Going GMO-free? Why rejecting biotechnology leads to environmental and financial losses

Challenges associated with supplying society with food have evolved from additional innovation and continual innovation will be required to meet the needs of humanity. The ability of genetic improvement techniques, like genetically modified organisms (GMOs), to provide such innovation cannot be trivialized. More than a decade ago, Fedoroff and colleagues (2010) published a perspective in Science stating that our ability to adapt agriculture would partly depend on acceptance of genetic improvement techniques, like genetically modified organisms (GMOs). Two years ago, much less a decade ago, we could not imagine the impacts of a global pandemic that compounded the need for a resilient food system (see CAST 2020a for a discussion).

Moreover, innovation in agricultural production is necessary to aid in combatting the negative effects of climate change and new pest and disease pressures that result from trade between geographical regions. Human behavior, and its influence on the climate, have caused a decrease in global agricultural efficiency by an estimated 21% since 1961 (Ortiz-Bobea et al. 2021). This is equivalent to losing seven years of production and future reductions in efficiency are anticipated to be greater for populations in warmer regions like Africa and Latin America. GMOs have the capability to increase nutrition security (De Moura 2016; Zimmermann and Qaim 2004), while also reducing land use (Brookes and Barfoot 2020a; Taheripour, Mahaffey, and Tyner 2016) and reliance on more toxic chemicals (Ahmed et al. 2021).

A framework for regulation of GMO plants and animals was established in the 1980s (OSTP 1986) and the first GMO food, a tomato, was sold to consumers in 1994 (FDA 2020). Commercialization of several other GMO crops occurred over the next several years, including the now largely adopted Bacillus thuringiensis (Bt) and herbicide-tolerant (HT) crops. Bt crops were modified to protect plants from insects and HT crops were modified to allow the plant to withstand specific herbicides so that competing weeds can be better controlled. By 1999, more than half of cotton and soybeans acres were planted to GMO varieties in the U.S. Presently, more than 90% of corn, cotton, and soybeans are planted to GMO varieties (USDA ERS 2020a). In 2013, there were more than 4,500 field release permits and notifications issued by USDA APHIS for GMO varieties with insect resistance, and more than 6,500 for those with herbicide tolerance (Fernandez-Cornejo et al. 2014).

While most commercialized GMO crops possess traits for either herbicide or pesticide tolerance, GMO applications can also provide resistance to viruses like the notable example of the Rainbow papaya. Papaya ringspot virus (PRV) was first detected in Hawaii in the 1940s and began affecting crop yields by the 1950s. By the late 1990s, PRV had affected every papaya producing region in the state, resulting in production dropping by over 50% between 1993 and 2006. The Rainbow papaya, a GMO papaya resistant to PRV, was commercialized in 1998 and within two years it accounted for over half of all papaya production in Hawaii. Ten years later, the Rainbow papaya accounted for over 90% of papaya production (Gonsalves and Gonsalves 2014). The story of the Rainbow papaya demonstrates how some pest problems can be very difficult, if not impossible, to control without genetic improvement. Thus, limiting GMO solutions would reduce the availability and quality of some foods in the marketplace (Van Esse et al. 2020).

Although GMO applications have provided tangible benefits throughout the food system (Ahmed et al. 2021; Qaim and Traxler 2005), citizens and consumers have displayed resistance to the technology which is counter to statements made by non-profit scientific societies (McFadden and Lusk 2015). The American Association for the Advancement of Science concluded:

> …consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques.

The United States National Academy of Sciences, World Health Organization, and American Medical Association have also made similar statements about the safety of GMOs on human health (NRC 2004; WHO 2014; AMA 2014).

The objective of this paper is to communicate the benefits of GMOs and the potential cost to society if the technology were removed from the marketplace. We blend results from academic research, public agencies, and statements from non-profit and scientific organizations to highlight the positive effects of GMO adoption. Much of the discussion is U.S. centric, simply because of the large-scale adoption of GMO crops in the U.S. When possible, we also discuss potential global impacts and the implications for less developed countries if GMOs were removed from the marketplace.

