The Case Against GMOs

An Environmental Investor's View of the Threat to our Global Food Systems

September 2014

Introduction

Genetically modified (GM) crops have been surrounded by controversy since their first deployment nearly twenty years ago, but have still become the fastest-adopted crop technology in recent history. In 2012, GM crops were planted on over 420 million acres, and for the first time over half of this area was in developing countries.

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To give a sense of the scale of this area, all of the 2012 GM crop fields would cover nearly all of the state of Alaska. Over the course of the twenty years since they were introduced, GM crops have been planted on a cumulative 4 billion acres of land, an area roughly the size of Russia.[1]

The steady upward trend of global GM crop adoption is well documented by the International Service for the Acquisition of Agri-biotech Applications (ISAAA), an industry trade group, in its yearly research brief "Global Status of Commercialized Biotech/GM Crops" however, ISAAA denied our request to publish their data in this report.[2]

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The adoption rate of these crops is astounding. Tens of thousands of farmers are now reliant on the agricultural biotechnology companies responsible for the sale and development of GM seeds. The GM food produced reaches hundreds of millions of consumers. And production impacts almost every part of the global food system, from small, independent farmers in South America to the regulatory bodies of the European Union.

The question remains, what exactly are these impacts? Purveyors of transgenic products claim that GM farming boosts yields and farming incomes by saving on fossil fuels, pesticides, and labor. Another claim arising from this assumption is that GM farming represents a step toward environmental sustainability by decreasing emissions and the use of agricultural chemicals. GM advocates also maintain that these products pose no health risks to either the farmers or consumers.

None of these arguments have held up over extended periods of use or in the face of independent testing. Pesticide and herbicide-resistant crops (by far the most widely used GM varieties) actually lead to an increase in pesticide and herbicide use over time horizons of as little as four years.[3]

Financial gains, which farmers make through increased yields, are offset by increased spending on patented seeds, fertilizer, and herbicides or pesticides, leading to a net decrease in income for all but the largest mega-farms. These higher input costs are especially damaging when small, more marginal farmers experience crop failure. Elevated levels of bankruptcy and consolidation have frequently occurred following the deployment of GM crops.

Perhaps the most pervasive argument for GM crops is centered on the message that these crops are needed to "feed the world." The underlying assumptions of this argument, however, are simply incorrect. At current levels of global production, there is enough food for every person on earth to have 3,000 calories per day.[4]

The problem lies with distribution, income, and food waste. GM crops can actually exacerbate hunger issues by pressuring farmers in marginal areas to grow cash crops for export or extensive processing. Farmers who make the switch to GM products usually get an initial increase in their yields, but this can be attributed to the varieties used as a base for the commercially available transgenic varieties. Furthermore, in repeated tests, conventional breeding has been just as or more successful at delivering "climate-ready" crops that incorporate drought or flood resistance.

For environmental, social, and governance (ESG) focused investment strategies, agricultural biotech represents an unacceptable level of risk across a wide range of factors. The problem lies less with individual companies or products, but rather with how GM agriculture in its current iteration jeopardizes the whole agricultural system. Just as these risks are system-based, the consequences would manifest themselves by changing the very biological, economic, and social framework of food systems.

Almost twenty years into the GM experiment, a range of these risks (Environmental, Social, Governance/Regulatory, Reputational, and Financial) have become clear.

When taken together, these risks form a very clear basis for exclusion from an ESG investment strategy. It is important, however, to distinguish between the systemic risk and the risk presented by the technology of genetic engineering. Genetic engineering, in and of itself, is simply a tool. Indeed, it represents an opportunity to change the parameters of agriculture, which could be beneficial if given the proper regulatory framework and directed toward health and sustainability.

In the current market, however, developing genetically modified organisms (GMOs) demands massive investments, which then drives the need for massive returns. When looking at the small number of transgenic technologies in use today, it becomes apparent that the nature of selection favors a certain set of crops that are best suited to large-scale, mechanized cultivation. This is amplified by the leveraging of intellectual property rights over seeds, planting materials, and tools used for genetic engineering. In its current state, the main goal of GM agriculture is to increase the sales of seeds and certain agro-chemicals.

Environmental Risk

Genetically modified agriculture reinforces many of the most damaging aspects of monoculture and mechanization. These include biodiversity loss, agro-chemical use, and accelerated soil exhaustion. Additionally, the foreign genetic material can spread beyond its intended area through cross-pollination and interbreeding, as well potentially migrate across species.

Social Risk

The demographic shifts that have accompanied the marketing and adoption of GMOs show disturbing patterns, especially in developing countries. Small farmers often become trapped by seed licensing fees and other rising input costs. Furthermore, the switch to crops that then get exported for processing can exacerbate local food supply and quality issues.

Governance/Regulatory Risk

The intellectual property system allowing for corporate patents on organisms opens the door for a range of ethically problematic business practices. Also, agricultural biotech companies have repeatedly used their undue influence on regulators to gain product approval, circumvent regulations, and suppress dissenting independent studies.

Reputational Risk

Consumers are becoming increasingly educated on their eating habits and the consequences of these choices. In addition to raising questions concerning the health effects of consuming GMOs, the spread of this information builds up negative perceptions of the agricultural biotech corporations and the industry as a whole.

Financial Risk

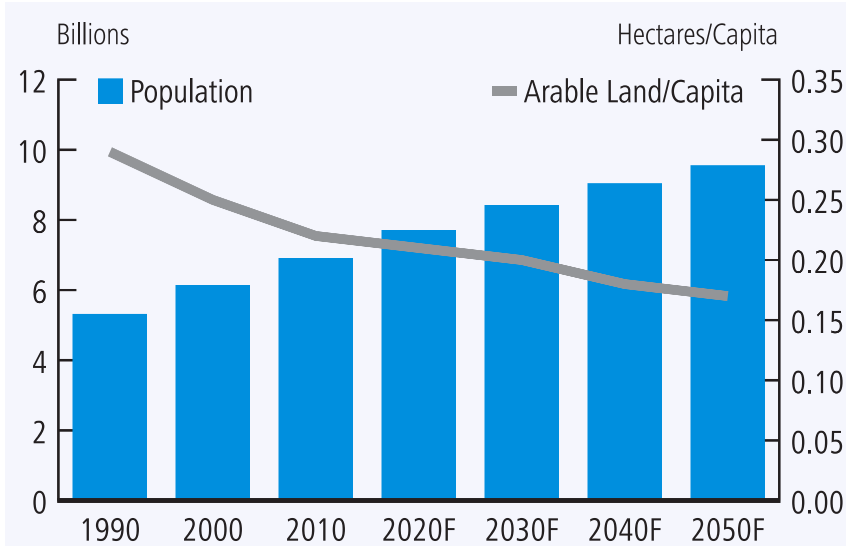
Given the information and the choice, an increasing number of consumers (and the companies that cater to them) are becoming less accepting of GMOs. The market, especially among consumers in wealthy countries, has pushed GM crops to the low end of the market, where they are now a cheap choice for animal feed, biofuel feedstock, and heavily processed food. Additionally agricultural biotech companies must contend with litigation costs, settlements, and “restructuring charges” arising from failed deployments.

The coming decades will likely see significant increases in food pressures stemming from both population growth and climate change. By 2050, the global population is expected to reach 9 billion, while the amount of arable land per person will be roughly half what it was in 1990.

Managing the agricultural system in more sustainable ways is made harder by the spread of monocultures and large-scale, mechanized farming. In the developing world especially, GM monoculture and the industrial approach to agriculture have spread hand in hand. Yields may be higher, but they are not, in the very long run, sustainable.

