Slow Food®

Slow Food Position Paper on Genetically Modified Organisms

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This position paper has been written out of a need to clarify Slow Food's view of genetically modified organisms and to provide as comprehensive a picture as possible of the problems linked to the use of these crops. In general, our analysis focuses on genetically modified organisms as part of a global agricultural, economic and political system that is increasingly depriving farmers of their own means of production and subsistence, while at the same time concentrating control over food in the hands of multinationals.

Firstly, we look at the socio-economic consequences of genetically modified crops and the fact that they are a negation of the principle of food sovereignty. Subsequently we present their environmental consequences, starting with the impoverishment of animal and plant biodiversity, then explore the uncertainties around their effects on human and animal health. Lastly, we briefly examine issues linked to research and regulation.

Slow Food's position and proposals have developed out of a constant and on-going dialog with international academics and experts in a range of different fields. However, they are also the result of our daily work in rural communities around the world promoting good, clean and fair food, food whose quality is determined by attention towards sensory aspects, by respect for the environment and labor and by the cultural diversities and traditions of its producers. For this reason, we believe it useful to point the reader towards our other position papers, which together provide a clearer view of our overall vision:

Position Paper on Agroecology
(http://www.slowfood.com/sloweurope/wp-content/uploads/ING_agroecologia-1.pdf)

Position Paper on Biodiversity
(http://www.slowfood.com/sloweurope/wp-content/uploads/ENG-bio-paper.pdf)

Position Paper on Seeds
(http://www.slowfood.com/sloweurope/wp-content/uploads/ING_position_paper_semi.pdf)

Position Paper on Soil
(http://www.slowfood.com/sloweurope/wp-content/uploads/ING_suolo-2.pdf)

Introduction

In the 1970s there were over 7,000 companies producing seeds. Since then, through a long wave of mergers and acquisitions, the number of companies in the sector has gradually fallen (Howard, 2009), and today the seed market is concentrated in the hands of a very small number of companies[1] (ETC Group, 2011). According to a study commissioned by the Greens/EFA Group, 75% of the corn seed market in the European Union is controlled by the top five companies in the sector (Pioneer, KWS, Bayer-Monsanto, Vilmorin, Syngenta), with even higher numbers for sugar beet seeds (86%) and vegetable seeds overall (95%) (Mammana, 2014). Over time, the seeds produced and sold by seed companies, which serve an industrialized agriculture model, have replaced those that in the past were saved and reproduced by farmers, improving their yield, flavor, nutrition, ability to adapt to climatic conditions in harmony with the distinctive nature and resources of the local environment. Commercial seeds largely respond to the criteria of novelty through the characteristics of Distinctness, Uniformity and Stability (DUS) required by different forms of industrial registration, which were introduced based on the International Convention for the Protection of New Varieties of Plants (UPOV, 1961). Because of the natural variability that characterizes them, farmers' seeds cannot meet the UPOV requirements needed for official registration. This variability is the basis of agricultural biodiversity and reinforces the role of farmers as the only guardians of the food sovereignty represented by traditional varieties.

The same companies that control both hybrid and genetically modified seeds are also the leading producers of chemical inputs such as herbicides, pesticides and in many cases fertilizers, creating a direct dependence between plant material and chemicals. This suggests an unbreakable link between those seed producers and those who produce synthetic chemicals for combating weeds, pests and fungal diseases. In 2011, for example, Monsanto–which until its recent acquisition by Bayer was the largest seed company in the world and the world's fourth-largest producer of pesticides–controlled more than a quarter (27%) of seeds on the global market (ETC Group, 2011). As well as the glyphosate-based weedkiller Roundup®, the company also produces transgenic Roundup® Ready seeds, which are genetically modified to be glyphosate-resistant and so may be sprayed indiscriminately without damaging the crop (though not without avoiding the accumulation of herbicide residue in the plants which are then consumed by animals and humans).

Against this general backdrop, genetically modified organisms are the extreme point of an agricultural, economic and political system that is increasingly concentrating power in the hands of a few, not only benefitting corporations but also harming rural communities and consumers as well as the environment and biodiversity. For that reason, our campaign in defense of a food system free of GMOs is an integral part of a wider strategy on seed and food policy.

Starting in the 1960s, developments in legislation have enabled the establishment of "food monopolies". With waves of mergers and acquisitions, the concentration of power in the food industry has been increasingly dramatic in the United States, Europe, and through ever-more influential multilateral trade agreements, the rest of the world. Along the whole food production chain and in all the different sectors, no area has been immune from this trend. From the 1980s onwards, multinationals have taken the opportunity to patent living organisms, including seeds, subjecting the agricultural world to the laws that govern industrial production and turning a vital public good into an industrially-controlled commodity.
The progressive imposition of industrialized agriculture, with its need for uniformity and homogenization and focus on the concept of "yield", has entailed a reduction in the number of cultivated species and varieties, gravely eroding vegetable biodiversity. This perhaps unnoticed but momentous change was then fully realized, first with the introduction of hybrid seeds, and then with transgenic technology.

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1 In September 2016, the pharmaceutical giant Bayer closed down Monsanto's operations by buying the leading US seed company for $57 billion and thus forming a new global agribusiness company. According to a 2011 study by the ETC Group, the top three seed companies (Monsanto, Pioneer Dupont and Syngenta) held 53% of the global market, while the top ten held 74%.

The first transgenic plants were developed in 1983[2] but were released on the market in the 1990s, when the United States Food and Drug Administration authorized their release by applying the principle of substantial equivalence, whereby a genetically modified product is treated as equivalent to its conventional counterpart obtained by means of traditional crosses.

However, GMOs are not the same as varieties selected via traditional methods, which are based on cross-breeding and selection within the same plant species or at the very least on natural biological compatibility (i.e. crossbreeding wherein offspring are also capable of sexual reproduction). All individuals of any given species have the same genes, which perform the same functions, though they are present in different variants and combinations in individual specimens. Two different species, on the other hand, contain different genes with different functions. What's more, genes are aligned along chromosomes and are in the same position in individuals of the same species. When a gene from an unrelated species is inserted (for example, a bacterial gene added to a plant), we cannot know, from scientific deduction, how many copies of the DNA fragment will be inserted into the host, whether it will break or deactivate a single gene or whole zone of the host DNA, whether or not the added gene will be changed by the plant, whether or not the product of the gene will agree with the metabolism of the host, how long the effect obtained will last and so on. While the expression of certain traits can be verified before a plant is put on the market–e.g. herbicide resistance–other factors remain unknown, particularly in terms of potential consequences in the cultivation environment and for the consumer. These are products that we eat, yet we do not know if the repositioning of genes will have a long-term impact on human health. The results of operations of this kind are therefore extremely unpredictable, and always in some way different from what was expected (Buiatti, 2011). Worse, the effects might only become apparent after many years.

What is a GMO?

The World Health Organization defines genetically modified organisms as "organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally." According to European legislation, GMOs are "organisms and microorganisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination." Genetic engineering consists of manipulating the genetic material (genome) of an organism in the laboratory by inserting or removing one or more new pieces of DNA or altering one or more basic letters of the genetic code. This operation reprograms the cells of the genetically modified organism, enabling or disabling the expression of proteins or altering the structure and function of existing proteins. Genetic modification intentionally gives the organism new properties or traits that it does not naturally have, or at least did not have before.

In addition to the element of unpredictability, applicable to every complex system and therefore also to every living organism, it should also be emphasized that although genetic engineering technology was initially innovative, in the years since its arrival, the processing technology has remained practically unchanged (Buiatti M., 2011).

1. GMOs do not feed the world, and instead negate food sovereignty and distort the role of farmers

Ever since they first appeared, GMOs have been presented as crops that will increase food production and feed the world's ever-growing population. However, so far they have not shown that they can provide any actual solutions to problem of hunger. **Their development and their production, in fact, satisfy the economic interests of multinationals rather than the need to feed an expanding population**. So far, at a commercial level, they have proven to be water- and energy-intensive, and not affordable or convenient as food-supply crops in developing countries.

2 This was the year in which Chaleff unveiled a tobacco plant that incorporated Bacillus thuringiensis genes, making the plant insect-resistant. The first product brought to market was the Flavr Savr tomato in 1994, which contained a gene that prevented it from rotting. It was withdrawn from the market as it was a commercial failure. In 1996, the marketing of plants that were insect-resistant and/or could withstand herbicides, both as a result of bacterial genes, was approved.