Realized and potential costs of restricting GMO applications

The slow and unpredictable pace of GMO crop regulatory approval and commercialization is limiting investment in research and development. A survey of companies responsible for 95% of all new GMO traits introduced in EU and the U.S. estimated that the average costs associated with regulatory science, registration, and affairs to get a new trait introduced was $35 million between 2008–2012, and in 2011 this process took, on average, over nine years (McDougall 2011). These regulatory hurdles essentially largely preclude public institutions from obtaining approval for GMO applications, and the private sector has reduced investment in areas with strict regulation. The EU has largely forbidden farmers from growing crops containing gentically modified traits, but allowed the importation of GMO crops and their derivatives (Tagliabue 2016). Strict regulation of GMO crops in the EU has driven $250 million in R&D investment out of the EU over the past 30 years; in the 1990s, the EU accounted for one-third of global agricultural R&D investments and by 2014 this had dropped to 8% (Smyth 2017; McDougall 2013). BASF halted investment in GMO crops developed for growing conditions in the EU after developing a potato with resistance to the disease late blight (Dixelius, Fagerström, Sundström 2012) and publicly acknowledged this would lead to a loss of 140 jobs in the EU, while unconfirmed industry reports later placed the number closer to 900, most of which were highly trained scientists. A survey of EU producers estimated that more than one-third of producers were likely or very likely to adopt GMOs, citing reduction of weed control costs and higher income as motivations for adoption (Areal, Riesgo, and Rodríguez-Cerezo 2011). Some EU producers are calling for a streamlined approval process of GMOs; however, possible adopters may still be hesitant to plant approved GMO crops due to additional administrative requirements (FSN 2012).

Trade barriers targeted at GMOs reduce access to food, limit farm revenues, and increase overall prices. When countries lift trade barriers, it was estimated that imports would increase by an estimated 14.7% which result would result in an estimated 4.86% reduction in food prices; conversely, a trade barrier decreases access to imports by almost 10% and food prices increases by 1% (Nes et al. 2021). Regulatory barriers have important implications for global food security, and many of the countries that have not adopted GMOs are among the world's least food secure and most reliant on imports as a source of food (Nes et al. 2021). Although 2016 global production of GMO crops generated an estimated $57B in farm-gate revenues, widespread approval of GMOs would generate an additional $65 billion if crops were adopted at similar rates where adoption is possible — with developing countries receiving the majority of additional revenue (Scheitrum, Schaefer, and Nes 2020).

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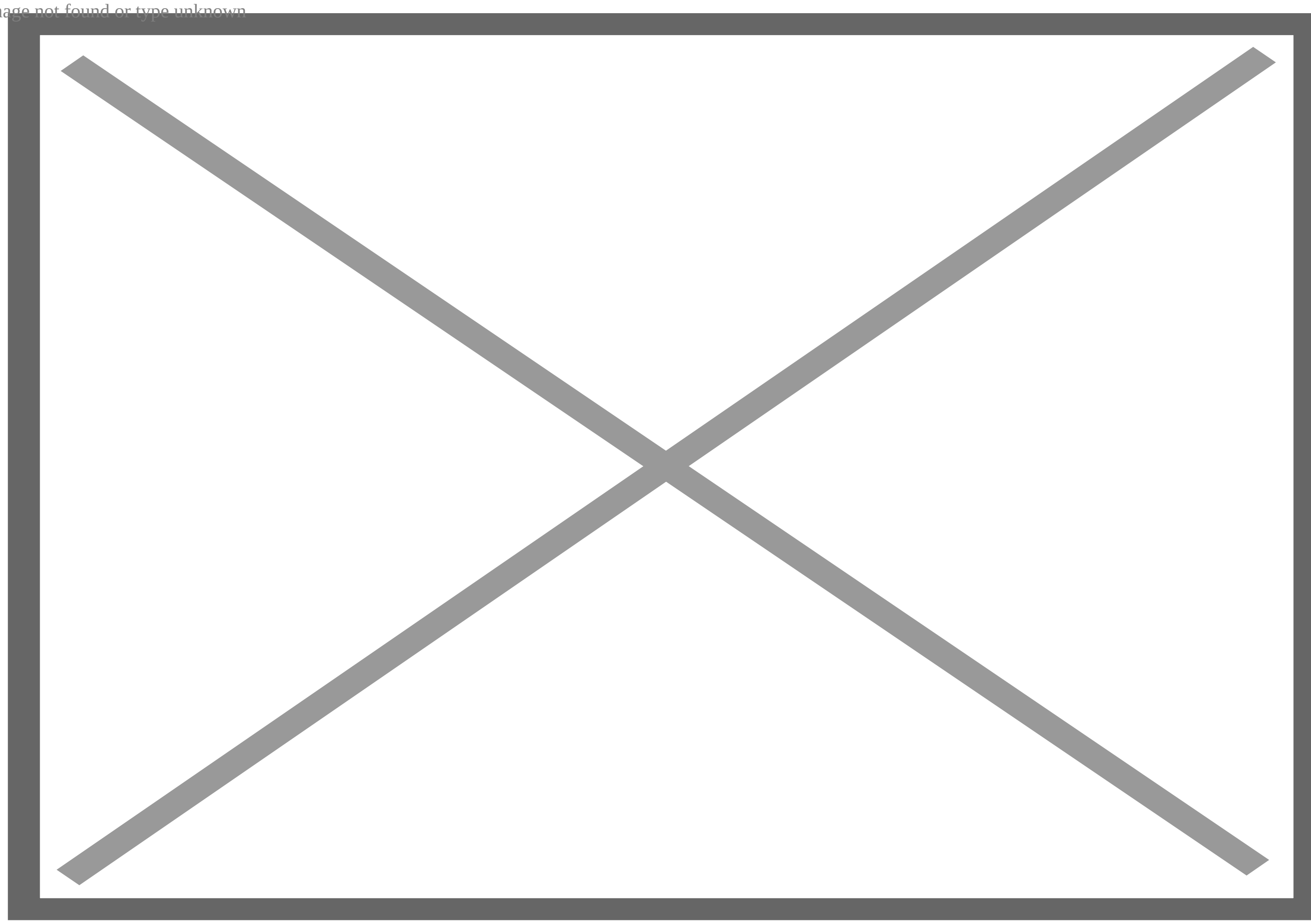