Figure 1: Global Population and Arable Land Per Capita

Pressure to increase productivity on existing land



Source: FAO, United Nations, PotashCorp

Mechanized agriculture, in some form, is likely necessary to feed the number of people in the world today. GM agriculture is not. It has so far provided insufficient and inconsistent benefits for the amount of risk it entails. Genetically modified agriculture, as it is currently practiced, should be far down the list of solutions for securing the global food supply.

Industrialized Agriculture as the Foundation for Genetic Modification

An understanding of GM agriculture and its systemic effects requires an understanding of the enormous changes wrought by industrialized agriculture. The groundwork that industrialized agriculture laid has been the framework for the development of the giant agro-chemical companies and the implementation of their products.

While these systemic shifts occurred over decades in the United States, many of the developing markets that are the new targets for GM marketing are experiencing both at the same time, as the GM system cannot function in more traditional, smaller-scale and sometimes organic farming.

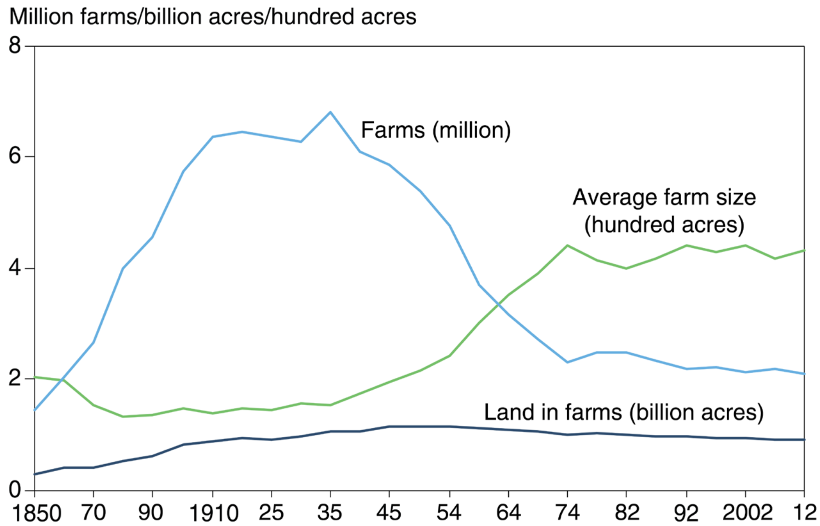
Thus when these GM crops are introduced they necessarily come as a part of a larger system. The changes caused by the implementation of industrialized agriculture, while economically productive, are enormously disruptive. GM crops exacerbate and accentuate these disruptions, and fail to provide commensurate increases in economic or social well-being.

Through the 10,000 year history of agriculture, starvation and famines have been a regular occurrence. Early nineteenth century English scholar Thomas Malthus provided some of the first modern intellectual commentary on the nature of population and food needs, originating the concept of the “Malthusian dilemma” to describe when population overtakes food production and leads to mass starvation.

While his ideas have been extensively debated since, this commentary has provided important concepts that have helped motivate the search for more sophisticated, reliable food production. Achieving sustainable productivity becomes even more important as farmland disappears to accommodate the developmental needs of modern society.

The beginning of the 20th century ushered in an era of rapid population expansion, as well as technology, which heralded significant changes in all parts of the economy. In the United States, World War I prompted a massive increase in heavy equipment manufacture. With the encouragement of the Department of Agriculture and the Agricultural Extension Service, farmers rushed to purchase this equipment for the increase in productivity it provided. However, the consequences of this buying spree would be a key driver of the economic devastation of rural America during the Great Depression. By the early 1930s agricultural commodity prices had dropped 60%, while prices for heavy farm equipment dropped only 20%.[5]

Figure 2: Farms, land in farms, and average acres per farm



Source: USDA, Economic Research service using data from USDA, National Agricultural Statistics Service, Census of Agriculture.

Many farmers found themselves in debt and were forced to sell to larger farms, leading to an increase in tenancy and migration to urban areas. While the larger economy recovered in the wake of World War II, the further deployment of technology continued this process. Instead of just tractors and trucks, however, large farms gained access to mass-produced chemicals and airplanes to spread them. Farms consolidated even further, with the total number of farms in the United States halving in under two decades.

While industrialization is often equated with the shift from an agrarian to a manufacturing economy, it encompasses more than this. It means the establishment of a model for managing resources (capital, human, and natural) that seeks economic efficiency through specialization, standardization, and consolidation. In the context of farming, this standardized a set of practices that can be recognized as running counter to environmental sustainability:

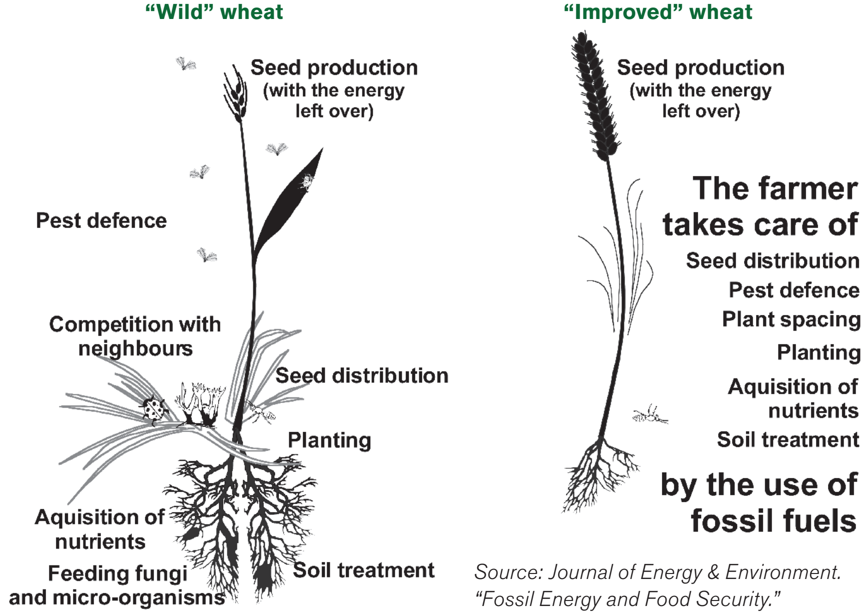
- **Monoculture** – The repeated cultivation of a single type of crop on a piece of land. These crops are usually non-native and grown for processing or export. Local ecological balances become massively upset, and carbon uptake in the soil is significantly diminished. Pests and disease spread much more easily without barriers provided by ecological differentiation. Non-native plants also usually require higher amounts of water and energy inputs.

- **Pesticides/Herbicides** – Instead of manual removal or planting naturally resistant varieties (which have necessarily lower yields as the plant uses energy and nutrients for defense rather than size), industrialized farming employs the mass application of toxic chemicals to kill weeds and pests. Up to 99.7% of herbicides never even contact target organisms.[6] These chemicals then leech into the soil and local water supplies.

- **Fertilizer** – Nitrogen is essential to plant nutrition, with a strong correlation between nitrogen levels and yield. Industrialized agriculture depletes nitrogen and other nutrient stocks in soil much faster than they can be replaced, necessitating industrial manufacture of nitrogen and other forms of fertilizer. However, less than 20% of synthetic nitrogen used in agriculture finds its way into crops or animal products used by humans.[7] The rest is released into the surrounding environment, sometimes with cascading effects on water systems such as "dead zones" caused by nitrogen-fueled algae blooms.

