Why Genetically Modified Crops Pose a Threat to Peasants, Food Sovereignty, Health, and Biodiversity on the Planet

Introduction

Almost twenty years of genetically modified crops… What have we gained?
Contrary to what companies promised, official statistics from the United States—the leading producer of genetically modified (GM) crops in the world—demonstrate that the truth of GM crops is that they produce less per hectare than the seeds that were already available on the market, but have resulted in an exponential increase in the use of agritoxins (Benbrook, 2012; Gurian-Sherman, 2009).

They have also had serious negative impacts on both public health[1] and the environment in every country where they have been grown on a large scale. Genetically modified crops have been a key instrument to facilitate a greater corporate hold on the history of food and agriculture.

Six transnational corporations control all the GM crops commercially grown in the world. The same six corporations are the greatest global manufacturers of agrochemicals, which explains why 85% of GM crops are manipulated to resist large doses of herbicides and pesticides, since this is the greatest profit area (ETC Group, 2013b).

Have they helped reduce hunger around the world?
No. In addition, as a result of the advancement of industrialization of the food chain at the hands of agribusiness corporations since 1996—the year when genetically modified crops started being grown—the number of undernourished and obese people—a phenomenon that is now synonymous to poverty, and not wealth—has increased (FAO, 2012; OMS, 2012).

GM crop cultivation accelerated the displacement of small and mid-sized producers and impoverished them, while replacing a considerable part of the workforce with machinery, thus increasing rural unemployment. For example, in Argentina, GM crops and their so-called "sowing pools" (*pools de siembra*) led to a veritable "reverse agrarian reform," eliminating a large part of small and mid-sized agricultural establishments. According to the 1988 and 2002 censuses, in those years 87,000 such establishments disappeared, of which 75,293 were smaller than 200 hectares—a trend that continues to this day (Teubal, 2006). The consequence is that, today, 80% of farmed land is leased to 4,000 investment funds. This is not a model for food production; it is an agricultural platform for speculation.

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 These impacts are evident in the case of populations directly affected by the increase in the use of agritoxins in areas where GM crops are grown. In addition, many studies point to other impacts on human health, extrapolated from the results of experiments with laboratory animals.

They have aggravated problems for the basis of survival on the planet.
In the same period when GM crops started being grown, the climate crisis and eight of the planet's nine most serious environmental problems—defined by the Stockholm Resilience Center as the "planet's limits," which we cannot exceed if we want the Earth to survive—greatly worsened. Seven of these problems—climate change, loss of biodiversity, ocean acidification, pollution and scarcity of fresh water, soil erosion, excessive amounts of phosphorus and nitrogen dumped in the oceans and soil, and chemical pollution—are directly related to the corporate industrial food production system, of which GM crops are the central paradigm (Rockström, 2009; ETC Group, 2013a, GRAIN, 2011).

Do we need genetically modified crops?
A large variety of peasant and small-scale food systems currently feeds 70% of the world's population—30 to 50% of that is provided by small farms, 15 to 20% by urban orchards, 5 to 10% by artisanal fisheries, and 10 to 15% by hunting and wildcrafting (ETC Group, 2013a). They are healthier forms of food production, mostly free of agritoxins and genetically modified organisms (GMOs). On the contrary, food products from the agro-industrial food system only reach 30% of the population, but use 75 to 80% of the world's arable land and 70% of water and fuel for agricultural use (GRAIN, 2014). From harvest to homes, 50% of food products from the industrial chain end up in the trash.

Feeding the world does not require uniform, high-tech and high-risk crops in industrial systems. It requires a diversity of seeds in the hands of millions of peasants and small- and mid-scale farmers. The advance of agribusiness corporations using GM crops and agritoxins poses a serious threat to this option, which already feeds the poorest populations and most of humanity.

1. An Inexact and Uncertain Technology

Contrary to what the biotechnology industry claims, GMO technology is an inexact method that provides no control over its consequences. Isolating different DNA sequences from different organisms and putting them together to form a transgene is quite simple. However, up to now, it has been impossible to introduce this intact sequence in a specific locus of the genome. It is also impossible to control how many intact copies or parts of the modified sequence will be integrated in the host organism's genome. And it is even harder to avoid interactions between these sequences and the host's other genes. It is impossible to control the gene expression of the inserted transgenes or their dispersion or rupture in the new loci of the genome.

Because of this, it is impossible to predict the transgenes' impact on the genomes or genetically modified organisms and on the environments where they are released. In these artificially modified organisms, life restrictions have been broken—<u>restrictions that are not yet well understood by science</u>. They will give rise to <u>unprecedented</u> forms of biological interaction and evolution, with unpredictable consequences and uncertainties for biodiversity (Filipecki and Malepszy, 2006). Releasing GMOs into the environment is a global experiment that affects the natural dynamics of life and humanity as a whole, unilaterally decided by a handful of corporations and some governments.

In contrast with the scientific evidence that corroborates the above, the sectors that defend genetic engineering assume that genetically modified organisms will behave as they do in the lab once released into nature—that is, that they are equivalent to organisms that are not genetically modified.

They claim that GMOs "*are natural*" and that they "*are new varieties*," assuming that the experimental technique used is precise, safe, and predictable, and that it is equivalent to conventional improvements in agriculture.

This is a serious mistake and demonstrates "lack of awareness" on the part of the biotechnological field of the theories and knowledge of contemporary biology. The notions put forth by those who produce GMOs do not consider the natural restrictions to genetic recombination, the role of time in the genesis of biodiversity, and an assessment of the natural mechanisms that sustain it through organic evolution. Both the evolutionary process and the varieties of the species are based on sexual reproduction, the recombination of genetic material, and biological and environmental mechanisms that restrict and regulate the genome's dynamics in each generation and, through them, throughout evolution. Furthermore, recombinant DNA biotechnology has broken important restrictions to evolutionary recombination of the genetic material, without yet understanding the nature or role of many of these restrictions established by organic evolution itself.

