, we cannot afford this, and neither can SMEs [small to medium-sized enterprises], which are being pushed out of the market in that regard." The current laws favour large multinationals, allowing them to consolidate their market dominance. Their sole requirement for a successful business model is that their seeds must be slightly cheaper than the combined cost of natural seeds plus the necessary pesticides. Reducing the influence of large multinationals by opening the GM crop marketplace would resonate with consumers. A study on public perceptions regarding the introduction of genetically edited potato crops in Canada revealed that the public's preferred developer of GM crops was government-funded (Muringai et al., 2020). Government support for GM crop development in Ireland will be crucial for cultivating crops in a sustainable system that benefits the public good rather than favouring a single multinational company.

In the past, efforts have been made by non-profit organizations to develop GM crops independently of multinational corporations. One notable example is Golden Rice, which holds significant importance in regions where rice is a staple food. While rice is energy-rich and provides starch and protein, it lacks carotenoid pro-vitamin A, the precursor to vitamin A. This deficiency leads to vitamin A deficiencies in developing nations heavily reliant on rice as a dietary staple. Vitamin A deficiency remains prevalent in sub-Saharan Africa and South Asia, contributing to 1.7% of deaths in children under 5 in low and middle-income countries in 2013, as well as causing blindness and increased infection risks (Stevens et al., 2015). In 1997, researchers successfully increased the pro-vitamin A content in rice by introducing

daffodil DNA encoding the enzyme phytoene synthase (Burkhardt et al., 1997), which laid the foundation for the development of Golden Rice. However, Golden Rice faced substantial opposition from anti-GM activists, GM regulation procedures, and a prolonged process for Intellectual Property rights approval. It was finally approved for cultivation in the Philippines in 2021, 24 years after its initial discovery (Wu et al., 2021). Greenpeace spearheaded the campaign against Golden Rice, arguing that alternative methods to address vitamin A deficiency, such as food supplements, fortification, and home gardening, already exist and are more responsible and necessary. However, these solutions rely on individuals having access to supplements, gardening resources, or the means to afford a varied diet. As new technologies permeate all aspects of our lives, it is important to embrace advancements in the agricultural sector that can provide necessary vitamins and minerals through the food we eat.

Conclusion

At this point, the opposition to GM crop cultivation in Ireland and the EU may indeed be futile. GM crops are already making their way into our food chain despite existing regulations. Although the cultivation of GM crops is prohibited in Europe, they are still being imported from other countries. The majority of soybeans and corn imported into Ireland are genetically modified. In the 2022 Seanad Debate, it was disclosed that 55% of the animal feed imported into Ireland is genetically modified. As aptly stated by Dr. Thomas McLoughlin, "the train has left the station" in terms of preventing GMOs from entering the diets of Irish consumers.

Our persistent efforts to keep GM crops out of the Irish market have only hindered local farmers. According to the 2018 Genetically Modified Crops Market Analysis conducted by Coherent Market Insights, the global GMO crop market is projected to reach a value of $37.46 billion by 2027, representing a substantial increase from $18.15 billion in 2018. By denying farmers access to this expanding market, we are depriving them of potential benefits. Consequently, they are compelled to rely on conventional methods that are increasingly susceptible to evolving plant pathogens. Notably, annual crop losses caused by pests alone contribute to 20-40% of global crop losses (Raman, 2017). The Food and Agriculture Organization (FAO) estimates that plant diseases cost the global economy over $220 billion annually, with an additional $70 billion lost due to invasive insects (IPPC Secretariat, 2021).

However, perhaps farmers would grow too heavily reliant on GMO crops. Traditional farming practices may be lost overtime resulting in loss of cultural farming practices. Drastic changes in farming practices can often have unintended consequences. For example, a study of agricultural climate insurance in developing countries found that farmers heavily leaned on the insured cash crop. Other crop varieties and traditional land use strategies to manage climate risks fell to the wayside leading to maladaptive consequences of a policy put forth by international donors (Müller et al., 2017). Maladaptation to climate change leads to the wasting of time and resources (Schipper, 2020). Thus, it is important that an introduction of GMO crops is not provided as a one size fits all solution for mitigating the consequences of climate change. Their introduction should not be marketed as such as this would inevitably lead to anger if the desired outcome were not reached.

Current EU regulations do not align with the progress made in scientific advancements. Although organic farming is often proposed as a solution to preserve biodiversity in agricultural areas, certain organic farming practices can be environmentally harmful (Hole et al., 2005). For instance, organic farmers in Europe are permitted to use copper sulphate as a fungicide to control potato blight, a disease which Irish farmers continue to tackle each year. Yet copper sulphate has proven detrimental effects on the aquatic environment (Gharedaashi et al., 2013). Relying solely on organic farming is insufficient to meet our biodiversity objectives, and therefore, we should expand the range of methods available to farmers by introducing the cultivation of genetically modified (GM) crops. Furthermore, our current approach hinders the progress of scientists and entrepreneurs in developing new technologies, causing us to fall behind in agricultural research and development. In terms of agriculture-related CRISPR patents, as of 2017, China held 259 patents, the US held 61, while Europe as a whole held only 18 (Martin-Laffon et al., 2019). Ireland will continue to fall further behind if anti-GMO laws remain.

The pandemic played a significant role in enhancing public confidence in scientific authorities. As the lockdowns progressed, trust in scientists grew, whilst trust in politicians declined (Jensen et al., 2021). Nevertheless, the implementation of lockdown measures demonstrated that the public supports decisive government actions during emergencies. It is crucial to acknowledge that resistance to new scientific advancements will always exist. However, disregarding the potential benefits they can offer will only contribute to further inaction in combating anthropogenic climate change. Merely expecting individuals to modify their daily habits and behaviours is no longer sufficient to address climate change, as it is a complex issue that surpasses the efforts of a single person. Collective action is imperative in tackling this challenge.

Given that only three years have passed since the global outbreak of Covid-19, it is impossible to determine how history will retrospectively evaluate that period, including its impact on people's perspectives and the lasting changes it brought about. Additionally, excessive deference to scientific authority has been found to correlate with anti-democratic views on decision-making processes (Howell et al., 2020). It is crucial to ensure that the public continues to feel engaged in this discourse and that their opinions are considered. Scientists were not infallible during the pandemic, and failing to acknowledge this could further erode public trust in the academic community. The nature of the pandemic demanded strong leadership and swift action, which was not always executed in the most democratic manner, resulting in outbreaks of riots and occasional breakdowns in social order. The pandemic also gave rise to political utilitarianism, a moral theory asserting that the right action is the one that maximizes overall societal well-being (Savulescu et al., 2020). While it is important to present the introduction of GMOs as a means to ensure a stable food supply chain and promote the greatest good, it is essential to avoid adopting an authoritative stance in the process. Opposing viewpoints hold validity and contribute to a political debate that, ultimately, yields the most favourable outcomes.

For the past 12,000 years, humans have engaged in the modification and enhancement of crops. Molecular genetic modification represents the next progressive phase in our agricultural production. We have profoundly altered landscapes, the crops themselves, and in the process, our progress as a species. Agriculture resides at the intersection of culture

and biological sciences, and since its inception, it has continually transformed and developed, elevating productivity through successive regenerations of practices. To deprive modern-day farmers of the next innovative stride contradicts the entire historical foundation upon which our farming practices are built.

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