What's more, not only do GMOs not resolve the problem of hunger, but they make it worse, thanks to the control wielded by multinationals over seeds and the gradual abandonment of local seeds by rural communities, as well as the loss of rural communities. This results in a reduction in agrobiodiversity and its economic, social and cultural value.

According to the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) the number of hectares of GM crop cultivation increased from 1.7 million to 179.7 million from 1996 to 2015. There was a year-on-year fall for the first time in 2015, with 1.8 million fewer hectares than the previous year (Clive, 2015). ISAAA figures (2015) also show that in terms of GMO production, the United States is in first place, with 70.9 million hectares cultivated; followed by Brazil with 44.2 million, Argentina with 24.5 million, India with 11.6 million, Canada with 11 million, and China with 3.6 million (Clive, 2015).

Four GMO crop species are currently widely available on the market: soya, maize, cotton and canola. Grown in 28 countries around the world, they are designed to develop only two characteristics, either together or separately: herbicide and pest resistance. No other traits, such as tolerance of arid conditions or the ability to grow in particularly nutrient-poor soils (two conditions common in poor, famine-prone countries) have been successfully developed so far, despite being frequently mentioned in the media. Of these four GMOs, **the two most common worldwide are soya and corn** (Bøhn et al., 2013). **They are used mostly for animal feed** (90% in the case of soya), **followed by agrofuels, in the case of corn** (Fagan et al., 2014). In smaller quantities, both raw materials are used as ingredients in a wide range of mass-produced and often highly processed foods. A negligible percentage is consumed in its natural form (corn kernels or meal and soy beans, oil or sprouts). Other genetically modified crops have been grown in the United States, such as potatoes, pumpkins, sugar beet, papaya and alfalfa, as well as eggplant, which has also been grown in Bangladesh (ISAAA, 2015).

According to supporters of the agroindustrial model, the planet's food security depends on increasing the amount of arable land and boosting yields per hectare by means of irrigation, more intensive use of fertilizers and the development and propagation of selected plant hybrids, improved animal species and genetically modified organisms. As a result, production is increasingly concentrated on large-scale industrial farms, further marginalizing small-scale farmers.

Hunger, however, is caused by poverty and a lack of access to healthy, nutritious food among wide swathes of the world's population, not by a lack of food or the fact that not enough is produced (Holt-Giménez et al., 2012). To better understand this, you need only look at FAO figures, according to which **enough food to feed over 12 billion people is currently being produced, much more than would be needed to feed the global population**. Nonetheless, in 2015, 792.5 million people out of the world population of 7 billion were still malnourished (www.fao.org/faostat/en). These figures help highlight how the **solution** does not lie in increasing the amount of arable land or yields per hectare, but in **a completely different system in terms of food production, storage, distribution and access.** Increasing production and consuming more energy, land and water only fuels market principles that have no place in the dynamics of the supply of means of subsistence.

The real causes of hunger and malnutrition are complex (WFP, 2016) and include factors such as poverty, difficulty in accessing food and increasingly in accessing land in which to grow it (Ziegler, 2002; Holt-Giménez and Patel, 2009), food waste,[3] market instability, climate change and even conflicts that systematically damage agriculture and food production. It is clear that GMOs are not the solution to the problem, but rather describe a further manifestation of it.

3 Every year, over 1.3 billion tons of edible food are wasted, equivalent to a third of all the food produced globally. If just a quarter of all the food that is thrown away was saved, it would be enough to feed over 800 million people (FAO, 2011).

The Case of Transgenic Soya and Corn

The most widespread GMO in the world is Roundup®-resistant soya (Bøhn et al., 2013), followed by insect-resistant corn (known as Bt because it is engineered with genetic sequences from the bacterium *Bacillus thuringiensis*).

GM soya is widespread predominantly in Latin American countries, some of which are among the leading producers of GM crops. Soya is one of the most important agricultural raw materials in the world, and one of the most profitable at a commercial level. Around 313 million tons were produced in the 2015/2016 season (USDA, 2015), of which 93% came from just six countries: the United States (106 million tons), Brazil (97 million) Argentina (61 million), China (12 million), India (9 million) and Paraguay (7 million).

Before the 1970s, soya cultivation was negligible in Latin America. However, between 1976 and 2010, the amount of soya grown in Argentina, Brazil, Paraguay and Uruguay combined rose from 1.58 million tons over 1.37 million hectares to 130 million tons over 45 million hectares (Valdemar, 2016). In Brazil, the world's second-biggest producer of GM soya, the surface area planted with transgenic soya reached 33.3 million hectares in 2015; in Argentina, on the other hand, in the same year the surface area covered by GM soya plantations was 19.3 million hectares (USDA, 2015). This increase in production has had a heavy influence on the loss of natural ecosystems. Over the course of recent decades, vast areas of forest, grassland and savannah have been converted for agricultural use.

Transgenic soya is exported and used in the production of animal feed. This plant–alien to local food culture–has in a few decades completely transformed the fabric of agriculture, reducing the diversity of agricultural activities, marginalizing more traditional crops such as potatoes, corn, wheat and millet and leading to an extreme concentration of land ownership and production businesses with a resulting loss of farmers' sovereignty. In Brazil, for example, between 1975 and 2006 the number of soya producers fell from 487,000 to 217,000, even though during the same period the cultivated surface area grew by 216% and production increased by 430%. In Paraguay, the number of producers with more than a thousand hectares grew by 487% between 1991 and 2008 (Valdemar, 2016).

Another product that has seen incredible market success in the last 20 years is genetically modified corn. Corn (or, rather, the few varieties patented by seed companies, whether obtained through conventional hybridization or transgenesis) has overtaken other agricultural products, because it grows quickly, produces high yields and is versatile. It can be turned into flour, animal feed, an ingredient in thousands of mass-produced products, ethanol (used as fuel) and the raw material for the production of biogas or biodegradable materials.

Supported and prioritized by agricultural policies (particularly in the United States and Europe from the 1970s onwards), corn has become the most important agricultural product in the world. In the last 50 years, global production has risen by 374%. With 345 million tons, the United States is the world's largest producer of corn, well ahead of the second (China, 224 million tons) and third (Brazil, 67 million tons) largest. North America is also the top exporting country, followed by Argentina and Brazil (USDA, 2015).

Globally, the share of hectares planted with genetically modified corn out of the total hectares cultivated with corn is 32%. In the United States, GM corn represents 90% of the total, while the figure is 98% in Canada, 86% in South Africa, 82% in Brazil and 80% in Argentina.

Most of the corn produced globally is used for animal feed (in Europe, some 80% of the crop goes to livestock). The second most common use is for producing ethanol. The remainder is processed by the food industry, as well as the plastics and pharmaceutical industries. Corn is found as an ingredient in the majority of industrially-produced packaged foods: cookies, cakes, puddings, ice cream, spreads, peanut butter, chips, ketchup, hot dogs, ready meals, candies, nutritional bars, chewing gum, mayonnaise, jams, sauces, cake mixes, cereal flakes, muesli, preserved fruit, flavored yogurts, margarine, baby food and more. Corn is used to thicken, bind, sweeten and leaven, to improve the acidity of sauces and to make bread more golden in color. But it is hard to trace because the words

"corn" and "maize" rarely appear on the label. Corn derivates tend to have names unrelated to the raw material: glucose, glucose syrup, ascorbic acid, citric acid, malt, maltodextrin, dextrin, crystalline fructose, modified starch, sorbitol, lecithin, baking powder, dextrose, lysine, lactic acid, maltose, sucrose, caramel, xantham gum, invert sugar, monoglycerides, monosodium glutamate. And, in the last 30 years, the number-one source of sugar in the world has become fructose syrup. The cheapest, and therefore most common, version, High-Fructose Corn Syrup (HFCS), is made from corn starch. The majority of sodas, for example, are sweetened with fructose syrup made from corn. The percentage of corn eaten in the form of whole or ground kernels, without having undergone chemical separation processes, is negligible: less than 1% (Pollan, 2008).
The rise of corn is simultaneously the cause and consequence of the industrialization of farming. Corn has become the main ingredient in the diet of animals that would rarely eat it normally, such as cattle, or would never eat it in the wild, such as farmed salmon.