It is vital to understand that, in any kind of genome modification through engineering, the biological **time** necessary to stabilize varieties and the evolutionary process and the **history** of the species—which are unaltered by conventional improvement methods—disappear for the sake of technological procedures. This happens because the aim is instant genome manipulation to obtain "new varieties."

To insist that traditional procedures for crop adaptation and improvement of food species are comparable to techniques of genetic modification of organisms by design carried out by industry is a reductionist, obsolete, and irresponsible idea, considering what we already know.

To claim that the improvements carried out by humans in agriculture for 10,000 years and modification by design in the lab are the same is to ignore the human farming culture developed by millions of peasants in thousands of different biogeographic and climatic situations, which has respected natural mechanisms throughout all those years, selecting new varieties brought about by interbreeding until the adequate phenotype is found and stabilized. These processes of adaptation and adjustment of crop characteristics carried out by agrarian communities throughout time continuously test their impacts on human health and the environments where the new varieties are generated.

More importantly, this improvement is not the consequence of a simple change in the DNA sequence or the incorporation or removal of genes, but of the consolidation of an **adjustment in the behavior of the genome as a whole (the notion of a fluid genome) that respects nature's own restrictions to recombination** and, therefore, makes the resulting variety useful and predictable (it is for that reason that it becomes a new variety). This adjustment can involve genes associated to the new phenotype, but accompanied by many adjustments of an epigenetic nature (non-genetic factors or chemical processes in the development of organisms) which are mostly unknown. Thus, a new variety represents an **integral improvement of the phenotype** for a given condition where, given its fluidity, the entire genome was most probably affected by a physiological adjustment in accordance to nature's *time* and respecting the *history* of each species.

This new knowledge of genetics is not taken into account in the analysis, projection, and assessment of the risks of GMOs developed and released, since, in the conceptual framework that sustains genetically modified organisms, a gene or set of genes introduced in a plant or animal embryo in a laboratory suffices for analysis. By definition, with GMOs the natural conditions of natural regulatory biological processes and the "fine epigenetic adjustments" that lead to the development of phenotypes in nature are not respected, contrary to what happens with traditional improvement and the natural evolution of organisms.

In effect, GMO technology **violates biological processes** through rudimentary and dangerous procedures with unpredictable consequences involving the **combination of genetic material from different species**. Transgenesis not only alters the modified genome's structure but also makes it unstable through time, produces undesired disruptions or activations of the host's genes, and directly or indirectly affects the operational state of the entire genome and the regulatory networks that maintain its dynamic balance, as demonstrated by the variation in the phenotype response of the same genotype to environmental changes (Álvarez-Buylla 2009, 2013).

The classical notion of the gene understood as the basic unit of a rigid genome, conceived as a "Meccano," as a predictable machine based on gene sequences and the assumption that its products can be isolated, recombined, and manipulated without consequences, is an expression of an obsolete scientific reductionism that has been widely refuted and whose falsehood has been proven. This epistemic reasoning has been abundantly critiqued by thinkers such as Richard Lewontin,[2] among others, and refuted by numerous scientific articles on the importance of the interactions between genes and the importance of regulatory mechanisms of gene expression at the epigenetic level, which demonstrate dynamic changes in the effects of an organism's own genes as well as the genomes in their responses to the environment and even to food consumption.

More than a scientific viewpoint, the epistemological insistence on considering GMOs as "natural" varieties instead of regarding them as foreign bodies or industrial artifacts that, when installed in nature by human hands, alter the course of evolution, is an arrogant and presumptuous position that disregards the most current scientific knowledge. In most cases, this apparent ignorance is fueled by conflicts of interest, since those who uphold such viewpoints have relations of direct or indirect financing by agribusiness transnational corporations that profit from GMOs. In other cases, pro-GMO scientists defend their career, founded on outdated paradigms, and their prestige, which depends on the same agro-industrial interests, as well as the possibility of doing business by licensing their patents to large corporations.

Complexity is not a theoretical position, but an integral configuration of nature. Breaking nature apart into small pieces in order to "understand it" is increasingly insufficient.

What the GMO industry intends by avoiding the debate on the logic that sustains it is to stage a turnabout for a technology that was born in the lab to achieve a limited understanding of molecular processes, extending it into nature without credible or predictable criteria.

We insist: the process of generating organisms is indecipherable. We can study it, but we must take into account the limits that the *fluid* genome's physiology has demonstrated. Altering an organism with a piece of its own DNA or that of another organism will affect its entire physiology, and using the natural environment—or human diet—as a laboratory is an unacceptable experiment.

A number of studies have researched this type of unpredictable alteration. A very illustrative one has to do with the alteration of the protein profiles of a variety of GM maize (MON810), which expresses 32 different proteins, as compared to the protein expression of conventional maize (Agapito-Tenfen et al, 2013).

GMOs, which are today in the eye of the storm, bring to the forefront that strange and increasingly evident relationship between reductionist scientific thought and the ideology that sustains neoliberal hegemony. The need to concoct a legitimizing scientific narrative that disavows all impacts of GMOs on nature and health, that upholds the oversimplified claim that non-GM foods are equivalent to GMOs, that defines the latter simply as new varieties, is equivalent to the silences on the complexity of the genome and the consequences of interfering in it.

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Especially in his book *Not in Our Genes* (2009), Lewontin has denounced the theoretical shortcomings of genetic reductionism.

According to the notion of "genomic fluidity," genes are no longer ontologically defined, but are part of a relational complexity that defies classical hierarchical linearity, replacing it with a complex functional network. Among other examples of complexity are the controlled changes during DNA development (amplification or reduction) in normal embryo cell through the regulation of the cell environment, trans-generational epigenetic inheritance, or the modulation regulatory processes (cytoplasmic and/or nuclear) of the products of transcription, which sustain the variability of phenotypes. These are examples of *genomic fluidity*, whereby genes are subordinated to cell signals to sculpt each phenotype (Fox Keller, 2013).

In short, industrial agriculture and the introduction of GM crops have not only filled the environment with agritoxins and transformed the global food production into a merchandise in the interest of transnational corporations but also created the artifice of a science to legitimate the procedures used for genome modification, disregarding their uncertainties and risks.