- **Fossil fuel reliance** – while all sectors of the modern economy depend on fossil fuels at some level, the industrialization of agriculture has a particularly transformative effect on energy inputs. In 1940, the agricultural system was able to make 2.3 calories of food for every calorie of fossil fuel energy, while as of 2008 more than 10 calories of fossil fuels are used for a single calorie of food.[8] Industrialized agriculture operations leverage cheap fossil fuels to mechanize as many phases of the cultivation process as possible.

Figure 3: Wheat Comparison



Source: Journal of Energy & Environment. "Fossil Energy and Food Security." Volume 12. 2001.

These issues may seem a small price to pay for the health and growth of human society, but there are much more sustainable ways to grow food. Between 1910 and 1983, corn yields in the US increased by 346% on a per area basis. However, the energy inputs for corn over this same time period increased by 810%.[9] Beyond this, millions of tons of agricultural chemicals are released into the environment every year. In the long term, the destructive externalities of these practices will be felt. When GM crops are added to this process, many of these effects are amplified without providing increases in food supply. Additionally, GM products come with a whole new set of issues, including genetic contamination and health risks to the end consumer.

The First GMO

The development of an industrialized genetic modification process began not with crops, but with livestock. While the gene transmission mechanism was slightly different, it formed the scientific basis for later ventures into transgenic research. Perhaps more notably, it laid the groundwork for the manipulation of the regulatory system, which has since become a hallmark of corporate agricultural biotech practices.

Somatropin is a growth hormone that is naturally produced in abundance in cows following calving. It stimulates lactation by allowing the cow's body to use reserve energy stored in tissues for milk production. Since discovery in the 1930s, numerous laboratories and agricultural businesses attempted to find a method for mass production of the substance. Early attempts were unsuccessful, requiring the slaughter of twenty cows to produce enough hormone for a single effective dose for one animal. A breakthrough was made when researchers funded by the chemical corporation Monsanto were able to use genetic manipulation to introduce the hormone into E. coli, a bacteria found in the lower intestine. The bacteria multiply tremendously quickly, allowing for rapid manufacture of the somatropin proteins. The extracted hormone was named recombinant bovine somatropin (rBST), also known as recombinant bovine growth hormone (rBGH).

Serious questions remained, however, as to the full range of effects stemming from elevated levels of the hormone. Initially, the Food and Drug Administration (FDA) was concerned about this as well. All of the available research had been conducted by the chemical companies themselves, and the FDA scientists harbored serious doubts as to the accuracy and scientific rigor present in the reports. As Dr. Michael Burroughs, a veterinarian with toxicology training assigned to the product said, "I very quickly understood that the data were intended only to demonstrate that rBGH effectively boosted milk production. The scientists working for Monsanto had paid no attention to the crucial questions."[10] After raising the issue to his superiors and detailing his concerns to Monsanto, Dr. Burroughs found himself pulled off the study, ostracized, and eventually fired. He sued and won the appeal, but ended up resigning because he felt the agency willfully closed its eyes in its desire to protect the company's interests.

Beyond signaling the problematic relationship between corporate interests and the FDA, the controversial approval of rBGH products signaled an important shift in FDA policy. This transgenic hormone is not designed to treat any sort of disease or provide health benefits, but is instead a product with a strictly economic purpose. Indeed, it is detrimental to the health of both the animals (as evidenced by numerous studies citing uterine disorders, ovarian cysts, reduced fertility, and mastitis)[11] and to humans (mastitis increases the amount of white blood cells in milk, i.e., pus). Additionally, milk from treated cows has up to 75% higher levels of IGF-1 (insulin-like growth factor 1), a hormonal substance produced in the pituitary gland, and has been linked to higher levels of the hormone in humans who consume it.[12] This substance plays an important function in cell growth, development, and division. Elevated levels have been found to link strongly to lung, breast, colon, and prostate cancer. In Europe, which consumes more milk per capita than the U.S., rBST is banned.

Despite these concerns, the FDA proceeded with approval, and the substance was soon marketed and sold all over the country. Uptake was swift, with Monsanto embarking on a campaign of misinformation and intimidation of scientists and journalists who voiced criticism. Suppression through the courts and close ties with regulatory bodies proved to be an effective strategy and would be repeated for later products.

Genetically Modified Crops

Bovine growth hormone proved to be an informative first step in the application of genetic manipulation to food production. The next time these efforts would go beyond the manipulation of bacteria as a vehicle for chemical production, and venture into the creation of new species with specific genetic modifications.

The work the biotechnology companies poured into genetic research was extensive and in many cases impressive. However, the projects turned from more traditionally scientific pursuits and toward corporate interests. This research, while groundbreaking, was shaped most clearly by the commercial demands of large biotechnology companies. With their success at manipulating the regulatory process in the U.S., agribusiness set their sights on the largest crops in the U.S. at the time, corn and soy.

While biotechnology promoters would argue otherwise, the mechanisms used for creating transgenic organisms are entirely different from the agronomic techniques employed since the advent of human agriculture. Historically, seeds from the best harvested plants were saved and then planted in an attempt to induce cross-breeding. The most favorable, survivable traits are then passed on from one generation to the next through sexual selection. Transgenic modification, however, requires the integration of foreign DNA into another organism's genetic code. Unfortunately for the transgenic researchers, the genetic material lies in the nucleus of the cell and is extensively protected with mechanisms preventing the intrusion of foreign bodies.

Monsanto had been selling an herbicide under the name Roundup with an active ingredient called glyphosate since 1974. This chemical works by inhibiting the EPSP (5-enolpyruvylshikimate-3-phosphate) synthase enzyme, which is essential to cell growth in all plants. Initially, it was used to spray down fields before planting, as its broad spectrum of effectiveness caused it to kill any plants growing in the field in a matter of days. The dead plant matter could then be tilled under, as the glyphosate becomes essentially inert, not affecting germinating seeds. While this technique was effective, creating a glyphosate-resistant plant would allow farmers to spray the chemical even while the crops were growing, greatly increasing the versatility of the product. This became one of Monsanto's goals for the next decade.

Despite very well-funded research and development (R&D) efforts, scientists were unable to produce a resistant plant. In 1984, a new CEO refocused the research division, putting an end to more open-ended projects and pouring all resources into creating a viable glyphosate resistant soybean. Researchers tried a variety of solutions, for the most part abandoning their usual careful experiments in favor of wild home-run attempts where dozens of variables were changed at a time. A solution was finally found in 1987, in one of the polluted ponds located in close proximity to the company's glyphosate factory in Missouri. Scientists were able to identify the genes in the surviving type of bacterium that blocked the chemical pathways upon which glyphosate operated.

After two more years of searching for an effective delivery mechanism, success was achieved using the new "gene gun," developed by the biotech company Acracetus, which was acquired by Monsanto in 1996. Gene guns work by attaching genetic fragments to microscopic tungsten or gold "bullets" and shooting them en masse into an embryonic cell culture. Because this technique inserted the genes completely randomly, tens of thousands of trials were needed to come up with a few dozen plants. Another three years of field testing and breeding occurred before they came up with a single line of viable, glyphosate-resistant soybean plants. In 1994, the company felt the product was ready to market, and filed for approval with the FDA.

At the heart of their push for approval was the concept of Substantial Equivalence. Essentially, the argument put forth was that GM plants are roughly equivalent to their natural or conventionally bred counterparts. The enzymes and proteins produced by the plant are close enough to the ones that humans have been ingesting for tens of thousands of years.