In addition to not having kept their initial promise of helping to feed the planet (so far), GMOs have **rapidly distorted the role of farmers in economic, social and cultural terms**. The history of seeds dates back a very long time, from when, around 10,000 years ago, nomadic humans settled down and started to practice agriculture. Since then, rural communities around the world have always used and shared their own knowledge and what they learned from experience to select, preserve, multiply and reproduce seeds, improving their yield, flavor, nutritional value and other qualities, in harmony with the specific features and resources of their land.

The work of farmers has always been rooted in complex traditional knowledge, passed down and perfected from generation to generation. Within communities, based on cooperation and reciprocity, as well as on the ability to recover and preserve seeds from fruit, farmers were and still are accustomed to exchanging seeds, thus continuously helping to preserve biodiversity.

In addition, seeds are both the cornerstone of food sovereignty and a guarantee of food security. The right of farmers to freely select, produce, preserve, exchange, share or sell their seeds should be recognized. But the genetic diversity of crops and their natural variability are also vital to tackling unpredictable environmental and climate change, in order to ensure greater production stability and to protect the natural environment.

Food Sovereignty and Rural Communities in Latin America

The term "**food sovereignty**" was ratified in 1996 at the FAO's World Food Summit in Rome, and is defined as "the right of peoples, communities, and countries to define their own agricultural, labor, fishing, food and land policies which are ecologically, socially, economically and culturally appropriate to their unique circumstances. It includes the true right to food and to produce food, which means that all people have the right to safe, nutritious and culturally appropriate food and to food-producing resources and the ability to sustain themselves and their societies." This phrasing was revised in 2007 in the Nyéléni Declaration, made following a forum on food sovereignty: "Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems." According to international agreements, food sovereignty is a right and the system of traditional knowledge is a set of values, but they are not protected by adequate legislation. Similarly, Olivier De Schutter, in his 2014 report, emphasized how democracy in food systems would imply the possibility for communities to choose their own food systems and how to reshape them, showing how food sovereignty is a condition for the full realization of the right to food (De Schutter, 2014). But in much of the world rural communities are suffering injustices that violate their right to produce their own food and to select their own seeds. In 2008, the World Bank and four United Nations agencies concluded a four-year study on the future of agriculture carried out by over 400 scientists and experts from 80 countries and approved by 61 governments (but not the United States, Canada or Australia). The report, *International Assessment of Agricultural Knowledge, Science and Technology for Development* (IAASTD), underlines how the factors that limit production, fair distribution and environmental sustainability are primarily social in nature, not technological. It also points out that many agroecological practices proven to increase production sustainably are already common throughout the global south, but are unable to make a leap in quality because they lack support at the commercial, political and institutional level. The IAASTD recommends improving conditions for sustainable agriculture rather than focusing only on technological developments. Among other things, it shows how the patents linked to GMOs can undermine the practice of seed preservation and food security in developing countries (IAASTD, 2009).

GM agriculture represents the intensification of an agricultural, economic and political system that is increasingly depriving farmers of their means of production and livelihoods. At the same time, it is concentrating control over food in the hands of multinationals. With GM seeds, in fact, multinationals own seeds. Every time a farmer wants to sow again, they must buy the seeds from multinationals. Attempts to obtain varietal improvements taking GM seeds as a starting point often lead to complex legal disputes with the holders of the patent for the original variety, and the applicable laws vary widely around the world. The GMOs currently on the market are hardly ever sterile; they can be the result of hybridization and–as is the case also with hybrid seeds–they must be repurchased every year because successive generations gradually lose the improved characteristics. Even when they are not hybrids, however, farmers prefer to buy them again every year because their reproduction in a successive generation produces less satisfactory results due to the possible gradual degeneration of the genetic characteristics.

With GMOs, we are heading along the path of an **increasingly intensive agriculture with a widespread monocultural approach, in which species that often have no historic, cultural or gastronomic link with a place and the people who live there represent a growing threat to the survival of traditional seeds and even the rural communities themselves.**

Moreover, GMOs have undermine and obfuscate conscious consumption. In Europe, for example, legislation specifies that products that contain GMOs in a proportion equal to or greater than 0.9% (considered the allowable level of accidental contamination) must be labeled as containing GMOs. But this labeling obligation does not apply to animal products–meat, eggs milk and other dairy products–obtained from animals raised on transgenic feed. According to some estimates (Tecco, 2013), 30% of European animal feed consists of GMOs, which indirectly enters our food chain. Despite this, no special labeling is required for products of animal origin.

Elsewhere in the world, consumers do not even have this level of protection or choice. In the United States, for example, where GMOs are regularly sold for human consumption and are by now common ingredients in everyday food, there is still no national legislation to govern the labeling of products containing GMOs or produced from GMOs (Center for Food Safety, 2014). This is despite the fact that 92% of US citizens would like to see compulsory labeling for transgenic foodstuffs (Consumer Reports National Research Center, 2014). Evidently it is the lobbies that influence government policy and restrict consumer choice, albeit through public voting. This leads to serious questions about the compatibility of the GMO-based agricultural production model with democratic principles.

2. GMOs offer no environmental benefits

Supporters of genetically modified organisms often claim that they are beneficial for the environment and for farmers, as they guarantee higher production yields from the same land while simultaneously reducing chemical inputs such as pesticides and herbicides, and more generally the impact on the environment.[4]

4 Monsanto, for example, when speaking of its commitment to sustainable agriculture, defines its objectives as producing more, conserving more and improving lives. The second objective is worded as follows: "We've strengthened our goal of double crop yields by committing to doing it with one-third fewer resources such as land, water, and energy per unit produced. We're continuing to develop better seeds and improved on-farm practices that enable farmers to better manage weeds, pests, and environmental stresses." http://monsanto.info/1RmgDmF

These claims, however, are proved baseless when we look at the GMOs marketed on a wide scale, which are modified, as mentioned before, for only two characteristics, either separately or together: resistance to herbicides and resistance to pests.

There are, in fact, many documented environmental risks and harms related to GMO cultivation:

- *Transgenic crops impoverish biodiversity in wild and domestic animals and plants.* GMOs are the tip of the iceberg and the last gasp of an agroindustrial model that is one of the main causes of biodiversity loss. GMOs are grown as monocultures across large areas and are part of intensive farming systems that impoverish agricultural biodiversity by replacing the cultivation of traditional varieties (Modonesi and Oldani, 2011). In this respect, the transgenic cultivation systems developed so far pale in comparison with other farming systems–such as small-scale organic farming (Migliorini, 2015) and agroecology–which preserve and increase biodiversity and soil fertility; evidence even exists that they are more damaging than conventional cultivation in this respect (Burke, 2005).
  According to the FAO, 75% of the agricultural crops that existed at the start of the 20th century have by now been lost forever. Since 1930, Mexico has lost 80% of its corn varieties. In the United States, the loss of biodiversity for many crops is close to 95%.
  In Argentina's Quebrada de Humahuaca valley alone, around 70 different local potato varieties were being cultivated in the 1960s. Today the global market is based on four hybrid varieties, and GM potatoes with a higher starch content have recently been developed, ideal for industrial food demands (FAO, 2009).

- *Since GMOs were introduced into fields, the use of herbicides has not fallen but actually risen, as demonstrated by the spike in sales of the herbicide Roundup.* As discussed above, one of the two characteristics obtained to date through genetic modification is resistance to Roundup, a weedkiller that contains the active ingredient glyphosate. This substance, also used in many other chemical weed-control products, has contaminated surface water and groundwater (Scribner et al., 2007; Greenpeace, 2011), and has also been found in crops in fields adjacent to those in which it is used. This substance has a serious impact on wild biodiversity and on soil biology, and it also poses a high risk to the health of those who use it (De María et al., 1996; Di Cagno et al., 2011; Greenpeace, 2011). Despite this, the use of glyphosate is steadily increasing, in step with the increase in GM crops, particularly in the case of soya (Benbrook, 2012). In US fields, its use has risen from almost 2 million kilos in 2000 to over 10 million in 2005 and over 25 million in 2010 (Beyond Pesticides, 2016; USDA, 2010). These figures can only increase, given that when herbicides are used, invasive species tend naturally to develop forms of resistance, requiring the use of even greater quantities of chemical products and the constant introduction into the environment of new molecules, created as needed.