Distribution of Benefits from Early Adoption of Biotech Traits in the U.S.

While GMOs have been widely adopted in the United States, the National Bioengineered Food Disclosure Standard requires food companies to label foods derived from GMOs by January 1, 2022 (USDA AMS 2018). The policy was a source of uncertainty when it was established because which products would require a label and the threshold for segregation mishaps were yet to be decided (McFadden 2017; McFadden and Malone 2018). Ultimately, the threshold for segregation mishaps was set at no more than five percent (5%) of the specific ingredient (USDA AMS 2018). Penalties for segregation mishaps increase both the cost and risk of adopting GMO technology, and segregation may be extremely difficult for widely grown commodities like corn and soybeans (Zilberman et al. 2018). A 2012 mandatory labeling ballot initiative in California would have increased costs for in-state food processors by an estimated $1.2 billion (Alston and Sumner 2012). Some of the costs from mandatory labeling polices would be transferred to consumers, and it was estimated that a mandatory label in New York would have increased annual household food expenditures by approximately $224 per year for a family of four (Lesser and Lynch 2012). Although, estimates from scanner data indicate that associated costs could be orders of magnitude higher (Kalaitzandonakes et al. 2018).

When asked, consumers typically indicate support for mandatory labels on GMOs; however, consumers also indicate support for mandatory labels for food containing DNA (McFadden and Lusk 2016). The fact that consumers also want a mandatory DNA label suggests that simply asking someone if they want something may not always be a reliable measure to motivate policy, as it is completely rational to say “yes” to free information that may or not be valuable and is not accompanied by a cost. Consumers who are uncertain about the motivation of mandatory GMO labeling may incorrectly assume the label was motivated due to possible safety concerns (Bar-Gill, Schkade, and Sunstein 2019). Although, when a mandatory labeling policy was implemented for a short period in Vermont, attitudes toward GMOs improved in that state (Kolodinsky and Lusk 2018).

GMO labeling is unlikely to provide context to consumers and may deceptively influence purchasing decisions. For example, consumers may pay premiums for food labeled non-GMO even when there is no existing GMO alternative, as is the case for non-GMO labeled salt (Wilson and Lusk, 2020). There is evidence that GMOs can be desirable to consumers if the benefits are mentioned, particularly if the benefits are targeted at consumers (Lusk, McFadden, and Rickard 2015). Consumers may pay a premium for GMOs if the GMO application provides a benefit to the consumer (e.g., Bugbee and Loureiro 2003; Lusk 2003) or reduces reliance on sensitive feedstuffs like wild fish stocks (Weir 2019). Given that consumers are concerned about GMOs while also having low levels of knowledge about GMO, and perhaps genetics in general, it is not surprising that information can significantly influence purchasing decisions (Lusk et al. 2004; Rousu et al. 2007).