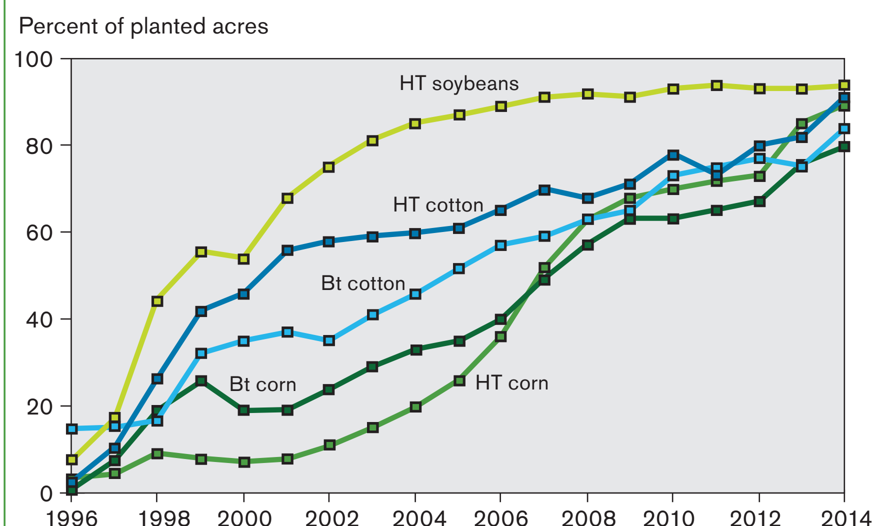
This allows these products to escape categorization as artificial food additives, which must undergo toxicological testing. Instead, they are labeled as "generally recognized as safe," which is reserved for food products in use before January 12, 1958 (when the Food Additive Act was passed) or because "scientific procedures" have demonstrated that there is no health risk.

What Monsanto argued, was that humans have a long history of consuming DNA (indeed it is in everything we eat) and that therefore the DNA inserted into transgenic organisms wouldn't pose a health risk. Despite the patent absurdity of this argument, the FDA went ahead with approval of the transgenic soybeans, and established a precedent that allowed for the future deployment of a number of GM crops. The regulatory mechanisms behind this will be discussed in more depth in the next section, but this development illustrates the dangerous level of influence that large agricultural biotech companies had (and still have) on the regulatory process. While the FDA's stated mission is to ensure safety for consumers, on the subject of GMOs it has acted more like a promotional organization for its large corporate sponsors.

GM Crops in the United States

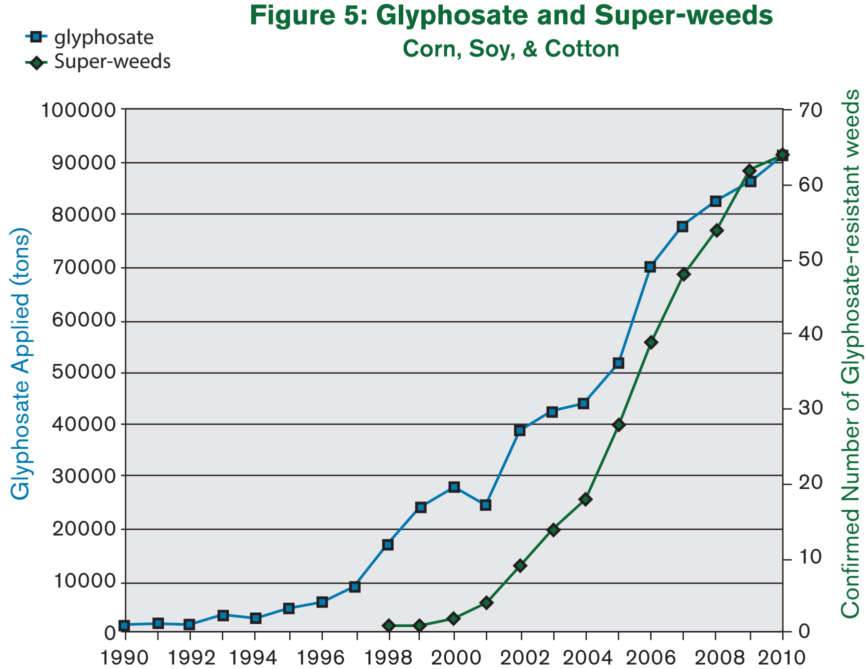
The enormous influence and aggressive tactics of agricultural biotechnology companies have drastically changed the composition and quality of American crops. While this change has been limited to the corn, cotton, and soybean crops, well over half of all acreage for these products is being cultivated with GM varieties. These crops are also the most common ingredients in processed foods, which has led to over 70% of processed foods found in supermarkets containing GM products.[13] This, along with restrictions on GM labeling have made it tremendously difficult for American consumers to choose non-GM alternatives.

Figure 4: Adoption of genetically engineered crops in the United States, 1996-2014



Data for each crop category include varieties with both HT and Bt (stacked) traits. Sources: USDA, Economic Research Service using data from Fernandez-Cornejo and McBride (2002) for the years 1996-99 and USDA, National Agricultural Statistics Service, June Agricultural Survey for the years 2000-14.

Figure 5: Glyphosate and Super-weeds
Corn, Soy, & Cotton



Source: Farmwars.info. . GMO Crops Increase Pesticide Use, September 2013.

Herbicide resistance is the defining trait of some of the most popular GM products, but a 2008 study by the Center for Food Safety shows that herbicide resistant soy, corn, and cotton have actually led to a 122-million-pound increase in pesticide use since 1996. Glyphosate usage has increased over 15-fold since the introduction of Roundup-Ready crops in 1996.

As early as 1998, only two years after these products were introduced, glyphosate-resistant weeds began to appear. The instances of these "super-weeds" has increased quickly, with more than 65 varieties identified by the end of 2010. Farms deal with this by either increasing the number of glyphosate applications, or turning to higher-toxicity herbicides. This puts farmers in a compromising financial situation as well, as finding resistant weeds on a farmer's land can reduce its value by an average of 17% per acre.[14]

Furthermore, in a four-year long study from 2001 carried out by researchers from the University of Nebraska, soybean yields were shown to decline 5% when conventional varieties were replaced with transgenics. This "yield drag" was caused by multiple factors. Another study carried out at the University of Arkansas demonstrated that the use of glyphosate impedes the rhizobium bacteria, which are present in the roots of soybeans, and affix atmospheric nitrogen into the soil. Without additional artificial fertilizer added, the yield of the plants was affected by up to 25% during dry periods. Additionally, both GM soy and corn crops have been shown to have reduced resistances to a variety of diseases.[15]

The usage of GM crops imposes a wide variety of negative effects, not just on the farmers that choose to use them, but on the entire agricultural system and on consumers. The accompanying increase in agro-chemical use is good for the large corporations that sell the GM seeds and herbicides/pesticides, but does unnecessary damage to the rest of the agrarian model.

The positive economic and environmental effects that have been claimed have not stood up in the face of independent testing. They have further entrenched spending on agricultural subsidies, which end up depressing food prices and ultimately finding their way to the large corporate interests, which then continue the cycle through spending these resources to gain more regulatory favors.

The Regulatory Environment

The United States: Friends in High Places

While GM crops have become an inescapable part of the American food system, they are almost impossible to find in Europe, either growing on farms or in consumer products. The difference in regulatory responses indeed illustrates disparate political climates, while also showing the abilities of large corporations with long-term strategies and the right political connections to compromise regulatory practices. Chemistry and biology may be objective processes, but the exposure and use of testing in these fields can be subject to extensive manipulation. The large agricultural biotech companies that develop GM crops and organisms have consistently employed a range of such tactics in the pursuit of unfettered market access and higher margins.