This genetic colonialism purposefully ignores current genetic knowledge in order to justify genome manipulation, defying the integrity of ecosystems and putting human beings at risk. Transgenesis as an industrial procedure applied in nature is not very scientific and quite rudimentary.

"State of the art" technologies to generate GMOs not only collide with peasant and ancient knowledge but also conflict with the most advanced scientific views of biological complexity. This conceptual frailty calls for scientific support of transgenesis, displacing it from the realm of science to that of profit-seeking speculation.

2. More than an agricultural technology, GM crops are an instrument of corporate control over agriculture

Never in the history of agriculture and food has there been such a large concentration of seeds—the key to the entire food web—in the hands of such a small number of corporations. The six largest manufacturers of agrochemicals in the world control 76% of the global agritoxin market. The same six corporations are among the largest seed companies in the world and control 60% of that market. And these six corporations control 100% of the global GM seed market (ETC Group, 2013a and 2013b).

Since practically the same corporations control the development of GM crops and the trade of agritoxins and seeds—both GM and not—they prioritize the promotion of GM crops for two reasons:

a) since they are resistant to certain herbicides, they guarantee the sale of seeds and farm inputs;
b) since they are a product of engineering, seeds are patented, which means that it is illegal for farmers to store a part of their own harvest for the next sowing season, thus guaranteeing new sales for those companies every season, and even additional profits from suing farmers whose plots are "contaminated" by

patented transgenes. Hundreds of lawsuits have been filed against farmers in the United States, and this is the road for all countries that adopt them (Center for Food Safety, 2013).

In order to ensure complete control over farmers, agribusiness corporations also developed a technology that acts as a “biological patent”: Genetic Use Restriction Technology (GURT), commonly known as “Terminator” technologies. With this method they develop *suicide* seeds—they can be planted, they can yield seeds, but they become sterile once they are harvested, forcing farmers to purchase new seeds for each sowing. This technology was internationally condemned as immoral and there is a UN moratorium against it, but as a result of corporate pressure it could become legal in Brazil in the next few months (Convention on Biological Diversity, 2000; ETC Group, 2014).

Because of all this, allowing GMOs in a country is equivalent to relinquishing sovereignty and decisionmaking on a crucial aspect of survival such as food, and putting it in the hands of a few transnational corporations. It violates the rights of farmers to replant their own seeds, a right even recognized by the FAO, as a legacy of the 10,000 years of agriculture with which they have contributed to the sustenance of all of humanity.

3. The reality: they produce less

There are several research studies on the productivity of GM crops (from the Universities of Kansas, Nebraska, and Wisconsin, among others) that demonstrate that, on average, GM crops produce less per hectare than hybrid crops.

The broadest and most detailed study on the productivity of GM crops until now was coordinated by Dr. Doug Gurian-Sherman, from the Union of Concerned Scientists in the United States, and is entitled “Failure to Yield.” In it, 20 years of experimentation and 13 years of commercialization of GM maize and soy in the United States are analyzed, using official figures from that country (Gurian-Sherman, 2009).

The study shows that GM crops played a marginal role in increasing agricultural production in the United States, while conventional hybrids or organic crops contributed significantly to increasing agricultural performance in the country as a whole.

In the case of soy, GMOs lowered net production per hectare (a fact that is repeated everywhere else), while herbicide-tolerant maize resulted in neither an increase nor a decrease, and pesticide-tolerant maize (resistant to the Bt toxin) resulted in a slight annual increase of 0.2 to 0.3%, which gives a total of 3 to 4% in the 13 years analyzed. This increase was observed in areas with very frequent onsets of the plague for which they are manipulated, which practically does not exist in the countries of the South.

The most significant fact is that the total increase in the productivity of maize per hectare in the United States in those years was 13%. In other words, 75 to 80% of the increase was due to non-GM varieties and production methods. In short: **if no GM crops had been planted in the United States, the total production of maize would have been greater**.

4. They use much more, increasingly dangerous agritoxins

GM crops have resulted in an unprecedented use of agritoxins (increasingly toxic herbicides and pesticides). This translates into extremely serious environmental and public health problems. In the three main GM crop producing countries (the United States, Brazil, and Argentina), which together produce almost 80% of the global harvest, there are already clear and worrisome evidences to that effect.

A scientific report published in 2012 (Benbrook) analyzes the use of agritoxins in the United States in the production of GM soy, maize, and cotton from 1996 to 2011, and it demonstrates that GM varieties increased the use of agritoxins by more than 183 million kilograms in those eighteen years. The United States is the largest and oldest producer of GM crops, which means that the data on their performance in that country is globally significant. The report specifies that, while crops with the Bt toxin may have reduced the use of pesticides by 56 million kg, herbicide-tolerant crops increased the use of agritoxins by 239 million kg, which explains the total average increase of 183 million kg of agritoxins in 16 years.

The study demonstrates that the decrease in the use of herbicides with Bt crops—which has been widely publicized by the biotechnology industry to argue that GM crops reduce the use of agritoxins—has been declining every year, because the resistance generated during plagues requires ever-increasing amounts of pesticides. On the other hand, the industry is removing from the market the seeds that only contain the Bt gene. The new generation of GM seeds contains a combination of the Bt toxin and genes tolerant to one or more herbicides, thus prioritizing an intensive use of those agritoxins. In the case of Bt maize, the magnitude of the increase of ever-more toxic herbicides "invalidates any modest, punctual decrease in the use of agritoxins that may have occurred in the 16 years analyzed" (Benbrook, 2012).

On the other hand, because of the intensive use of herbicides there are dozens of weeds that are resistant to agritoxins, which has led companies to genetically manipulate crops to make them tolerant to increasingly stronger herbicides, such as 2,4-D (one of the components of Agent Orange, used as a biological weapon during the Vietnam War), ammonium glyphosate, dicamba, and others. This new generation of herbicides is much more toxic and has a much greater carcinogenic potential. Farmers in the United States have expressly stated their opposition because fumigating with them causes neighboring crops to wither. Charles Benbrook argues that, if crops resistant to 2,4-D are approved, the use of this potent agritoxin will increase by 50% (Union for Concerned Scientists, 2013).