Conclusions and looking towards gene editing technologies

Technological advancement in agricultural production has allowed humanity to increase the amount of food produced and more consumption of agricultural products in non-food uses while conserving the environment and resources. Continued advancements in production have allowed the U.S. to maintain a surplus in agricultural trade (USDA ERS 2020c) while, as a sector, emitting less than half the greenhouse gases of the global average associated with agricultural production (US EPA 2020a; US EPA 2020b). GMOs use less land, energy, and chemicals (Paarlberg 2020), and the carbon footprint of agriculture would certainly increase without GMOs. It is important that these results be considered in public discussion of the social and economic value of GMO technology.

Differences between GMO and non-GMO counterparts represent differences in costs, yield protection, and overall efficiency, which could continue to grow if the technology is not blunted. Certainly, the economic benefits from GMO crops are crucial, as without economic benefits for adopters, the technology would not have lasted for very long. Producers who currently grow GMO crops will likely suffer if nudged towards adopting non GMO alternatives, because those producers have developed expertise in what they currently grow (Kalaitzandonakes and Magnier 2016).

As the technologies used in plant breeding shift from gene insertion genetic modification to targeted gene deletion or mutation, crop and food production are on the verge of a significant revolution. Targeted and controlled mutagenesis is increasingly being used by plant breeders, both public and private, particularly when it comes to the application of the gene editing (GnEd) technologies (Gleim et al. 2020). The use of GnEd is providing phenomenal experimental yield increases, such as 20% for rice (Chen et al. 2020) and 200% for sorghum (Gladman et al. 2019). The technology is also being used to enhance the ability of plants to photosynthesize, increasing the amounts of CO_2that a plant is capable of sequestering while also increasing yield (Kromd?k et al. 2016). GnEd has the potential to significantly improving food and nutrition security (Asanuma and Ozaki 2020; Lassoued et al. 2019).

While GE crops have been, or are close, to commercialization in Argentina, Australia, Canada, Japan and the United States, the EU continues to struggle in how to regulate agricultural innovation (Smyth 2019). In 2018, the Court of Justice of the EU ruled that GnEd crops must be regulated within the EU’s GMO regulations; thus, GnEd crops will be regulated like GMO crops. This ruling contradicts the EU’s Farm to Fork strategy that aims to provide nutrition security, lower the environmental impacts of agriculture, and increase biodiversity. Immediately after the ruling, large and medium-sized agricultural technology firms announced they were relocating all agricultural R&D capacity developing GnEd applications (Smyth 2019). The scientific community responded by encouraging revisions to the EU regulations of GnEd application, and calls for a revised framework is perhaps best reflected by the European Commission’s Group of Chief Science Advisors, which recommended:

> …revising the existing GMO Directive to reflect current knowledge and scientific evidence, in particular on gene editing and established techniques of genetic modification. This should be done with reference to other legislation relevant to food safety and environmental protection.
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> – (EC 2019).

Furthermore, there is evidence, in the United States at least, that consumers are supportive of GnEd applications to reduce the prevalence of agricultural diseases like citrus greening (McFadden et al. 2021), and consumers in Canada may be more accepting of GnEd applications compared to GMOs (Muringai, Fan, and Goddard 2020).

GMOs are not a silver bullet and need to be combined with good agronomic practices and future innovations. However, without GMO crops as a part of the global cropping systems and food production, the second of the 17 Sustainable Development Goals of the United Nations, to end hunger, achieve food security and improved nutrition and promote sustainable agriculture, will be compromised. Within the span of 25 years since their first widespread commercial adoption, GMO crops have transformed cropping production systems in the places where the technology has been used and contributed to better pest and weed control, facilitated the adoption and maintenance of reduced and no tillage agriculture which have helped reduce levels of soil erosion, increased soil moisture conservation, improved soil health and reduced levels of greenhouse gas emissions. Without continued innovation and adoption of biotechnology like GMOs, the future of reducing food insecurity becomes an increasingly remote and unlikely scenario.

This is an excerpt. Read the original post here.