Is GM agriculture sustainable?

Food security, environmental and health implications of transgenic crops

Fondazione Barilla

il tuo cibo, la tua terra

people, environment, science, economy

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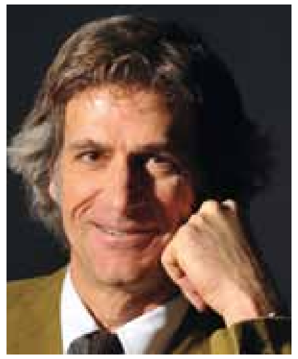


Dear Reader,

The progress of science and technology often draws the attention of people, of companies, of Governments, and of society as a whole on issues that are hardly understood. These are often important matters that have the power to influence the perspectives and the quality of life of millions of people.

In most cases, these issues are the subject of a debate that makes the matter even more complicated, both for its undisputed complexity and for a general inclination to focus on the most sensational aspects. The final outcome for an individual trying to develop an opinion is a kind of confusion that prevents any judgements based on actual facts.

This is the perceived status of the debate on biotechnologies in the food sector and, particularly, on Genetically Modified Organisms (the so-called GMOs), especially in our Country.

The wish to analyze and share such an important issue is at the origin of this paper, meant as an educational tool available to the general public, though being drafted with a rigorous scientific approach. In particular it is intended as an input to make the current debate – if possible – more engaging and transparent.

On the other hand, the theme of biotechnologies in the agro-food sector appeared – for its comprehensive nature – perfectly suited to be addressed by a multi-disciplinary think-tank like the BCFN. In this case, in fact, while biological sciences are the starting point, health-related issues are particularly critical in terms of crop safety (for men and animals). Significant implications also exist for the environment and for biodiversity. This relates with the broader issue of the possible economic development and the geopolitical and social impact that certain business models can generate. Finally, the perceptions of people as consumers and citizens are important, and will determine the medium-long term outcome of GMOs; in this respect the social dynamics and the media (both modern and traditional), as well as their role in shaping the opinion of the different stakeholders, should be taken into account.

We have tried to answer a single question, albeit quite complicated: to what extent can the extraordinary progress of knowledge, which allowed to affect the genetic code of plants in the past few years, provide a sustainable (and as such persistent) response to major food safety issues (food for all), environmental issues (sustainable development), health issues (food for health), and the improvement of lifestyles (food for culture)?

The Barilla Center for Food & Nutrition does not claim to have a solution but, as for other addressed issues, is keen on tackling problems according to its traditional approach – based on data, aimed at the search of the most reliable sources, built on a multi-disciplinary rationale – and trusts that this output can be useful for the future of our society.

Enjoy your reading!

Guido Barilla

Executive summary

Amy White & Al Petteway/National Geographic Image Collection

GMOs do not seem to play a significant role in alleviating hunger in the world, for one simple reason: they were not developed with this goal in mind.

Carsten Peter/National Geographic Image Collection

ARE THERE HEALTH RISKS TIED TO EATING GENETICALLY MODIFIED FOODS CURRENTLY ON THE MARKET?

Scientific studies have not shown evidence of serious effects on human health.

The issue of the safety of genetically modified foods is the one on which there is most agreement between the various opinions in this area.

The European authorization system for selling genetically modified ingredients would seem to be the most restrictive of those adopted by countries. However, some aspects of risk assessment must be further improved, for example, through the introduction of evaluations of tests made by independent bodies.

To-date, scientific studies undertaken on an international level have not shown evidence of serious effects on human health, at least not in the short-term. Over the long-term, there is nothing to give rise to the fear of negative effects, although there are no studies which would provide definitive confirmation of this.

Among the areas of attention for human health are:

- the onset of allergies, but which the current authorization system seems able to detect;
- resistance to antibiotics, even if the use of gene markers resistant to antibiotics[1] was the subject of a recommendation of the European Commission;
- the risk of gene transfer, regarding which the results of scientific studies still differ.

The most positive aspects of scientific research in this area is the creation of genetically modified foods with nutritional characteristics superior to traditional ones or even protective characteristics against some pathologies.

CAN GENETICALLY MODIFIED ORGANISMS CONTRIBUTE TO TAKING ON AND RESOLVING PROBLEMS OF ENVIRONMENTAL SUSTAINABILITY AND SCARCITY OF NATURAL RESOURCES, OR, ON THE CONTRARY, ARE THEY A THREAT TO BIODIVERSITY?

With the exception of the emerging phenomena of resistance to herbicides, no clear consensus on environmental risks.

This is the question in which there seems to be the lowest agreement between scientists and the highest level of uncertainty.