In Brazil, after GM crops started being planted in 2003, the use of agritoxins increased by more than 200% and continues to do so at an annual rate of approximately 15%. Brazil became the largest consumer of agritoxins in the world since 2008, using more than 850 million liters per year, which is equivalent to 20% of the world's production. The average rate of consumption of agritoxins in Brazil is 5.2 kg of active ingredient per hectare, which, together with Argentina, is one of the highest in the world (Menten, 2008).

In studies conducted in Mato Grosso, the Brazilian state with the greatest production of industrial agriculture and GM soy, serious health and environmental harms from the use of agritoxins have been recorded, not only in rural areas but also in urban contexts. In 2006, in the municipality of Lucas do Rio Verde, Mato Grosso, toxic rain was observed in the urban region due to fumigations with Paraquat in the area by plantation owners seeking to dry the soy for harvest. The wind spread the toxic cloud, drying thousands of decorative plants and gardens, 180 medicinal plant beds, and all the orchards in 65 small farms around the city, which has a population of 37,000 inhabitants (Pignati, Dores, Moreira et al., 2013). Afterwards, studies conducted between 2007 and 2010 in the same municipality discovered contamination with several agritoxins in 83% of all wells supplying drinking water (city and schools), in 56% of water samples in school patios, and in 25% of air samples taken in a 2-year period. High percentages of residues of one or more agritoxins were also found in human breast milk, urine, and blood (Pignati, Dores, Moreira et al., 2013).

In Argentina, 23 out of 33 million cultivated hectares are planted with GM crops, which has resulted in an exponential increase in the use of agritoxins, especially glyphosate. 250 million liters of glyphosate are used per year, out of a total of 600 million liters of agrochemicals on a surface populated by 11 million inhabitants, which is equivalent to 6 liters of glyphosate and 10 liters of agrochemicals per inhabitant. In 2012 new versions of soy and maize seeds were approved, which include several "stacked" genetic modifications; i.e. they combine the expression of the Bt insecticidal toxin with resistance to glyphosate and glufosinate herbicides (the latter, as a competitive inhibitor of glutamine, has been shown to produce malformations in laboratory animals). This will allow producers to fumigate these crops with both agrochemicals simultaneously in the near future, which will increase the contamination level and the risks to environmental and human health.

5. They pose serious risks to agrobiodiversity and the environment

Superweeds.
The existence of at least 24 invasive weeds resistant to glyphosate and other agritoxins has been documented, as a direct result of the massive increase in the use of poisons that goes hand in hand with GM crops. In a study published in December 2013, the United States' Union of Concerned Scientists indicates that there are resistant weeds in 50% of the country's farms and, in the southern states, where the problem is greater, there is one or more glyphosate-resistant weed in 92% of all establishments (Union of Concerned Scientists, 2013). Similar situations are found in Argentina, Brazil, and India, where invasive, resistant weeds are an increasingly serious problem, both because of the number of species and their geographic dispersion.

Contamination of native and *criolla* seeds.
Erosion and potentially irreversible alterations of natural and agricultural biodiversity is a serious global problem, gravely worsened by GM crops (Alvarez Buylla, Piñeyro Nelson, 2009). Biodiversity and local and peasant knowhow are the keys to the variety and diversity of adaptations to climate change. With GM contamination, this diversity is at risk, both because of the consequences to plants and because it leaves peasants either with damaged seeds containing patented recombinant sequences (transgenes) or without access to their own seeds.

It is important to emphasize that GMOs are not "just another option," as could be said of hybrid crops. Once GM crops are planted in the fields, contamination of other non-GM crops is inevitable, as is the accumulation of the recombinant sequences in the genomes of the varieties, whether they are hybrids, natives, or *criollas*; whether it results from pollination through winds and insects or from the handling, transportation, and storage of grains and seeds.

In addition to affecting biodiversity, GMO contamination has led to lawsuits for "inappropriate use" of the patented genes promoted by agribusiness corporations. Although the commercial planting of GM crops is only allowed in 27 countries and 98% of them are in only 10 countries, 396 cases of GM crop contamination have been discovered in over 50 nations (GeneWatch, 2013).

Contamination of *criolla* seeds entails a new risk for them—GMOs contain genes of species that would never interbreed naturally with the crops. There are scientific studies (Kato, 2004) that indicate that the accumulation of transgenes can have serious negative effects, including deformities or sterilization of native or *criolla* varieties when they reject the genetic material unknown to the species.

This has serious economic, social, and cultural impacts on peasants and indigenous peoples, who developed all of the seeds available today and who continue to preserve them. Especially worrisome is GM contamination at the centers of origin and diversity of the crops, such as maize in Mesoamerica and rice in Asia.

In Mexico, which is the center of origin for maize, the issue is GM contamination of the genetic and biodiversity reservoir of one of the three most important grains in the diet of the entire planet, which means that consequences are not only local, but global as well. The same would apply in the case of Asia if GM rice were to be approved there (ETC Group, 2012).

In Mexico, GM contamination of maize was detected before it was approved for experimental planting. Given the imminence of its commercial release, the Union of Scientists Committed to Society (UCSS-Mexico) drafted a report on the multiple risks to biodiversity, diet, health, and food sovereignty posed by the release of GM maize. Based on that report, the UCSS delivered a request to the president of that country not to allow that crop's commercial release. The report and the request had the support of over 3,000 scientists in Mexico and the world (UCSS, 2012). In 2013, the UCSS and several universities in the country published an extensive compilation of the problems related to the release of GM maize in Mexico, with the participation of 50 scientists who specialize in the topic (Álvarez-Buylla and Piñeyro-Nelson, 2013).