- *The Bt toxin expressed by some GM plants has not led to a significant reduction in insecticides in agriculture. Moreover, it harms useful insects while pests quickly develop forms of resistance to the toxin.* Bt technology does not offer significant environmental benefits and does not lead to the elimination of insecticides in agriculture, just to insecticides being used in different ways. In fact, instead of being sprayed on to plants, with Bt technology insecticides are developed by the plant itself, independently of need, with serious consequences for the environment. For example, in a study carried out by the University of New York, it was shown that the roots of Bt corn were able to release the Bt toxin into the soil, where it remained active and was protected against microbial degradation (because it was absorbed by clay particles) for between 180 and 234 days, suggesting possible long-term effects on non-target organisms and the selection of target insects resistant to the toxin (Saxena et al., 2009 and 2002). Furthermore, the Bt toxins expressed by GM crops kill not only harmful insects, but also useful pollinating insects, such as bees, butterflies and moths (Hilbeck et al.; 1998; Ramirez-Romero et al., 2008; Han et al., 2010; Aqoob et al., 2016). Not least, pests can develop resistance to the Bt toxin (Tabashnik, 2008; Carrière et al., 2016) with which plants have been modified to a greater extent than when insecticides are sprayed according to an agronomically rational calendar. GM plants that contain

Bacillus thuringensis genes are always toxic to insects, while the conventional plant is only toxic for a limited time after spraying. This means that the GM plant is constantly "working" on the selection of mutations of plant-attacking insects, which then develop resistance over generations.

- *According to supporters of GMOs, herbicide-resistant transgenic crops prevent soil erosion because they mean the land does not need to be plowed.* Deep plowing, which is done mechanically in intensive farming, is one of the causes of erosion and thus the loss of soil fertility. This is because it significantly alters the structure of the soil, upsetting the balance of microorganisms. In GMO-planted fields, mechanical plowing is avoided by applying herbicides that perform the same function of removing wild plants. Agriculture of this kind is unsustainable from an environmental point of view, as it involves the intensive use of chemical inputs, generating high levels of greenhouse gas emissions and making it one of the leading causes of climate change (Intergovernmental Panel on Climate Change, 2001). In fact, according to the FAO, agriculture, forestry and animal farming are responsible for between 22% and 25% of greenhouse gas emissions. There is also a direct relationship between the indiscriminate use of glyphosate-based weedkillers and alterations in the behavior of the microbial biomass which, though based on the soil type, are much more significant the greater the amount of herbicide applied (Nguyen et al., 2016).

- *Coexistence of GM crops with other types of crops is impossible.* The use of GMOs leads to the genetic pollution (gene flow) of natural varieties (Migliorini, 2008) and those traditionally grown by small-scale farmers due to pollen being carried by the wind or by pollinating insects to other crop varieties or to wild relatives (Pollack, 2004). This pollution then effects the reproduction of traditional seed varieties in the years following. Multinationals do not patent only GMOs, but also their descendants: If a genetically modified plant fertilizes a (normal) plant in a neighboring field, the neighbor faces the risk of a lawsuit for infringement (in 2012, Monsanto took more than 450 farmers to court: 142 lawsuits, 70 of which won the multinational $23 million). Patents thus become a dual source of income, through sales and through lawsuits (Bové and Luneau, 2016).

- *GMOs are less effective than traditional crops in dealing with climate change*. The promise that GMOs will provide a solution to climate change has still not been fulfilled. On the contrary, judging by the high use of chemical inputs and the resulting greenhouse gas emissions, the opposite appears to be true. Once again, non-GM crops seem to be potentially more effective than transgenic crops in dealing with this emergency. For example, the fact that India has over 2,000 indigenous rice varieties with different characteristics has led to better adaptation of production, allowing the crops to resist climate fluctuations and develop forms of resistance against pests and disease (Commodity Online, 2007). It is the same story for all species and varieties that are in harmony with their cultivation environment, and in this environment they evolve genetically year after year, strengthening and adapting. On the contrary, a genetically modified rice seed is the same everywhere in the world, at any temperature, climate, soil type and altitude, and is the same year after year, unless the matrix is modified. Cultivating biodiversity and improving it continuously is a much more effective way to adapt to climate change. Ultimately with GM seeds we lose the actions of humans who from each harvest select the plants, fruits, spikes, etc. from which to take the seeds for the following year. In this way they bring about a continuous adaptation of the species to constantly evolving environmental and climate pressures.

What emerges is not only that GMOs do not offer significant improvements over the industrial agrifood model, but that they also exacerbate specific aspects: the increasing use of oil derivatives, particularly herbicides; intensive production, based on monocultures and a small range of plant species and varieties and so on. By pursuing the objectives of maximizing yields and reaching international markets, the priorities of transgenic agriculture do not include protecting the environment, which should be one of the central principles of any agricultural system.

Agriculture must not and cannot ignore the impact it has and the challenges that the future will bring. There is an urgent need for good practices that can simultaneously **remedy**, tackling the causes of climate change, reducing the impact of agriculture on the climate and reducing carbon dioxide and nitrogen oxide emissions; **mitigate**, reducing the impact of climate change on agriculture and making farmers less vulnerable in social, economic and environmental terms; and **adapt**, improving farmers' ability to react to climate change by favoring local management practices in favor of biodiversity and protection of ecosystems (Holt-Giménez and Patel, 2009).

To date, GMOs have not shown that they are able to meet these needs.

3. Questions regarding human and animal health

Although repeated reassurances are given that GMOs are safe for human and animal health, in reality the situation is controversial. No rigorous clinical studies and independent long-term research have so far been published to prove they are actually safe. The consumption of GMOs continues to raise doubts and concerns. These have not been allayed by risk assessment methodologies and criteria for evaluating the health safety of GMOs, which have proven to be inadequate and about whose scientific validity many doubts exist.

Given this problematic scenario, there are two possible responses to the issue of assessing and consequently regulating GMOs. In the United States, the principle of **substantial equivalence** is applied, which was formulated by the Organization for Economic Co-operation and Development (OECD) in 1991 and revised in 1996 by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). This principle should make it possible to determine whether GM food is comparable, in terms of characteristics and structural composition–i.e. the percentage of proteins, fat, vitamins and carbohydrates–to the equivalent conventional product. Substantial equivalence per se, however, is not a criterion for evaluating the health safety of foodstuffs, and has been repeatedly criticized as being pseudo-scientific (Pusztai et al., 2003; Robin, 2008).

Meanwhile, in the European Union, the **principle of comparative safety assessment** has applied since 2003. This principle was formulated by the European Food Safety Authority (EFSA) and touted as a single criterion for evaluating the environmental risks involved in transgenic crops, as well as the risks arising from food and animal feed containing GMOs and the reliability of peer-reviewed studies on the comparative safety of GM crops, food and feed. As has been shown, however, the main problem with the comparative safety assessment principle is that it is often considered an assessment of safety in itself, rather than the first in a series of compulsory steps in the assessment process (Fagan et al., 2014; Friends of the Earth Europe, 2016).

On the one hand, legitimate doubts linger over the safety of GMOs for human and animal health. In particular, doubts are linked to the fact that the expression of new proteins by the gene subject to genetic manipulation may cause allergic reactions, alter metabolic cascades with the formation of toxic intermediates or damage the host DNA at the insertion site or other segments of the genome (Bizzarri, 2011). In addition, some GMOs carry antibiotic-resistant genes and could therefore contribute to the spread of antibiotic resistance (Bizzarri, 2011).

On the other hand, as well as insisting that GMOs are safe, multinationals never fail to list their health benefits and properties. The most famous case is probably that of Golden Rice, whose ability to compensate for vitamin A deficiency, which is widespread among people living in developing countries, has long been much vaunted. In reality, this new variety has still not been brought to market due to glaring defects–the beta-carotene content of the first variety of Golden Rice developed in the early 2000s was so low that it would have been necessary to eat eight kilos of rice a day to meet vitamin A requirements (Ye et al., 2000) –as well as the fact that the required toxicological tests have still not been carried out.

It must be also be underlined that the studies which lauded Golden Rice, though numerous, were all carried out by a small number of research groups, casting doubt on their scientific validity and on the impartiality of the researchers.
Until now, this solution has therefore proven to be ineffective and costly (Wessler and Zilberman, 2016), whereas in order to achieve the goal it might be much more useful to start projects to educate and raise awareness among the local population, encouraging them to grow, buy and eat foods that are naturally rich in beta-carotene, such as carrots, certain fruits (Enserink, 2008) and mustard, which is an extremely important part of the local diet in some countries.