This special relationship with U.S. regulators has been taking shape since the Vietnam War, but it was during the 1980s that these agricultural biotech interests really solidified their ties to the federal government, all the way up to the Reagan administration. U.S. research and technology enterprises were, at the time, feeling rising pressure from foreign companies, particularly the large Japanese industrial conglomerates. Genetic engineering was considered the forefront of agriculture, where American companies had enjoyed a position of global leadership for decades.

This threat tied into two important policy planks of the Reagan and Bush administrations, promoting corporate interests and strengthening America's global presence. These directives appear to have left limited room for consumer safety or environmental considerations. In fact, FDA representatives wrote in a 1993 document that, in accordance with government policy, their purpose was not to ensure consumer safety, but to "promote" the U.S. biotechnology industry at home and abroad.[16]

Attaining this power over regulators and lawmakers required not only financial contributions, but an extensive network of people across multiple agencies with personal connections to the industry. Here, Monsanto and other companies have done an impressive job. The industry has put former higher-ups in positions of real power in the FDA, United States Department of Agriculture (USDA), Department of Justice, Environmental Protection Agency (EPA), and every presidential administration since Jimmy Carter. Supreme Court Justice Clarence Thomas, former Secretary of Defense Donald Rumsfeld, and even former Secretary of State Hillary Clinton all spent time working for Monsanto or its subsidiaries.[17] These friends in high places, helped by lobbying spending of over $70 million a year,[18] have allowed agricultural biotech corporations a truly remarkable amount of access and input to the regulatory process in the U.S.

Patent law is an important starting point for examining this undue influence. While living organisms were once expressly prevented from being patented, a series of congressional acts and Supreme Court decisions beginning in 1970 have made it possible to obtain multiple kinds of patent protection for GM plants.[19] The power and scope of these patents has grown with the industry, and is a critical piece of the industry model. Agricultural biotech companies have taken a severe approach to patent enforcement, actively seeking out violations and rigorously prosecuting.

The main focus of these actions is "brown baggers," or farmers who save seeds from previous crops and replant them. While this has been standard practice since the inception of agriculture, under the standard contracts for GM seeds this is no longer allowed. The seeds are essentially classified as intellectual property, and thus "reproducing" them for profit constitutes a violation. Hundreds of such cases are brought up every year, with the vast majority of them ending in out-of-court settlements. Farmers have little chance of fighting these large multinational corporations, and those that run afoul publicly often find themselves isolated and professionally ruined.[20]

Interestingly, granting these patents at all is contradictory to the argument of Substantial Equivalence, which has been a central tenet of the industry's arguments for less testing and regulation. Monsanto, for example, made the claim that Roundup Ready soybeans needed no additional field testing because they were essentially the same as non-GM soybeans. Their effects on both consumers and the environment would therefore be "substantially equivalent."[21] At the same time, they claimed that the special properties of the GM organism render it unique enough to warrant a patent.

This substantial equivalence argument forms the basis for the FDA's policy of allowing GM products without premarket approval. An approval process still exists, but is not mandatory or standardized, and is instead voluntary and consultative in nature. The USDA does have a premarket approval process, but allows companies to conduct and submit their own research. These companies have worked to mitigate the appearance of this obvious conflict of interests by collaborating with universities, think-tanks, and third-party laboratories.

American Research Institutions: In Search of Objectivity

Here the relationship between corporate interests and research institutions plays a key role. In 2005, almost a third of all agricultural scientists reported consulting for private industry. Beyond this, many universities grant corporate affiliate status in return for donations. In some extreme cases, university leadership and corporate boards may overlap, as in 2009 when South Dakota State's president was given a seat on the board of directors for Monsanto and a six-figure paycheck.[22] Agricultural research appears particularly beholden to corporate influence. Private industry funding accounted for only 6% of total university R&D funding in 2010, while it provided over 60% for land grant university agricultural research.

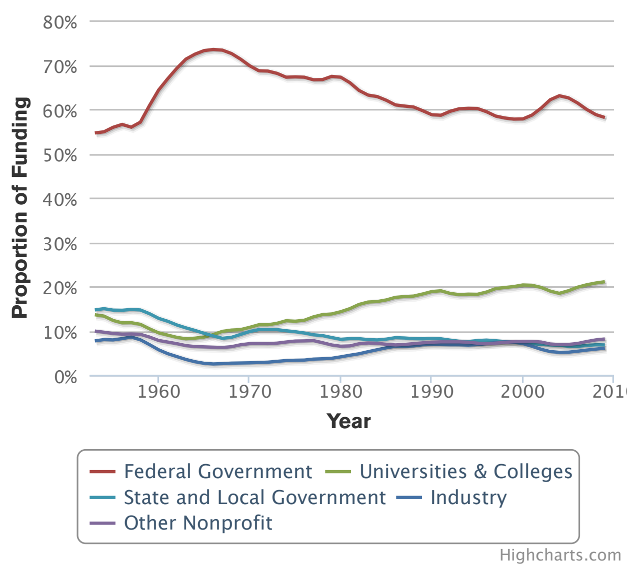
This undue influence on research has a number of serious policy implications. Finding experts in the field without bias becomes next to impossible as scientists and researchers must toe the corporate line or risk their livelihoods. Over the last couple of decades, these large multinational biotech companies have repeatedly retaliated in a vicious way to any independent research that contradicts their assertions. Instead of refuting their claims through the scientific method, dissenting voices usually find themselves under attack personally and professionally, often ending up jobless.

Manuela Malatesta, a university professor who experienced this states, "…research on GMOs is now taboo. You can't find money for it. We tried everything to find more financing, but we were told that because there are no data in the scientific literature proving that GMOs cause problem, there was no point in working on it."[23] Private companies have effectively been able to monopolize "legitimate" research on their own products.

A particularly telling episode occurred in 1996; the authorized level of glyphosate residue allowed on soybeans was increased from 6 parts per million (ppm) to 20 ppm, just weeks before the release of Roundup Ready soybeans. When asked for comment, the EPA's toxicologist stated that the change had been made because of studies provided by Monsanto.[24] These studies were revisited in 2003 for independent testing, several red flags were raised. Monsanto refused to provide any of the raw data from these studies, claiming that it was "business confidential" information.

While this confidentiality argument is often made for research data, denying access to raw data is highly unusual. For the data and lab reports they were able to access, the professors undertaking this examination noted a variety of inconsistencies and suspect science. In one of the studies using rats, they only used older lab rats, which are widely known to be much less sensitive to harmful dietary effects. In several more of the filings, organ inspection appears to have been carried out entirely by eyeballing, not even incorporating a microscope, much less actual toxicology tests. Despite all of these issues, the initial approval was never officially revisited.