In addition to a large number of scientists, the vast majority of Mexico's population, including its 60 indigenous groups, peasant and family farming organizations, consumer organizations, unions, intellectuals, artists, and many other social, cultural and educational movements and organizations oppose the release of GM crops in their centers of origin, a position shared by the Mexican state's technical bodies that are co-responsible for policies regarding biodiversity.

Water and soil pollution.

The massive use of agritoxins, as well as the adjuvants and surfactants added to them, has resulted in a fast and intensive pollution of waters and soils, even far away from the sites of cultivation. The problem of agrochemical pollution already existed because of the industrial agricultural model, but since GM crops are manipulated to resist agritoxins and the latter are therefore used in much greater volumes, the problem has reached devastating proportions, with very serious impacts on health.

In Lucas de Rio Verde, Mato Grosso, Brazil, residues of various types of agritoxins were found in 83% of drinking water wells and in two lagoons, as well as in the blood of toads in those places. The congenital malformations in those animals are four times more prevalent than those found in a control lagoon. In addition, agritoxins were found in 100% of samples of breast milk of women who were breastfeeding at that moment. Agritoxin residues (glyphosate, pyrethroids, and organochlorines) were found in the urine and blood of 88% of the teachers sampled in schools of that municipality (Pignati, Dores, Moreira et al., 2013).

6. Health Risks

Companies claim that "there is no evidence that GM crops pose a health risk." They are misusing an inverted form of logic since, in order to commercialize food products, the producers must demonstrate that they are healthy, and not that no evidence has yet been found to the contrary. In the case of GM crops, demonstrating that they are harmless is impossible. Because of that, in order to avoid lawsuits, corporations apply this inverted logic to their impacts on human health, and every time a scientific study demonstrates potential risks, they fiercely attack it. The most evident and probably most obvious impact of GM crops on health is related to the unprecedented increase in the use of agritoxins. The poisons required by GM crops are added to the agrochemicals that already existed in industrial agriculture, but in exponentially greater volumes, concentration of active components, and residues in foodstuffs.

Contrary to the industry's claims, there are increasing evidences of negative impacts on health. The American Academy of Environmental Medicine made its position on GM crops public in 2009, calling for authorities, "for the health and safety of consumers," to urgently establish a "moratorium on GM food [and the] implementation of immediate long-term independent safety testing" (American Academy of Environmental Medicine, 2009).

An important conclusion on which they base their position is that, based on dozens of scientific papers analyzed, "there is more than a *casual* association between GM foods and adverse health effects." They explain that, according to Bradford Hill's criteria, which are broadly recognized by scholars as a means to evaluate epidemiological and laboratory studies of agents that may pose risks to human health, "there is *causation* in the strength of association, consistency, specificity, biological gradient, and biological plausibility" between the consumption of GM foods and adverse health impacts.

Among the adverse effects, demonstrated by a number of studies with animals, they mention "serious risks" such as infertility, immune dysregulation, accelerated aging, dysregulation of genes associated with cholesterol synthesis and insulin regulation, changes in the liver, kidney, spleen and gastrointestinal system. Among others, they cite a 2008 study with mice fed with Monsanto's Bt GM maize, which associates the consumption of GM maize to infertility and weight loss, in addition to alterations in the expression of 400 genes (American Academy of Environmental Medicine, 2009).

This coincides with another independent scientific article review conducted by the researchers Artemis Dona and Ioannis S. Arvanitoyannis from the Universities of Athens and Thessaly, Greece, which demonstrates that GM crops are associated with toxic, liver, pancreas, kidney, and reproductive effects, hematological and immunological alterations, as well as possible carcinogenic effects (2009).

Health effects of GM crops with the Bt toxin

The use of the Bt toxin in GM crops is very different from the use of the whole bacteria for pest control in various agro-productive systems, since in GMOs the Bt toxin is present during the plant's entire cycle and even remains in the soil up to 240 days after harvest (Saxena, Flores, and Stotzky, 2002). It forces exposure to the toxin in unparalleled doses and periods. There are studies and documented cases of allergies to the Bt toxin in humans, and proof that feeding Bt GM maize to rats and pigs results in swollen stomachs and intestines as well as to tissue, blood, liver, and kidney damage (Schubert, 2013).

Health impacts of agritoxin-resistant GM crops

Eighty-five percent of GM crops are manipulated to make them resistant to one or more herbicides, either alone or in combination with pesticide genes. This has led to an unprecedented increase in the use and concentration of agritoxins, which has multiplied hundreds of times the level of residues in foods. Evidence of this is that is that, in order to authorize GM soy, several governments had to change their regulations to allow up to 200 times more glyphosate residues in foods (Bøhn and Cuhra, 2014).

Contamination of water sources with agritoxins and residues in foods were already a health problem in intensive rural production areas, but it has now become dramatic due to the increase in the use of herbicides to manage GM crops, and has expanded to urban areas.

In 2013, positive contamination with one or more agrochemicals was found in blood tests performed on groups of urban volunteers from Mar del Plata, Argentina. In Europe, where the consumption of GM soy is high due to processed foods and animals fed with GM fodder, traces of glyphosate were found in the urine of 45% of the citizens sampled in 18 cities in 2013 (Friends of the Earth Europe, 2013).

Malformations and cancer from glyphosate in GM crops

Scientific experiments with animals and studies published in peer-reviewed journals demonstrate that glyphosate, the most widely used herbicide with GM crops, has teratogenic effects, i.e. it can produce congenital deformities (Carrasco, Paganelli, Gnazzo et al., 2010; Antoniou, Brack, Carrasco et al., 2010; Benachour and Séralini, 2009).

In 2009 a simple experiment with animal models (birds and amphibians) in Argentina demonstrated that dilutions of RoundUp (the most widely used commercial formula of glyphosate) or the introduction in the embryo of an equivalent to 1/200,000 of the glyphosate present in commercial formulas produced effects on gene expression during embryonic development, capable of inducing malformations during its early stages (Carrasco, Paganelli, Gnazzo, et al., 2010).