On top of this, there is the fact that, despite repeated promises from manufacturers, GMOs are not "clean" crops and do not involve the use of smaller quantities of pesticides and herbicides, nor do they have reduced water and fertilizer needs. For example, if we consider the case of glyphosate, the opposite is true: Knowing that the crop will survive, it is easier for farmers to overuse the weedkiller. When evaluating the health consequences of GMOs, it is therefore necessary to also consider the consequences of food being contaminated by chemicals. Last year, a wide-ranging discussion was started on glyphosate with two opposing positions (Portier et al., 2016): that of the International Agency for Research on Cancer (IARC), which classified it as a probable carcinogen (IARC, 2015), and that of the EFSA, which conversely updated the toxicological profile of the substance, declaring that "glyphosate is unlikely to pose a carcinogenic hazard to humans" (EFSA, 2015). In 2016 Slow Food, along with a number of other European NGOs, called for the glyphosate's usage authorization not to be renewed by the European Union, given that it poses a threat to the environment and human health. However, in late June 2016 the European Commission provisionally extended the authorization for use of the herbicide while proposing a series of restrictions on its use, such as prohibiting the use of POE-tallowamine as a co-formulant in all glyphosate-based herbicides including Monsanto's Roundup, strengthening controls on the ban of the use of glyphosate as a drying agent to aid the harvesting of grains and restricting the use of the substance in public areas like parks and playgrounds. The Commission's definitive opinion is expected in late 2017.

Not least, the potential harm to the health of those who work in fields, and can easily come into contact with the undiluted product, should be taken into account. Glyphosate-related problems have been widely documented by research and investigations by journalists published in recent years (International Society of Doctors for Environment).

4. Research: Between deception and gray literature

One myth, which is absolutely deceptive, is still being promoted in the media. It claims that the scientific community is in favor of GMOs, while those who oppose GMOs are blinded by anti-modern and anti-scientific ideologies (Monastra, 2011). But this opposition between "favorable experts" and "incompetent opponents" is totally false and arises from the need to delegitimize and discredit the arguments of the critics of transgenic agriculture (Monastra, 2011). The conclusions of the research itself are not unequivocal, as they are generally presented. Within the scientific community there are many who are opposed to GMOs, and studies have been published that question the environmental sustainability of these crops, their safety for human and animal health and their ability to address world hunger. Secondly, dismissing as obscurantist the position of those in civil society, including the public and farmers, who are opposed to GMOs, is tantamount to claiming that choices that impact everyone should be made solely by scientists or multinationals, effectively excluding from the debate a large number of interested parties, some of whom are directly involved in agricultural production in the field. This claim derives from an unacceptable confusion. While it is the responsibility of science, using the scientific method, to make progress in research and confirm hypotheses, it is democracy's responsibility to take the decisions that concern fundamental freedoms, including the freedom to eat the foods one wants and avoid unwanted foods.

From the point of view of research, we should point out how the general framework in which we are operating is anything but clear and transparent. The impossibility of accessing data held by GMO manufacturers is a major problem, both for the regulatory process and in order to establish the validity and, consequently, the reliability of studies based on this data. Often, when a given GMO is approved, data relating to the safety of the product goes unpublished. Instead, they should be made available so that independent scientists and public researchers can scrutinize them.

Unpublished studies fall in the category of "gray literature" and are unreliable, as they are not subject to the quality control process traditionally used in the scientific community, specifically peer-reviewed publication. Although not yet perfect and subject to criticism, this still remains the best method to establish the reliability and authority of a study.

5. Legislation

Cultivation of GMOs is currently authorized in 28 countries.[5] With 73.1 million hectares cultivated in 2014, the United States is the world's biggest producer. As we have shown above, although many draft laws have been tabled in individual states, and although the population has declared itself to be largely in favor of labeling foods containing GMOs or made from GMOs, there is currently no national legislation to regulate labeling.

Unlike the United States, in Brazil it is compulsory to inform consumers about the presence of GMOs in products for human consumption or used for animal feed. A black T in a yellow triangle indicates that the product in question contains GMOs.

In the European Union, the decision about whether or not to grow GMOs is left to individual member states. At present, GM crops can be grown in only five EU countries[6] and the only GM crop grown is Monsanto MON810 corn. GMOs can be sold in all 28 EU countries, but not for direct human consumption. Hence why GM soya-based feed can be sold, feed which, according to some estimates, is already part of the diet of 30% of the animals reared in Europe. Legislation on labeling specifies that foodstuffs that contain GMOs in a proportion equal to or greater than 0.9% (the level allowed for accidental contamination) should be labeled as containing GMOs.

GMOs and International Agreements

This situation, which is already complex, may be complicated further, for example by transcontinental trade agreements such as the **Transatlantic Trade and Investment Partnership (TTIP)** and the **Comprehensive Economic and Trade Agreement (CETA)**, which aim to remove non-tariff barriers. This essentially means standardizing production standards between the two trade partners, namely Europe and the United States (TTIP) and Europe and Canada (CETA). At the heart of the negotiations lies the food and agriculture sector, or, rather, the need to "harmonize" and water down European legislation, which is much stricter on issues such as food safety, consumer rights and workers' rights than American and Canadian regulations. If TTIP and the CETA are ratified, the European Union will gradually replace safety standards—including those concerning food, consumer product safety and environmental protection—with weaker standards that are better suited to the requirements of the American and Canadian markets.

The United States was the first to authorize—through the US Food and Drug Administration—the cultivation and marketing of transgenic products, applying the aforementioned principle of substantial equivalence. Up to now, all GMOs on sale have been examined by the FDA, but there is no legal obligation for GMOs to undergo this examination.

5 GMO-producing countries, in decreasing order of importance: USA, Brazil, Argentina, India, Canada, China, Paraguay, Pakistan, South Africa, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Myanmar, Mexico, Spain, Colombia, Sudan, Honduras, Chile, Portugal, Cuba, Czech Republic, Romania, Slovakia, Costa Rica, Bangladesh.
6 Spain is in first place with 0.1 million hectares cultivated in 2014, followed by Portugal, the Czech Republic, Romania and Slovakia.

The European Union applies the comparative safety assessment principle, formulated by the European Food Safety Authority (EFSA) and incorporated in 2013 by the European Commission in its regulation on GMO foodstuffs and feed. However, some believe that this assessment principle should be only the first in a series of compulsory steps in the assessment process and not the only test which the GMO in question undergoes (Fagan et al., 2014).

New techniques in genetic modification

A further complication regards the regulation of products obtained through cisgenesis and gene editing. Cisgenesis involves inserting one or more genes from plants belonging to the same species or a similar species into a given genome, making them interfertile (Delwaide et al., 2015). Gene editing (or genome editing) allows the direct modification of genetic material at specific points in the genome through the breaking and successive natural reconstitution of the DNA in such a way that certain mutations arise (Altpeter et al., 2016). Recent technological developments such as CRISPR-Cas9 gene editing make the identification and modification of precise points in the genome cheaper and faster than ever.

These techniques can be more accurate than traditional genetic engineering, making it possible in practice to achieve in a few years similar results to what used to take decades of traditional genetic improvement carried out through a long process of selection in the laboratory and in the field. For this reason, they are considered to be of particular interest for tree species; classic crossing programs generally take a very long time to create a new tree variety. A recent example is that of the cisgenic apple with resistance to apple scab disease (caused by the fungus *Venturia inequalis*). Many years ago, classic genetic improvement had allowed the apple-scab-resistant gene found in *Malus floribunda* (a decorative species) to be exploited, and the first resistant cultivar was obtained through a series of crosses and recrosses (Hou et al., 2014) that took more than 20 years.

Cisgenesis allows objectives to be reached in just five or six years, transferring the process from the field to the laboratory and adopting the same technologies as transgenesis. But in order for these techniques to be truly effective and reliable, it is necessary to have a detailed knowledge of the genome of the species being improved, because it is necessary to know precisely where to intervene so that the modifications correspond to the objectives. Additionally, just as happens with the varieties resulting from classic genetic improvement, it is still not possible to be sure that the effects of DNA manipulation, in whatever way it is brought about, will be stable over time. There is also the serious risk that the availability of such precise technology will end up triggering processes of genetic transformation without any objective limit, carried out by less-conscientious researchers indifferent to any concept of environmental suitability and the link between product and place.