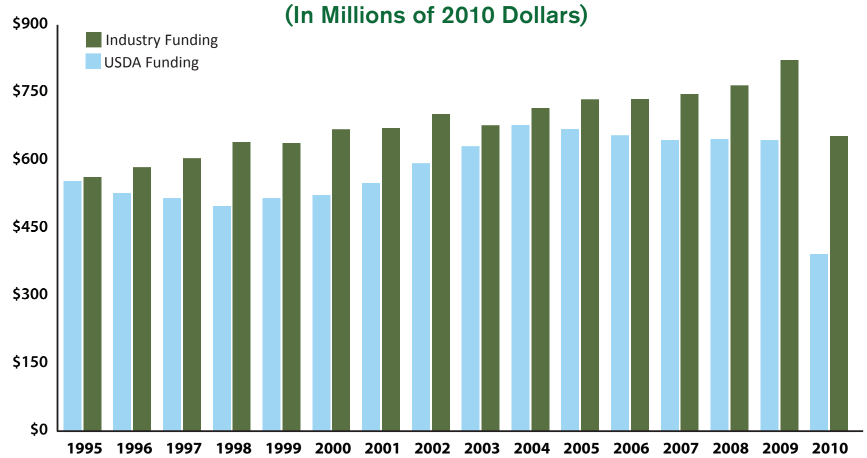
Figure 6: Sources of University & College R&D Funding



Source: New Atlantis, National Science Foundation . The Sources and Uses of U.S. Science Funding, 2012.

Large agricultural biotech companies are not opposed to all forms of regulation though. When it suits them, they have used their close relationships with various government agencies to pursue legal means of ensuring their products get to market. A clear illustration of this are the actions taken by large agro-corporate interests to keep consumers from knowing which foods contain GM products. The ban on labeling rBST/rBGH milk was to keep it from being stigmatized in the marketplace. Labels were technically allowed, as long as they stated that no difference had been found between rBGH and the naturally occurring cow hormone.

Figure 7: Funding of Land Grant Agricultural Research
(In Millions of 2010 Dollars)



Source: FoodandWaterWatch.org. Public Research, Private Gain: Corporate Influence Over University Agricultural Research, April 2012.

Clearly the aim of this regulation was not consumer safety, but promoting agribusiness and biotechnology. The man who wrote these guidelines, announced in February of 1994, was Michael Taylor, the FDA's deputy commissioner. Taylor had represented Monsanto for more than seven years prior to his appointment, and has spent his subsequent career bouncing between upper management at Monsanto and top positions at the FDA and USDA. While these regulations are being challenged with ballot measures and in the courts, this blatant corporate protectionism has succeeded in withholding information from consumers for over a decade.

The European Approach

The rollout of GM crops did not go as smoothly in Europe. The large agricultural biotech companies were still well-funded, but had nowhere near the influence on scientific and regulatory bodies they enjoyed in the U.S. In the U.S., the biotech companies were able to use their funding and favors to control research publication, and had an arsenal of legal, financial, and media tools they used to control the greater narrative of GM agriculture. In Europe, they had to work within the system, instead of dictating the system from the ground up. While these companies spared no expense in trying to take control of the process, they were ultimately unable to withstand the pushback that came with independent testing and a skeptical European public.

The regulatory protocol for GMOs in Europe was adopted in April of 1990 by the European Community (now European Union). Under this model, companies must present a technical dossier on the desired product to a member state's relevant commission. The member state then takes what steps it feels necessary to assess the risk. Following this, the commission sends this dossier to all of the other states, who have sixty days to request more information. After all member states are satisfied with the amount of data provided, the commission can then authorize importation.

Roundup Ready soybeans, as well as a variety of pest-resistant corn, managed to gain approval through this process in December of 1996, using research data provided by the sponsoring companies. In 1998, a new breed of aphid-resistant potato was submitted for approval. This time, the Scottish Agriculture, Environment, and Fisheries ministry directed Dr. Arpad Pusztai, a world-renowned biochemist to conduct independent testing. Pusztai had examined the Monsanto-backed studies on glyphosate-resistant soybeans published in 1996. He thought it was "very bad science," but considered himself a supporter of biotechnology and set out to give the credibility of his name and research to show that GMOs were harmless.[25]

The results of his experiments informed him differently. The protein (lectin) that the modified organisms produced varied significantly between trials. Furthermore, the rat's digestive systems did not appear to be processing the GM potato like conventional ones. Brains, livers, and testes were less developed, while there was a proliferation of stomach cells, which can facilitate the development of tumors. The immune system response suggested that the modified potatoes were being treated as foreign bodies. This was especially disturbing because the lectin gene tested safely in its natural state. The unexplained effects were therefore likely caused by the genetic insertion technique, which is in direct contradiction to what the parent companies and U.S. FDA had claimed.

Pusztai took his concerns back to the U.K. regulators, and expressed them again in an interview segment on British television. Initially the Rowett Institute, his employer, was happy for the attention, but things quickly took a turn. Two days after the interview was broadcast, Pusztai's contract was suspended, his team dissolved, and all of his research confiscated. He was threatened with prosecution if he spoke to the press. The head of the institute immediately embarked upon a media campaign aimed at discrediting the GM trials and Pusztai himself. The institute also formed an audit committee, which reviewed the experiment and had Pusztai's statements declared "unfounded."

The media coverage was extensive, and the controversy caught the attention of the British House of Commons. They asked for testimony from Pusztai, forcing the Rowett Institute to give him the research data back. Pusztai then sent the data to twenty scientists around the world, who agreed to prepare a report comparing the data to what had been presented in the audit. The results, put on the front page of one of Britain's leading newspapers, were not flattering to the Rowett Institute. They showed that significant results had been entirely ignored, and that the Rowett Institute's treatment of Pusztai had been unfounded and disturbingly harsh. They questioned the objectivity of the institute, calling attention to the fact that in February of that year, the Rowett Institute signed a contract with Monsanto, which pledged 1% of the institute's annual budget.

This turned out to be a media relations nightmare for GM proponents, setting the stage for defeat on a continental scale. British public opinion polls saw a rapid decline in approval ratings for the new technology. The issue gained a degree of political toxicity as politicians looked to distance themselves from the unpopular American biotech firms and their GM products.

Many of the largest food vendors in the U.K., including Tesco, Nestle, and McDonald's, made pledges to not include any GM ingredients in their products.[26] While attitudes vary across European countries and regions, political momentum built to such a point that in June 1999 the European Commission reversed its decision to allow importation of GM crops. By 2001, American corn exports to Europe had declined 99.4% from their 1996 levels, slamming American farmers who had been promised extra profits from the new technology.[27]

The fundamental feature separating biotechnology policy in the United States and the European Union concerns the requirement to undergo testing. The E.U. process qualifies products for testing through their method of creation alone (genetic engineering), while the U.S. policy specifies that only those organisms that could pose a threat to the environment need to be tested. This approach by U.S. authorities is predicated on the concept that organisms with genetic modification are no more risky than new organisms bred with traditional means.

The European approach on the other hand adheres to the Precautionary Principle, which states that when an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.[28] While U.S. policy allows for post-market testing (when obvious environmental or health risks arise), European policymakers have insisted on independent science-based assurances before allowing GM products on the market. As of 2014 only two GM crops can be cultivated in Europe, and neither are used for human consumption.

Targeting Developing Markets

South America: The United Republic of Soy

Even before the 1994 approval of GM soybeans in the U.S., GM seed producers were making moves to deploy their products in the next soybean hotspot, a rough cone of extremely productive cropland covering Paraguay, and parts of Argentina, Brazil, and Bolivia. Regional cultivation of the crop began in the early 1980s, and has since grown to over 45 million hectares, an area roughly the size of Sweden.[29] This area recently overtook the United States in soy exports, earning the nickname "The United Republic of Soy."