We know that glyphosate inhibits the production of aromatic amino acids in plants, causing them to die. In animals, glyphosate inhibits enzymes of the cytochrome P450 group (CYP), which play a crucial role in the operation of detoxification mechanisms for xenobiotic (synthetic) substances, by acting on the residues of toxins incorporated in the organism. In this context, glyphosate would inhibit forms of P450 associated to the degradation and distribution of retinoic acid in the embryo, thus explaining its teratogenic effect: the increment in retinoic acid can alter the normal development of tissues when its synthesis or degradation is altered in the embryo.

Experimentally induced malformations are the closest evidence of what is observed in the field and they should motivate health authorities to strictly apply the precautionary principle in order to safeguard human and animal health; however, this principle is systematically avoided. In Chaco, Argentina, a 400% increase in malformations has been reported (Carrasco, 2010). In Santa Fe, malformations, abortions, and low weight have doubled in the last 10 years, and a similar percentage has been observed in areas of Mato Grosso, Brazil.

Another chronic illness related to glyphosate is cancer. The close relationship between glyphosate and cancer results from the fact that glyphosate can block the DNA repair enzyme system in cells, which induces the accumulation of damages to the genetic material. This can be observed with high-sensibility tests that detect the level of damage. Genotoxicity testing in animals demonstrates that, in the populations of individuals exposed, the values are several times greater than those of individuals in the control group that is not exposed (López, Aiassa, Benítez-Leite et al., 2012).

These evidences of damage to the genome through exposure to agritoxins, in particular to glyphosate, are a warning of possible chronic effects and the doorway to oncological illness. In both Brazil and Argentina a very significant increase in congenital malformations and cancer has been reported in the states or provinces with the greatest production of GM crops.

Parts of the province of Santa Fe, Argentina, show an increase in cancer rates that is double the national average of 206 cases per 100,000 inhabitants. In Chaco, Argentina, several localities in agricultural zones show an increase of 30 to 40% of malformations and cancer in comparison to cattle raising localities (Report presented to the Ministry of Health).

More recently, Samsel and Teneff (2013b) demonstrated the relationship between the increase in the use of glyphosate and many metabolic illnesses as a result of P450 inhibition and imbalances in the physiological detoxification processes carried out by these enzymes. This demonstrates that glyphosate's interference with CYP enzymes acts synergistically with the disruption of the biosynthesis of aromatic amino acids by the gut flora together with the hindrance of serum sulfate transport. As a result, these processes have an influence on a wide variety of illnesses: gastrointestinal diseases and obesity, diabetes, heart illnesses, depression, autism, and cancer, among others.

In their last publication, both researchers associate the increase in celiac disease to the use of glyphosate, and establish that this is due the inhibition of CYP enzymes, which results in an increase in retinoic acid, one of the elements responsible for intolerance to gluten. This reinforces the mechanism proposed for the induction of malformations (Samsel and Seneff, 2013a).

Political decisions that promote a production model that combines the direct planting of GM seeds with its entire technological package, which includes intensive use of herbicides, are equivalent to approving a large-scale experiment out in the open with an enormous impact on human health, for the benefit of the economic interests of transnational agribusiness corporations.

Censorship and persecution of those who demonstrate worrisome impacts of GM crops on human health

A recent case of censorship that received much publicity had to do with Dr. Gilles-Eric Séralini's research at CRIIGEN, of the University of Caen, France. Séralini conducted studies of laboratory rats fed with GM maize over their entire lifecycle, which can be compared to human consumption for many years. His results showed that 60 to 70% of the rats fed with GM maize by Monsanto developed tumors, compared to 20 to 30% in the control group, in addition to liver and kidney problems and premature death.

The study is so relevant that the biotechnology industry immediately launched a campaign to discredit it. Partisan scientists argued, among other things, that the study was conducted without enough rats and that the rats used in the experiment had a propensity to develop tumors. However, Séralini used the same rats and in greater numbers than Monsanto used in the tests it presented to the European Union for approval of the same type of GM maize. Monsanto's experiment lasted only three months, and the negative effects in Séralini's tests only developed after the fourth month. Under pressure from the industry, the scientific journal where the article was published retracted it. Although the editor admitted that Séralini's article is serious and "not incorrect," he stated that its results "are inconclusive," which is part of the process of scientific debate and applies to a large number of scientific articles. Séralini and his studies received the support of hundreds of scientists around the world (Bardocz, Clark, Ewen S. et al., 2012), and the original article was later published by another scientific journal.

Séralini's case study should be taken seriously. It demonstrates that the consumption of food derived from GMOs can have very severe negative effects and that many, more extensive studies should be conducted before releasing them into the market. The GM industry's position and that of the scientists who support them is that, despite doubts regarding their risks, GM crops should be released to the market, placing consumers in the role of laboratory rats, even though there are many alternatives to produce the same crops, even industrially, without GMOs[3] (Séralini, 2012).

3

All articles, responses, and controversies regarding this case can be found at www.gmoseralini.org

7. Are there any advantages to genetically modified crops?

The truth – not the promises made by the biotechnology industry – is that after almost 20 years on the market, more than 99% of the GMOs planted in the world are still limited to four crops (soy, corn, canola, and cotton); all of them are *commodities*, i.e. industrial goods for export; all of them are managed by large corporations, from the seeds to commercialization; and all of them are used as fodder for confined animals, for agrofuels, or for other industrial uses.

Ninety-eight percent of GM crops are planted in just 10 countries—169 countries do not allow their commercial planting. GM crops cultivated today only have two genetically designed characteristics: resistance to one or more agritoxins (85%) or self-produced pesticide with strains of the Bt toxin (International Service for the Acquisition of Agri-biotech Applications, 2013).

All other types of GMOs play more of a role as propaganda and are not really consolidated. For example, drought-resistant crops or those genetically modified to improve their nutritional qualities, such as the so-called “golden rice,” which would presumably provide vitamin A, are not on the market, above all because they do not work.