In the same way, gene-editing techniques cause targeted modifications of the DNA without being able to predict the possible repercussions on the stability of the mutation obtained and on interactions with the expression of other traits. Unwanted and unpredictable effects cannot be excluded, with possible implications for foods, animal feed and the environment. The risk of biodiversity loss that derives from the application of these techniques is, in our view, the same, and the socioeconomic problems also remain unchanged. For this reason, we believe it is vital to address the issue with the same precautionary approach as transgenesis, not least because some laboratory techniques are identical. If products obtained through the use of these technologies were excluded from European GMO legislation, any obligation to detect involuntarily introduced modifications would disappear, along with the traceability and labeling obligations for these products, even though they involve direct modification of the genome (Greenpeace, 2016).

In Europe, a request has been made to exclude these new techniques from the legislation governing GMOs, but, to date, the European Commission has not presented its own proposal on new breeding techniques. This exclusion would do away with the traceability and labeling obligations for these new products which, as they include a direct modification of the genome, must still be considered GMOs. It would also reduce freedom of choice for European consumers who, for the most part, want to avoid food produced from GM plants, and erode their right to be informed about what they are eating.

6. What Slow Food wants

Slow Food has always promoted and defended agriculture that protects agrobiodiversity and the work of small-scale farmers. For the reasons set out above, GMOs are a threat both to the survival of biodiversity and to the food sovereignty of rural communities. Here we clarify our positions, dividing them into three specific areas: agricultural systems, research and legislation.

Food and agriculture systems

Modern food and agriculture systems are called upon to tackle multiple interconnected challenges: to **guarantee access for all to good, clean and fair food**, and to a healthy and appropriate diet; to **contribute to economic growth** and the resulting elimination of poverty; to **preserve biodiversity and natural resources**; to **tackle climate change**; and to **restore the central role of agriculture** (and farmers) in the food system itself.

The industrial farming system based on monocultures–and particularly the system based on GM monocultures–does not tackle any of these challenges and instead contributes to a general worsening of the situation, as we have shown in sections 1, 2 and 3 above by analyzing the social and economic consequences, as well as the environmental consequences, of GM crops.

While there are many alternatives to industrial agriculture and agriculture based on genetically modified crops, **Slow Food believes the most effective model is the agroecological model. Compared with other models of sustainable agriculture, it:**

- is based on local plant varieties and animal breeds and draws on their ability to adapt to changes in environmental conditions.
- reduces the use of synthetic chemicals and other technologies that have a negative impact on the environment, on biodiversity and on human health.
- uses resources effectively to reduce dependence on external inputs.
- values traditional technical skills, promotes participatory and cohesive systems through the creation of farmers' networks and encourages sharing innovations and technology.
- reduces the ecological footprint of production, distribution and consumer practices, thus reducing water and soil pollution.
- boosts the adaptability and resilience of the production and livestock farming system by maintaining the diversity of the agroecosystem.
- promotes agricultural systems based on social cohesion and a sense of belonging, reducing land abandonment and migration (Peano and Sottile, 2015).

Research

Far from promoting a backward-looking and obscurantist view, Slow Food has the most open approach possible to research, although it must be public, independent, based on rigorous methodologies and transparent about its specific objectives.

Public research is funded with money that comes from the contributions of citizens and has the common good as its objective. That is why this kind of research can and wants to listen to the needs of farmers in order to find practicable solutions to the real problems of both operators and citizen-consumers. Private research is instead supremely oriented towards the market and, using funds that derive from private profits, focuses on developing new products that can produce further profits. This is why research in agriculture cannot disregard public funds and structures; indeed, it has direct connections with common goods like natural resources, public health, the right to food, food sovereignty, the right to information: all elements that cannot and must not be directed by the market and the profit system.

Slow Food does not exclude, in principle, the possibility of field research, but only with absolute guarantees of non-contamination. Today, however, the conditions under which such field research could be carried out with zero risk of contamination for the already existing crops have yet to be described.

In talking about the difference between public and private research we must clarify that corporate-funded research is focused on obtaining results that can have a financial return. As we have shown above, research funded by multinationals leads to a general framework that are not clear or transparent, in which the inaccessibility of data held by GMO manufacturers is a major problem, both for the regulatory process and in order to establish the validity and, consequently, the reliability of studies based on the same data.

Slow Food believes in the need for research that produces consistent improvements in society. Without obstructing scientific research on GMOs, we would like funds to be earmarked for research into effective agricultural models, able to respond to future challenges, protecting ecosystems and preserving non-renewable resources without harming farmers.

There should always be **close monitoring of the objectives of any research**, which should always aim to produce useful results for the public, rather than serving economic interests.

Legislation

Based on the premise that the regulatory situation varies greatly from country to country, the first aspect to insist upon is **labeling**. Making it compulsory to flag up the presence of GMOs on labels would be an important step towards guaranteeing the right of consumers to choose what they eat, and promoting the work of all those producers that take special care not to use transgenic organisms. Flagging up the presence of transgenic foods should also be **extended to products of animal origin**, enabling consumers to choose meat, eggs, milk and cheese from animals that have not been raised on GM feed. The labeling of foods produced using meat from animals fed GMOs should clearly indicate this farming method, allowing consumers to immediately recognize which products do not have similar characteristics and therefore choose freely.

Another important element, in our view, is the transparency and rigor of authorization processes. In the countries where GMOs may be cultivated, legislation is required to establish more clearly which bodies are responsible for issuing authorizations and the different steps of the approval process for transgenic organisms. The authorities responsible for evaluating risk should adopt more transparent procedures and be constituted so as to guarantee impartiality from the influence of the big seed companies and producers of reproductive material.

As for cisgenesis and gene-editing technologies, we reiterate that it is necessary to continue to treat them similarly to GMOs and therefore not to exclude these technologies from legislation governing GMOs. As we have already pointed out, such an exclusion would lead to the traceability and labeling obligations for these products disappearing, thereby reducing consumers' freedom of choice.

For GMOs, Slow Food calls for regulations firmly anchored to the precautionary principle, expressed for the first time in the final document of the Rio Earth Summit. Therefore, until we can be reasonably sure about the harmlessness of long-term consumption, they must be excluded from direct human consumption.

Laws are also necessary to protect the farmers whose crops are affected by contamination by genetically modified plants. Whoever is responsible for the contamination must pay damages, whether the victim is an individual farmer, who can no longer sell their crops as GMO-free, or a community who has lost a piece of biodiversity due to the contamination.