The first point of entry was in Argentina. The government of Carlos Menem, ascending to power in 1989, was enthusiastically pursuing deregulation and looking to remove barriers to trade and foreign investment. Monsanto seized its opening in 1991, gaining an influential spot on the National Advisory Commission on Agricultural Biotechnology (Conabia). Unsurprisingly, the body adopted the regulatory models that were working well for GM companies in North America. No approval or independent testing was required, and the committee spent many of its resources promoting the new technology in the media.[30]

Figure 8: The United Republic of Soy

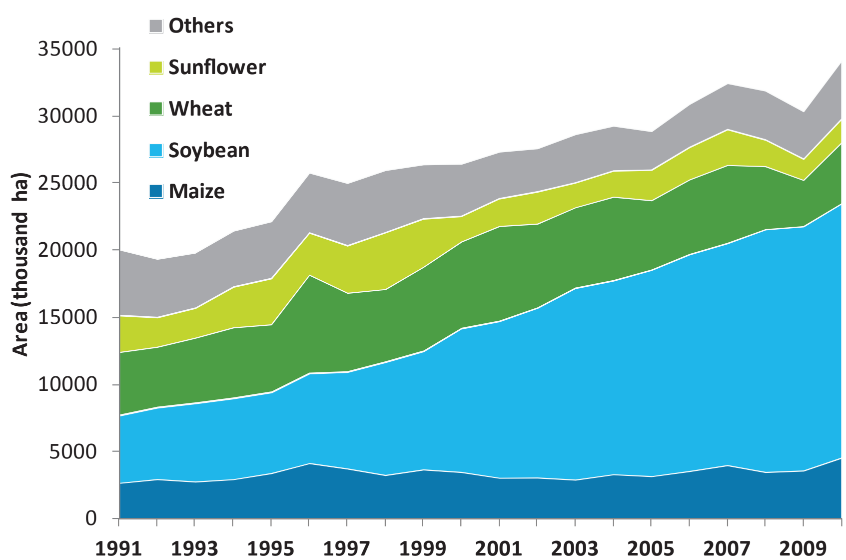
Source: Syngenta

The southern region of Argentina, known as the Pampas, has been a key resource for Argentina since its settlement. The pastureland was legendary, supporting hundreds of thousands of cows, both beef and dairy. Farmers grew corn, wheat, sorghum, peanuts, sunflowers, soybeans, and a range of fruits and vegetables. The arrival of GM soy completely changed the landscape. By that time in the mid-1990s, soil fertility had been dropping and serious productivity concerns had spread to many of the region's farmers.

Agricultural biotech companies leveraged this opportunity, selling seeds at one-third of the North American prices, and packaging them with technical advice, including direct planting techniques. The initial boost in yields from these techniques was notable, and the GM seed companies made sure to associate this with the new seeds. Due to the higher yields, profits were up and farmers began flocking to the new technology, planting more and more of their fields with the new "magic

Figure 9: Field crops at Argentina

Area, production, and grain yields from 1990 to 2010



Source: International Plant Nutrition Institute. Agriculture and nutrient Agriculture and nutrient management in the Southern Cone of Latin America, November 2011.

seeds."[31] It was not long before other farmers in neighboring Brazil and Paraguay took notice.

In the U.S. and Argentina, large agricultural biotech corporations brought their GM products to market by becoming so intertwined with the respective countries' regulatory processes that they ended up all but dictating the rules. In Brazil, they took a very different, but similarly effective approach, by essentially ignoring the regulatory authorities altogether. They recognized that the Brazilian government, while noted for its environmental policies and advocacy, often comes up short when it comes to enforcement. Parallels can be drawn to the struggle over deforestation, where despite official regulations, thousands of acres of Amazon jungle are illegally cleared every year.

The Brazilian government's initial GMO policy was rooted in a 1993 biodiversity agreement, which established the Precautionary Principle as the guiding policy for biotechnology, requiring before-market testing for any "genetically enhanced" organisms. However, by 1996 GM soy was flooding across the border, and thousands of new acres were being planted every month.

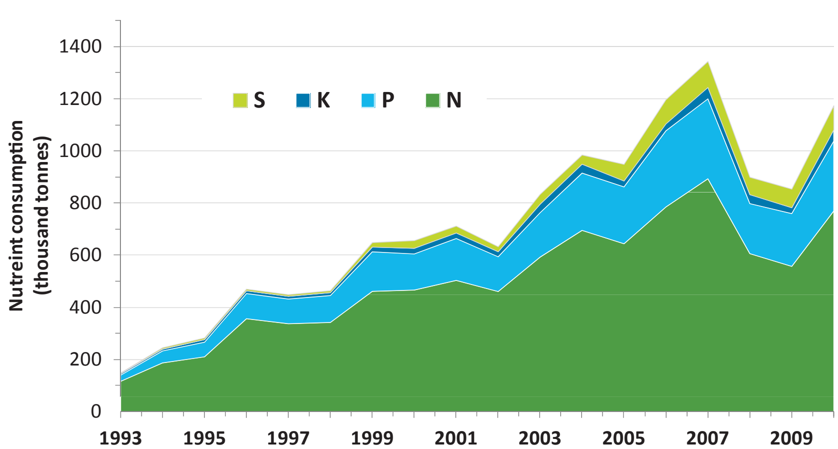
Regulators realized that preventing this spread was logistically impossible, and in the interest of gaining some level of regulatory sway, tentatively approved the crop in 1998. While opponents managed to pass a labeling law in 2003, successive "provisional measures" gave large agricultural biotech companies the regulatory environment they wanted with regards to the seed market.

Once the legal framework was in place, the GM seed companies commenced squeezing their customers for additional revenue. They had forced their way into the market with aggressive pricing and by foregoing the usual seed contracts, a wise strategy considering their products were technically illegal. Following approval they began using the standard purchase agreements, which made saving seeds illegal, and then gradually moved to ratchet up prices. Farmers who had bought into the GM agriculture system often found themselves unable to switch back after sinking money into multi-year contracts for seeds and agro-chemicals.

The transition to GM soy instigated momentous economic and demographic changes all across the region. Foreign capital and local enthusiasm caused land prices to triple within a year in some places, leading to rapid and extensive consolidation. Every other major crop experienced decreases in cultivation.[32] The wide variety of foods traditionally grown on these fertile plains turned into endless fields of soybean monoculture. The social upheavals have been particularly acute in Paraguay, where each year, half a million hectares are turned into soy fields, forcing the eviction of 9,000 rural families. Just 2% of the population now controls 85% of Paraguay's farmland.[33]

Soy farming has turned Paraguay from an exporter of food to a net importer, despite agriculture accounting for nearly a quarter of gross domestic product (GDP). Chronic malnutrition affects 14% of children in the country, and many more lack access to clean drinking water.[34] While Paraguay's economy has expanded with the GM soy boom, an enormous amount of added value is taken out of the country. An estimated 50-80% of production is controlled by Brazilian interests, and more than 70% of processing takes place after export. More than half of Paraguay's soy is sent to Argentina, where it is turned into cattle feed or biodiesel to fuel European cars.[35]

Figure 10: Fertilizer consumption in Argentina
1993-2010



Source: International Plant Nutrition Institute. Agriculture and nutrient Agriculture and nutrient management in the Southern Cone of Latin America, November 2011.

This lack of economic diversification also leaves the region exposed to price shocks. Even relatively minor fluctuations in soy prices can drive entire farms out of business, prompting yet more consolidation. Planting so much contiguous land with a single variety also leaves the entire region highly vulnerable to crop diseases. Large, dense populations combined with low genetic variety is a recipe for the evolution and rapid spread of pests and pathogens.