In both cases, they do not work because of what we described in section 1 regarding the rudimentary state of GM technology. Both drought resistance and vitamin production are multi-factor characteristics that do not depend on a single gene or the genome itself. Given the complexity involved and the limitations of the reductionist outlook of those who promote GMOs, these projects have failed and will continue to fail. Sadly, however, that does not mean that they will not be released to the market if their promoters are allowed to do it, despite their risks and the meager and harmful results obtained.

The drought resistance found in non-GM crops is the result of long-term environmental and local adaptations obtained by peasants, which can be promoted without GMOs or large research costs. Since it involves a multiplicity of factors, trying to reduce it to genetic manipulation is a costly and unsafe enterprise which in the best-case scenario would only work in some regions and not in the great diversity of locations and bio-geo-climactic situations where poor peasants and most small-scale farmers work.

The research projects endeavored by transnational corporations together with some international research institutes are precisely based on the appropriation of peasant knowledge, since those companies use and patent genes of plants that have been domesticated and adapted by peasants. They transform those crops, which were adapted, accessible, and of collective use, into the product of very costly technological processes, in spite of which their results are extremely minor and their eventual application is unsafe and quite limited (Union of Concerned Scientists, 2012).

If the aim is to ensure the ability of crops to adapt to droughts, it certainly cannot be done centrally for the entire planet. Rather, we should favor diversified peasant processes and collaboration with national public research centers, without introducing the risks associated to GMOs.

The myth of golden rice

The crops with presumed nutritional benefits added through genetic modification, such as "golden rice" or rice with provitamin A, have the same drawbacks. They involve a problem-ridden, costly research effort, financed through public and private investments. They entail all the GMO risks already discussed, as well as others resulting from the type of manipulation performed, which is different from the ones already on the market.

The first type of rice with beta-carotene (GR1), announced in the year 2000 and developed by Ingo Potrykus and Peter Beyer from the Swiss Institute of Technology, was an accident. The researchers were looking for a different result with genetic engineering on rice, but "much to their surprise," as they themselves stated, a precursor of beta-carotene was produced. This in itself should have been a warning to those researchers that their work did not account for many variables in a complex process. On the contrary, they publicized it as if it was a great achievement, even though in order to obtain the minimum daily amount of vitamin A required by children, a child would need to eat several pounds of that rice every day. Later, those researchers licensed their research to the multinational Syngenta, which in turn donated the license in 2004 to the *Golden Rice Humanitarian Board*, which was incorporated into the Syngenta Foundation; however, the company retained commercial rights. In 2005, Syngenta announced a new GM product called golden rice (Paine, Shipton, Chaggar, S. et al., 2005), which would contain greater amounts of provitamin A (GR2). However, the provitamin has not been shown to be stable in this case either, since once it is harvested and goes through the normal storage process, it oxidizes easily, reducing the declared content of provitamin A to 10%.

After 20 years and many millions of dollars invested in this research, according to the International Rice Research Institute, "golden rice" is still nowhere near being commercialized. This is due to the difficulties involved in that trying to create an entirely new biochemical route by means of genetic engineering (IRRI, 2013). In effect, golden rice does not involve a genetic engineering operation like those already in existence; rather, it entails manipulating a metabolic step, which implies complexities, uncertainties, and risks beyond those already known for other GMOs. There is no guarantee that the genetic constructs are stable or that the synthetic metabolic step will not behave differently when it grows in the plant or affect other metabolic pathways with unpredictable consequences for plants, the environment, and consumers. In fact, this has already happened in laboratory experiments (Greenpeace, 2013). In addition, the beta-carotene content could increase or diminish while promoting other precursors simultaneously, with potentially serious consequences for human health. There is scientific evidence that the process from beta-carotene to vitamin A can also generate components that are harmful to human health if they occur in large quantities (Schubert, 2008). This type of secondary components can block cell signals that are important for organisms (Ergolu, Hruszkewycz, Dela Sena et al., 2012). The metabolic results of this type of genetic engineering are little understood. As if that were not enough, the way in which this type of beta-carotene from golden rice would be processed by the human body and what secondary components it might produce, contrary to what happens with natural beta-carotene, are completely unknown.

In short, in addition to the problems already demonstrated with common GMOs (Bt pesticide crops and glyphosate-resistant crops), there are serious potential health problems related to the control of levels of retinoic acid and other retinoids in the process. Beta-carotene is transformed into retinal in the presence of the oxygenase enzyme, but is reduced to retinol, better known as vitamin A. However, retinal also oxidizes, forming retinoic acid, which in large quantities becomes a powerful teratogen (Hansen, 2014).

Rice is an essential component of everyday diet in Asia and a large part of humanity, and therefore these risks are very serious and unnecessary. In addition, the intention is to introduce it precisely at its center of origin. If that were to be done, it would inevitably lead to GM contamination of peasant rice, which would affect native seeds, farmer rights, and the health of the peasants who would consume it. Even though rice is not open-pollinated, there are many avenues for contamination during storage, handling, and transportation. Studies in China have already found GM contamination of wild rice and its relatives (Canadian Biotechnology Action Network, 2014).

The GM golden rice project has consumed over 100 million dollars from institutions and "philanthropy," among them the Bill & Melinda Gates Foundation and several national and international development aid institutions. With this money, vitamin A deficiency could have been addressed in a sustainable manner and without high technology in many of the countries where it exists.

For example, vitamin A is present in various plants that accompany the crops, which are commonly consumed by peasants who cultivate rice. When rice is produced uniformly on industrial farms using agrochemicals, this type of plant, which contains many more nutrients than a single vitamin, disappears. In other words, the supposed "solution" creates new problems. The same applies to GM maize planted in Mesoamerica. The necessary dosage of vitamin A can also be obtained by diversifying crops and planting different fruits and vegetables whose cultivation is adequate for each location, which can be done by peasants without becoming dependent, whether on the market or on public programs that change according to changes in government policies. However, inducing dependence is perhaps one of the goals of transnational corporations with this project, since their aim as business enterprises is not charity.

Amaranth, spinach, cabbage, and many other vegetables that are common in Asian cuisine have at least more than five times the amount of beta-carotene that golden rice would contain in a normal serving (Shiva, 2014).