Works Cited

- Altpeter F., Springer N.M., Bartley L.E., et al., 2016. "Advancing Crop Transformation in the Era of Genome Editing" in *The Plant Cell,* 28(7):1510-1520. DOI: 10.1105/tpc.16.00196.
- Aqoob, A., Shahid, A. A., Samiullah, T. R., Rao, A. Q., Khan, M. A. U., Tahir, S., Mirza, S. A., Husnain, T, 2016. "Risk assessment of Bt crops on the non-target plant-associated insects and soil organisms" in *J. Sci. Food Agric*., 96: 2613–2619.
- Benbrook C., 2012. "Impacts of genetically engineered crops on pesticide use in the US – The first sixteen years" in *Environ Sci Eur*, 24. DOI: 10.1186/2190-4715-24-24.
- Beyond Pesticides, 2016. *Glyphosate*: *A Beyond Pesticides Fact Sheet* [https://www.beyondpesticides.org/assets/media/documents/pesticides/factsheets/Glyphosate.pdf].
- Bizzarri M., 2011. "Ogm: implicazioni per la salute umana" in *Scienza incerta e dubbi dei consumatori. Il caso degli organismi geneticamente modificati*, Slow Food Editore.
- Bøhn T., Cuhra M., Traavik T., Sanden M., Fagan J., Primicerio R., 2013. "Compositional differences in soybeans on the market: Glyphosate accumulates in Roundup Ready GM soybeans" in *Food Chemistry*, 153, 207-215.
- Bové J. and Luneau G., 2016. *L'alimentazione in ostaggio*, EMI.
- Buiatti M., 2011. "Le piante geneticamente modificate: questione di scienza o sociale ed economica?" in *Scienza incerta e dubbi dei consumatori. Il caso degli organismi geneticamente modificati*, Slow Food Editore.
- Burke M., 2005. *Managing GM crops with herbicides: Effects on farmland wildlife*, Farmscale Evaluations Research Consortium and the Scientific Steering Committee, Defra [http://webarchive.nationalarchives.gov.uk/20080306073937/http://www.defra.gov.uk/environment/gm/fse/results/fse-summary-05.pdf].
- Carrière Y., Fabrick J.A., Tabashnik B.E., 2016. "Advances in Managing Pest Resistance to Bt Crops: Pyramids and Seed Mixtures" in Horowitz A.R. and Ishaaya I. (eds.), *Advances in Insect Control and Resistance Management*, Springer International Publishing, Switzerland.
- Center for Food Safety, 2014. *GE Food Labeling: States Take Action* [http://www.centerforfoodsafety.org/files/ge-state-labeling-fact-sheet-92014_02919.pdf].
- Clive J., 2015. ISAAA Brief 51-2015: Executive Summary [http://www.isaaa.org/resources/publications/briefs/51/executivesummary/default.asp].
- Commodity Online, 2007. *GM and India's rice fields*, March 2 [http://www.rediff.com/money/2007/mar/02comod4.htm].
- Consumer Reports National Research Center, 2014. *Consumer Support for Standardization and Labeling of Genetically Engineered Food*, Survey Research Report [https://consumersunion.org/wp-content/uploads/2014/06/2014_GMO_survey_report.pdf].
- De María N., Becerril J.M., Garca-Plazaola J.I., Hernandez A.H., de Felipe M.R., Fernández Pascual M., 1996. "New insights on glyphosate mode of action in nodular metabolism: Role of shikimate accumulation" in *Journal of Agricultural and Food Chemistry,* 54: 2621–2628.
- De Schutter O., 2014. *Report of the Special Rapporteur on the Right to Food – The Transformative Potential of the Right to Food*, 2014: 20, submitted to the Human Rights Council in accordance with its resolution 22/9/2014 [http://www.srfood.org/images/stories/pdf/officialreports/20140310_finalreport_en.pdf].
- Delwaide A-C., Nalley L.L., Dixon B.L, et al., 2015. "Revisiting GMOs: Are There Differences in European Consumers' Acceptance and Valuation for Cisgenically vs Transgenically Bred Rice?" in *PLoS ONE*, 10(5): e0126060.
- Di Cagno R., De Angelis M., De Pasquale I., Ndagijimana M., Vernocchi P., Ricciuti P., Gagliardi F., Laghi L., Crecchio C., Guerzoni M.E., Gobbetti M., Francavilla R., 2011. "Duodenal and faecal microbiota of celiac children: Molecular, phenotype and metabolome characterization" in *BMC Microbiology*, 11: 219.
- EFSA, 2015. "Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate" in *EFSA Journal*, 13 (11): 4302.
- Enserink M., 2008. "Tough lessons from Golden Rice" in *Science*, 230: 468-471.

- ETC Group, 2011. *Who Will Control the Green Economy*?
- Fagan J., Antoniou M., Robinson C., 2014. *GMO Myths and Truths,* 2nd edition, Earthopensource: 66.
- FAO, 2009. *The State of Food and Agriculture*.
- FAO, 2011. *Global food losses and waste: extent, causes and prevention*, Rome.
- Friends of the Earth Europe, 2016. *The Risk to Nature of GM Maize*: 2. [http://www.foeeurope.org/sites/default/files/gmos/2016/foee-briefing-gm-maize-authorisations-130916.pdf].
- Greenpeace, 2011. *Resistenza agli erbicidi e colture Ogm – I problemi legati al glifosato* [http://static.aboca.com/www.aboca.com/files/attach/news/report_glifosato.pdf].
- Greenpeace, 2016. *Gene-Editing: Ogm che escono dalla porta e rientrano dalla finestra?* [http://www.greenpeace.org/italy/Global/italy/report/2016/Briefing_Greenpeace_Gene-editing_21_01_2016.pdf].
- Han, P., Niu, C.Y., Lei, C.L., Cui, J.J., Desneux, N., 2010. "Quantification of toxins in a Cry1Ac+CpTI cotton cultivar and its potential effects on the honey bee Apis mellifera L." in *Ecotoxicology* 19, 1452–1459.
- Hilbeck A. et al. 1998. "Effects of transgenic Bt corn-fed prey on immature development of Chrysoperla carnea (Neuroptera: Chrysopidae)" in *Environ Entomol.*, 27(2):480-487.
- Holt-Giménez E. and Patel R., 2009. *Food Rebellions – La crisi e la fame di giustizia*, Slow Food Editore.
- Holt-Giménez E., Shattuck A., Altieri M., Herren H., Gliessman S., 2012. "We Already Grow Enough Food for 10 Billion People… and Still Can't End Hunger" in *Journal of Sustainable Agriculture*, 36:6, 595-598.
- Hou H., Atlihan N,. Lu Z-X., 2014. "New biotechnology enhances the application of cisgenesis in plant breeding" in *Frontiers in Plant Science* 5:389.
- Howard P.H., 2009. "Visualizing Consolidation in the Global Seed Industry: 1996-2008" in *Sustainability Journal*, 1.
- IARC, 2015. *Some Organophosphate Insecticides and Herbicides: Diazinon, Glyphosate, Malathion, Parathion and Tetrachlorvinphos*, IARC Monographs on the Evaluation of Carcinogenic Risk to Humans, vol. 112.
- Intergovernmental Panel on Climate Change (IPCC), 2001. *Working Group III: Mitigation. A Report of Working Group III of the Intergovernmental Panel on Climate Change*.
- International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), 2009. *Agriculture at a crossroads: Synthesis report of the International Assessment of Agricultural Knowledge, Science and Technology for Development: A Synthesis of the Global and Sub-Global IAASTD Reports*, Washington, DC, USA: Island Press [http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture%20at%20a%20 Crossroads_Synthesis%20Report%20%28English%29.pdf].
- International Society of Doctors for the Environment (ISDE). [http://www.isde.it/wp-content/uploads/2015/06/2015.04.13_Comunicato-Tavolo-Associazioni-contro-Pesticidi-futuro-biologico.pdf]..
- Mammana I., 2014. *Concentration of Market Power in the EU Seed Market*, Greens/EFA Group.
- Migliorini P., 2015. "Eco e bio: agricoltura sostenibile o insostenibile?" in Capatti A. and Montanari M. (eds.), *Cultura del cibo – 3: L'Italia del cibo*.
- Migliorini P., 2008. "L'impatto ecologico degli Ogm" in *Scienza incerta e dubbi dei consumatori. Il caso degli organismi geneticamente modificati*, Slow Food Editore.
- Modonesi C. and Oldani M., 2011. "Agricoltura industriale, colture transgeniche e biodiversità" in *Scienza incerta e dubbi dei consumatori. Il caso degli organismi geneticamente modificati*, Slow Food Editore.
- Monastra G., 2011. "Introduzione" in *Scienza incerta e dubbi dei consumatori. Il caso degli organismi geneticamente modificati*, Slow Food Editore.
- Nguyen D.B., Rose M.T., Rose T.J., Morris S.G., van Zwieten L., 2016. "Impact of glyphosate on soil microbial biomass and respiration: A meta-analysis" in *Soil Biology and Biochemistry*, 92, 50-57.
- Peano C. and Sottile F. (eds.), 2015. *Position Paper on Agroecology*, Slow Food, 7-8 [http://bit.ly/27ZWXuw].
- Pollack A., 2004. "The travels of a bioengineered gene" in *The New York Times,* September 30.
- Pollan M., 2008. *Il dilemma dell'onnivoro*, Adelphi.
- Portier C.J, Armstrong C.K., [.....], Shu-Feng Z., 2016. "Differences in the carcinogenic evaluation of glyphosate between the International Agency for Research on Cancer (IARC) and the European Food Safety Authority (EFSA)" in *J Epidemiol Community Health*, jech-2015-207005.