Repeated planting of a single crop also has well-documented detrimental effects on soil productivity, which has re-emerged as a serious concern a decade after beginning this transition to GM soy. This soil degradation is further compounded by the overuse of agro-chemicals. Since the introduction of GM soy, glyphosate use in Argentina has grown from 1 million liters annually to over 150 million liters. The repeated spraying of these chemical compounds renders the soil inert, unable to support the bacteria that are fundamental to the decomposition process.[36] To make up for this, farmers must use more and more fertilizer, further raising input costs. From 1997-2010, fertilizer consumption in Argentina almost tripled, while total crop production rose around 50%.[37]

The indiscriminate application of agro-chemicals has been an insidious threat to public health. Local advertising for glyphosate conveys that it is "good for the environment" and "biodegradable." While it may be less toxic than 2,4-Dichlorophenoxyacetic acid, commonly called 2,4-D (an active ingredient in the new generation of herbicides), growing pest populations and lax spraying regulations have made the chemical omnipresent. Overall, Argentine farmers use 4.3 pounds of agro-chemical concentrate per acre, more than double what U.S. farmers use.

In the Chaco province, birth defects quadrupled in the decade following the introduction of GM farming, and in nearby Santa Fe, cancer rates are two to four times higher than national averages. Nearly 80% of the children in the region carried traces of the pesticide in their blood.[38] While many would think this warrants a new approach to agro-chemical use, the national conversation has been dominated by the GM companies and their captive regulatory bodies insisting on the necessity and safety of these products.

India

The negative impacts of the GM system have also been felt in India. Familiar issues, such as regulatory tampering, played a factor, but it was a combination of aggressive marketing techniques and disregard for local growing conditions that proved especially destructive. Cotton has long been an important crop in India, but is highly vulnerable to insects and pests, commanding 55% of all pesticide use while occupying only 5% of cropland.[39] In 2002, Indian regulators approved pest-resistant cotton (known as Bt cotton for the Bacillus thuringiensis bacterium that has been added to it), swayed by claims that it would reduce the need for toxic chemicals, while boosting yields and profits for farmers.

Due to the monsoons, the soil during planting season is often saturated. While this is how regional agriculture worked for the last 5,000 years, the companies selling GM cotton seeds neglected to account for this. In this extremely wet soil, the GM seeds were simply not viable. This did not stop the dealers from marketing the products. In addition to being more than four times the price of local seeds, buying the seeds necessitated buying into the whole GM system, requiring new equipment, chemicals, and repurchasing seeds every year. Predatory lending is rampant, and failing crops and falling cotton prices triggered waves of bankruptcy across rural India.[40]

A popular narrative concerning GM cotton in India blames its deployment for the suicides of over 250,000 farmers. While media outlets have found plenty of cases where GM cotton seemed to be a leading factor, suicide rates for farmers did not actually increase after the 2002 deployment of the crop, and remain lower than the overall suicide rate.[41] Nonetheless, this narrative reflects strengthening negative public sentiment, which seems to have spurred official action by the country's courts and regulators. The field trials for GM rice have encountered resistance in the Indian Supreme Court, which acknowledged that the current regulations governing GMOs are inadequate to ensure public health and safety.

Africa

Over the last 15 years, rising global food prices and falling foreign investment barriers have fueled a significant rush for agricultural land, headed up by large multinational corporations. Africa, with the largest remaining reserves of arable land, has become a major destination for such investment. While foreign direct investment can be profitable for both sides, these relationships must be managed carefully to prevent exploitative practices. This heightened focus on agricultural land use has also served to intensify the debate over GM crops. While some claim that GM agriculture is Africa's path to stability and prosperity, a significant collection of corporations, governments, and non-governmental organizations are working to promote organic farming as a more sustainable future.

Currently, the African Congress is neutral on the issue, with commercial use of GM crops allowed only in South Africa, Egypt, Sudan, and Burkina Faso. South Africa has embraced GM crops most enthusiastically, cultivating almost 5 million acres of GM corn, soybeans, and cotton in 2013.[42] This stands in sharp contrast to countries such as Malawi, Mozambique, Zambia, and Zimbabwe, which have all rejected food aid from the United States because it included GM corn, even in the face of famine that affected millions.[43]

Enormous upheavals would follow the implementation of GM agriculture. In sub-Saharan Africa, agriculture provides 30% of GDP and almost 70% of employment. Just as in South America, the implementation of GM crop systems would very likely lead to land consolidation and unemployment. Nearly one in every four people in sub-Saharan Africa struggle with food insecurity, which GM agriculture would exacerbate.[44] GM proponents repeatedly assert that their crops will bring higher yields, which will in turn be beneficial to everyone. Even if these assertions held up consistently under independent testing (they don't[45]), yield is a misleading indicator of success. Aggregate global food production could already provide 3,000 calories per person per day. Food scarcity occurs because of poverty, waste, and problems with food distribution.[46] Simply growing more food is not a satisfactory solution, especially when it jeopardizes future health and productivity.

Dependence on large multinational corporations is also a growing concern. In September of 2013 the Council of Ministers of the Common Market for Eastern and Southern Africa (COMESA) ruled that only standardized, certified seeds may be commercially sold among the 19 member states. This essentially prevents small farmers from jointly collecting and selling seeds, a widespread practice in many regions. As large corporations are the only ones with the resources to adhere to the testing and certification requirements, this makes them the only legal source for seed purchases.

The dependency trap the GM system relies on would put further strain on already precarious economies. GM crops would also jeopardize agricultural exports to Europe, Africa's largest trading partner. While proponents argue that organic and traditional farming will still be options, trade incidents with the U.S. have demonstrated that any risk of GM contamination can be grounds for completely cutting off food shipments to European markets. Furthermore, the tremendous biodiversity that is one of the continent's greatest assets would be threatened by creeping monoculture and genetic contamination.

Conclusion

The arguments made in favor of the current generation of GM products simply fail to hold up to extended time periods or independent testing. Instead, GM corporations manipulate regulators, research institutions, and media outlets. These companies have been exposed for these practices time and time again, but still insist that they have the customer's best interests at heart. Monsanto's recent refusal to release data regarding the effects of their pesticides and GM crops on bee populations is indicative of their myopia and disinterest in any well-being beyond their sales revenues.[47]

Furthermore, the traits that the organisms are genetically manipulated to express have not delivered the promised benefits. In an analysis of 77 studies conducted in eight countries, a team of U.S. and French scientists found that nearly half of major pest species had become resistant to Bt cotton or corn plants.[48] Herbicide tolerant (HT) varieties have fared little better, with new varieties of glyphosate-resistant "superweeds" being discovered on an almost monthly basis.

Of the several thousand GM crop field trials conducted since 1987, over 650 have named higher yields as their genetically targeted trait. Yet, none of these have made it to commercialization, indicating the failure of GM technology to be more effective than conventional breeding. The higher reported yields that follow the introduction of GM crops is in large part due to changing farming techniques, and increasing inputs such as fertilizer and agro-chemicals. A recent study conducted by the USDA's Economic Research Service concluded that the average per-acre cost of soybean and corn seed increased 325% and 259%, respectively, between 1995 and 2011. This is also the time period when planted acreage of GM corn and soy grew from less than 20% to more than 80-90%.[49]

All things considered, the risks associated with GM agriculture outweigh the benefits. While genetic modification as a tool is neither inherently negative nor positive, the history of its use indicates that the GM product is largely deployed to increase short-term profits for agricultural biotech corporations at the expense of consumers, small farmers, and the environment. Industrialized agriculture is enough of a sustainability challenge on its own, and examples from across the globe illustrate the extra level of distress that comes with adding genetically modified organisms into this system.

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