Are state-produced GM crops better?

The Empresa Brasileira de Pesquisa Agropecuária (Embrapa), a Brazilian agricultural research institution, genetically manipulated a common bean to make it resistant to the golden mosaic virus, an illness that can become a plague in that species. This event, called Embrapa 5.1, is an emblematic case because, although it is patented, it is a product of public research and up to now it has not been licensed to transnational corporations. However, its approval by that country's biosecurity commission (CNTBio) was not very "public," since significant parts of the research and information on the gene construct were labeled "confidential," so that neither independent researchers nor some biosecurity reviewers had access to all the information (Agapito and Nodari, 2011).

This GM bean entails the same uncertainties regarding potential impacts of genetic engineering described in section 1. But, like "golden rice," it adds new risk factors, since it was developed with a technology that has not been applied for large-scale use in any country in the world.

The technology used in the Embrapa 5.1 bean, called small interfering RNA (siRNA), causes a direct reaction to the pathogenic virus. The plant produces a molecule that silences or interferes with the production of a molecule in the pathogenic virus and keeps it from replicating itself in the plant cells. But this siRNA molecule can also affect the expression of other genes in various organisms, since its mechanism for action is still not well understood.

There is scientific evidence that points to possible risks associated to this type of technology. In 2006 a literature review on the use of this technology in GM plants was published in the scientific journal *Genes and Development*. It describes how RNA agents can move around plant tissues, and therefore their action not only affects the cell where they are produced, but can also give rise to other reactions (Vaucheret, 2006).

There is proof that these molecules can affect other non-target molecules, with unexpected and potentially negative results (Agapito and Nodari, 2011). Later studies, including those conducted by researchers from the Environmental Protection Agency (EPA), the official United States agency, confirm this hypothesis (Lundgren and Duan, 2013).

Once again, beans are a basic component of Brazilian diet. Small-scale farmers are responsible for more than two thirds of production. Instead of offering high technology, which poses new risks to the environment and to health and whose effectiveness is not even proven, peasants and family farmers should be supported to strengthen their own agroecological strategies, which are adequate for a diversity of situations, in order to confront the golden mosaic plague and other problems.

8. Are there winners and losers with genetically modified crops?

There is no doubt that those who benefit the most with genetically modified crops are the six transnational corporations that control 100% of GM seeds worldwide: Monsanto, Syngenta, DuPont, Dow Agrosciences, Bayer, and Basf. They are the six largest chemical producers and together they control 76% of the world's agritoxin market and 60% of the world's seed market. In addition, they hold sway over 75% of all private research on crops. Never before in the history of food had there been such a corporate hold on a sector that is essential for survival. This also explains why GMOs imply an immense increase in the use of agritoxins, since this is the most lucrative part of the business: the agritoxin market is much larger than the seed market.

The biotechnology industry claims that GM crops are the "most studied" crops in history. That is false, because in the countries where they have been authorized, such authorizations are based on studies and conclusions *by those same companies*. In Europe, where additional studies are required, practically no GM crops are planted, and several European countries have gone as far as prohibiting their cultivation.

The truth is that GM crops are plagued with uncertainties and health and environmental risks and do not contribute any advantage over already existing crops. Seeds are much more expensive, they produce less on average, they use much more agritoxins, and, since they are patented, GM contamination becomes a crime for its victims. In addition, according to data from the industry's analysts, research and development of a GM seed costs an average of 136 million dollars, while the development of a hybrid seed costs one million dollars (Phillips McDougall, 2011).

The only reason to commercialize GM crops is that companies obtain more profits even though they are more faulty products than the hybrids already in existence. They are products that, in the diversity of terrains, climates, and geographies of the vast majority of small-scale producers in the world, do not even work.

Considering these facts, people often ask themselves: how did the industry get away with this? It has been a many-sided process. On one hand, in the last three decades large transnational corporations have been buying national and regional seed and agribusiness companies in order to control the market. Simultaneously, they convinced governments that genetic engineering meant a great progress for agriculture and food production, but that, because of its costs and risks, they could only develop it and evaluate it within the industry itself, and they therefore needed their support, to the detriment of independent risk analysis and other public agricultural research alternatives. Public agricultural research has been progressively dismantled. And, to help the industry "feed the world," governments have adopted national and international intellectual property laws for seeds and biosecurity that ensure the wellbeing of oligopolistic cartels (ETC Group, 2008).

If producers in the United States and Canada continue planting GM crops, it is because they have no option. The same agribusiness corporations control the entire seed market and only reproduce those they want to sell, which means that when it is time to sow, only GM seeds are available. A similar situation occurs in industrial markets in Brazil, India, and Argentina (those five countries account for 90% of the world's GM market), with added particularities, such as smaller royalty payments because farmers reproduce their own seeds (against the companies' will), or other resources that have nothing to do with the "advantages" of GM crops, but with the market's economic power and transnational corporations' control over governments.

Those who lose with GM crops are most of the peoples on the planet, from peasants and small-scale farmers to urban consumers, as well as public researchers and all of us who have to suffer the chemical contamination of foods, water, and soils.

Around the world, surveys confirm that the vast majority of consumers do not want to eat GM foods. Corporations know it, and because of that they oppose labeling their products and spend millions of dollars to avoid it. If GM crops are not harmful, as they claim, there should be no problem with labeling.

The vast majority of peasants and family farmers oppose GM crops because they pose yet another threat to their precarious economic situation, displacing their markets and contaminating seeds, land, and water. As we stated in the introduction to this document, it is small food suppliers (peasants, artisanal fisheries, urban orchards, etc.) who feed more than 70% of the world's population. The GM industry displaces them and threatens their seeds and forms of production in many ways, and by doing so, it increases hunger and malnutrition much more than any "miraculous" technological seed could ever offset.

There are many alternative agricultural systems that are diverse and more in accordance with nature, that do not create dependence on transnational corporations, that favor the poor in the countryside and the cities, that increase work opportunities and local markets and agribusinesses, that pose no threats to health and the environment, and that are much more economical and ethical.

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