- Pusztai A., Bardocz S., Ewen S.W.B., 2003. "Genetically modified foods: Potential human health effects" in D'Mello J.P.F. (ed.), *Food Safety: Contaminants and Toxins*, CABI Publishing.
- Ramirez-Romero R. et al., 2008. "Does Cry1Ab protein affect learning performances of the honey bee Apis mellifera L. (Hymenoptera, Apidae)?" in *Ecotoxicol Environ Saf.*, 70:327-333.
- Robin M.M., 2008. *Le monde selon Monsanto*, La Découverte.
- Saxena D., Flores S., Stotzky G., 1999. "Insecticidal toxin in root exudates from Bt corn" in *Nature,* 402, 480.
- Saxena D., Flores S., Stoztky G., 2002. "Bt toxin is released in root exudates from 12 transgenic corn hybrids representing three transformation events" in *Soil Biology and Biochemistry*, 34, 133-137.
- Scribner E.A., Battaglin W.A., Gilliom R.J., Meyer M.T., 2007. *Concentrations of Glyphosate, Its Degradation Product, Aminomethylphosphonic Acid, and Glufosinate in Ground-and Surface-Water, Rainfall, and Soil Samples Collected in the United States, 2001-06,* US Geological Survey, Scientific Investigations Report 2007-5122 [https://pubs.usgs.gov/sir/2007/5122/pdf/SIR2007-5122.pdf].
- Tabashnik B.E., 2008. "Insect resistance to Bt crops: Evidence versus theory" in *Nat Biotechnol*, 26:199–202, DOI: 10.1038/nbt1382.
- Tecco N., 2013. "Quanto ne sai sugli ogm?" in *Consumers' Magazine*, 3.
- UPOV, 1961. International Convention for the Protection of New Varieties of Plants, approved December 2, modified November 10, 1972, October 23, 1978 and March 19, 1991.
- USDA, 2010. Agricultural Chemical Use Program, National Agricultural Statistics Service.
- Valdemar J. W. Junior, 2016. "La filiera della soia nell'America del Cono Sud: dinamiche, processi e attori" in *Rivista di Economia Agraria*, Anno LXXI, p. 32.
- Wesseler, J. and Zilberman, D., 2016. "Golden Rice: no progress to be seen. Do we still need it?" in *Environment and Development Economics*, 1–3.
- World Food Programme (WFP), 2016. [http://it.wfp.org/la-fame/le-cause-della-fame].
- www.fao.org/faostat/en.
- Ye X., Al-Babili S., Kloti A., 2000. "Engineering the provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm" in *Science*, 287: 203-205.
- Ziegler J., 2002. *Economic, social and cultural rights: The right to food. Report by the special rapporteur on the right to food, Mr Jean Ziegler, submitted in accordance with Commission on Human Rights Resolution 2000/25* (Geneva: UNECOSOC E/CN.4/2002/558).

Works Consulted

- AA.VV., 2015. *Cultivos transgénicos en Uruguay. Aportes para la comprensión de un tema complejo desde un abordaje multidisciplinario, Fondo Universitario para Contribuir a la Comprensión Pública de Temas de Interés General* [http://www.universidad.edu.uy/prensa/renderItem/itemId/38195/refererPageId/445].
- AA.VV., 2016. *Cultivos transgénicos en Uruguay* [http://colectivoogm.blogspot.it].
- Altieri M., 2000. *The myths of agricultural biotechnology: some ethical questions* [http://nwrage.org/content/myths-agricultural-biotechnology-some-ethical-questions].
- Antonelli M. and Greco F., 2013. *L'acqua che mangiamo. Cos'è l'acqua virtuale e come la consumiamo*, Edizioniambiente.
- Belcher K., Nolan J., Phillips P.W.B., 2005. "Genetically modified crops and agricultural landscapes: spatial patterns of contamination" in *Ecological Economics*, 53: 387-401.
- Bevilacqua P., 2002. *La mucca è savia. Ragioni storiche sulla crisi alimentare europea*, Donzelli.
- Borlaug N.E., 2000. "Ending world hunger, the promise of biotechnology and the threat of antiscience zealotry" in *Plant Physiology*, 124: 487-190.
- Bray G. A., Joy Nielsen S., Popkin B. M., 2004. "Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity" in *The American Journal of Clinical Nutrition* [http://ajcn.nutrition.org/content/79/4/537.full].
- Buiatti M., 2005. *Biologies, Agriculters, Biotechnologies*, Tailoring Biotechnologies.

- Buiatti M., 2007. "L'interazione con il genoma ospite" in *Agrobiotecnologie nel contesto italiano*, INRAN, Rome.
- Clive J., 2014. *Global Status of Commercialized Biotech/GM Crops: 2014*, ISAAA Brief 49: 7.
- FAO, 2014. *Report on Food Security and Climate Change*.
- Gallacher M., 2009. *The changing structure of production: Argentine agriculture 1988-2002. Documento de trabajo 415*, Universidad del CEMA, Buenos Aires.
- Glover D., 2009. *Undying promise: agricultural biotechnology's pro-poor narrative, ten years on*, STEP Centre, ESRC, UK.
- Lawrence F., 2005. *Non c'è sull'etichetta. Quello che mangiamo senza saperlo*, Einaudi.
- Modonesi C. and Oldani M., 2010. "La natura dentro la cultura, la cultura dentro la natura" in Pereira M., Salvi A., Sani M., Villa L. (eds.), *MAPforID (Museums as Places for Intercultural Dialogue). Esperienze, sviluppi, riflessioni,* Editrice Compositori, Bologna.
- National Academies of Sciences, Engineering, and Medicine, 2016*. Genetically Engineered Crops: Experiences and Prospects.* Washington, DC: The National Academies Press. DOI: 10.17226/23395.
- National Research Council, Committee on the Impact of Biotechnology on Farm-Level Economics and Sustainability, 2010. *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States*, National Academy of Sciences.
- Pollan M., 2009. *In difesa del cibo*, Adelphi.
- Raisson V., 2010. *Atlante dei futuri del mondo*, Giunti.
- Ramasundaram P., Vennila S., Ingle R.K., 2007. "Bt Cotton Performance and Constraints in Central India" in *Outlook on Agriculture*, 36 (3), 175-80.
- Reymond W., 2008. *Toxic*, Nuovi Mondi Media.
- Roberts P., 2008. *La fine del cibo*, Codice Edizioni.
- Robin M.M., 2012. *Il veleno nel piatto – I rischi mortali nascosti in quello che mangiamo*, Feltrinelli.
- Piovano P., 2015. "The Human Cost of Agrotoxins" in BurnMagazine.org.
- Schimmelpfennig D.E., Pray C.E., Brennan M.F., 2004. "The impact of seed industry concentration on innovation: a study of US biotech market leaders" in *Agricultural Economics*, 30, 157-167.
- Soto A.M. and Sonnenschein C., 2010. "Environmental causes of cancer: endocrine disruptors as carcinogens" in *Nature Reviews Endocrinology*.
- Stotzky G., 2004. "Persistence and biological activity in soil of the insecticidal proteins from *Bacillus thuringiensis*, especially from transgenic plants" in *Plant and Soil*, 266: 77-89.
- Tabashnik B.E., Brévault T., Carrière Y., 2013. "Insect resistance to Bt crops: lessons from the first billion acres" in *Nature Biotechnology*, 31, 510–521.
- Tank J.L., Rosi-Marshall E.J., Royer T.V., Whiles M.R., Griffiths N.A., Frauendorf T.C., Treering D.J., 2010. "Occurrence of maize detritus and a transgenic insecticidal protein (Cry I Ab) within the stream network of an agricultural landscape" in *Proceedings of the National Academy of Sciences*, 107 (41): 17645-17650.
- United States Department of Agriculture, Economic Research Service [http://www.ers.usda.gov/browse/view.aspx?subject=FarmPracticesManagementFertilizerUse].
- Van Eenennaam L.V. and Young A.E., 2014. "Prevalence and impacts of genetically engineered feedstuffs on livestocks populations" in *Journal of Animal Science*: 92/10; 4255-4278. DOI: 10.2527/jas.2014-8124
- Wang S., Just D.R., Pinstrup-Andersen P., 2006. *Tarnishing Silver Bullets: Bt Technology Adoption, Bounded Rationality and the Outbreak of Secondary Pest infestations in China*. Paper presented at the American Agricultural Economics Association Meeting, Long Beach, California, USA, July 22-26.
- Wang S., 2008. "Bt Cotton and Secondary Pests" in *International Journal of Biotechnology*, 10 (2-3), 113-121.
- WWF International, 2014. *The Growth of Soy: Impacts and Solutions*, Gland, Switzerland.

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