On the other hand, the difficulty in obtaining reliable data is due to two factors:

- the very nature of scientific research in the field which makes it extremely difficult to isolate causes and effects and establish related correlations, within a complex biological context;
- reference data from the past which is still too recent;

However, analysis of available scientific studies does reveal a number of environmental risks connected with the introduction of GMOs into the environment. Specifically:

- loss of biodiversity;
- risk of contamination (especially in the areas involving species origin);
- increased use of pesticides/herbicides;
- increase in the phenomenon of resistance to herbicides;
- damage to the natural habitat of wild fauna.

1 *It's a recommendation not always respected. See the case of potato Amflora.*

With the exception of the emerging phenomena of resistance to herbicides, to-date, no clear consensus within the scientific community exists for any of these risks.

Some recent episodes demonstrate that the mere introduction of GMOs, even if only within experimentation of limited scope, can be the cause (including years later) of unexpected and widespread contamination which not only impacts on the local market, but also exports.

This explains the heated debate on an institutional level regarding key regulatory criteria and control of the coexistence of genetically modified and traditional crops.

CAN GENETICALLY MODIFIED ORGANISMS CONSTITUTE AN EFFECTIVE SOLUTION TO THE WORLD'S FOOD SECURITY PROBLEM OR, ON THE OTHER HAND, CAN THEY INCREASE INEQUITY?

GMOs do not seem to play a significant role in alleviating hunger in the world, for one simple reason: they were not developed with this goal in mind.

Food security is a complex problem involving a range of economic, social and political variables intertwined into an overall picture that is difficult to interpret, even before deciding on the proper actions. Within this context, it is unthinkable that a single technology, alone, be able to play a role in taking on the problems still facing us. In order to provide a concrete contribution to this problem, genetic engineering products must be coherent with the nature of the challenge and, as a result, capable of adapting to the local characteristics of each regional context.

In reality, the GMOs on the market today were designed and developed "within" and "for" capital-intensive industrialized agricultural models with large surface areas under cultivation, massive mechanization and intensive use of agro-chemical products. The benefits they provide are connected to the "insurance" effect than the possibility of decisively increasing crop yield. They also tend to reinforce the commitment to single-crop production in vast regions of the world.

In addition, it should be remembered the GMOs on the market today are primarily for zootechnical, energy or textile use in which direct human consumption is very limited. They involve a low number of variants of vegetal species, primarily limited to just two types (Ht and Bt), in line with highly-integrated business models in which the sale of agro-chemical products plays a fundamental role in insuring profitability of the enterprise.

On the other hand, it is easy to understand the low interest of the sector in products and technologies aimed at marginal areas but which are, in fact, those in which lack of food security is greatest.

Completing this picture is the marginal role of public institutions in developing research on GMOs, not only as a consequence of political choices, but also through systems of protecting the property rights currently in the hands of a select group of multinationals.

To summarize, GMOs–as we know them today–do not seem to play a significant role in alleviating hunger in the world, for one simple reason: they were not developed with this goal in mind. On the contrary, concerns are high over the risk of imbalances deriving from the introduction of the intensive farming model in rural areas characterized by subsistence farming.

Changing this picture would require substantial change in the normative structure and incentives in this sector in order to promote the development of initiatives specifically aimed at developing countries.

WHAT IS PEOPLE'S EXPERIENCE OG GMOs?

From analysis of perceptions in Europe (and elsewhere) about the use of biotechnologies and GMOs in the area of food, there emerges a cognitive picture decidedly conditioned by a strong orientation towards natural products (seen as the lack or reduced presence of human manipulation), which is closely correlated to health.

Faced with risks people do not perceive any advantage.

This picture is cross-cultural in nature: in fact, there are no significant differences between Anglo-Saxon and continental European countries. People see GMOs as being essentially "unnatural", even in their original structure, especially when they are created through the transmission of genes between different species. Products modified through cisgenic techniques (genes introduced into the DNA of the plant come from the same species) are more acceptable than corresponding transgenic varieties.

According to the Eurobarometer, the level of GMO acceptance has been decreasing in recent years. In particular, this drop is significant within those countries (Spain, Portugal and the Czech Republic) in which GMO cultivation has been allowed for some time.

This trend also depends on the fact that, faced with risks (still vague and not clearly defined), people do not perceive any advantage from the introduction of this new technology.

THE QUESTIONS ON GMOs POSED BY BARILLA CENTER FOR FOOD & NUTRITION

In the following pages you will find a datailed answer to all questions that are contained in the following scheme.

FOOD FOR HEALTH

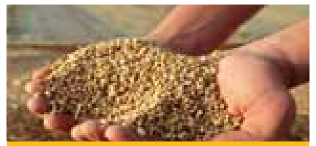
ARE THERE HEALTH RISKS TIED TO EATING GENETICALLY MODIFIED FOODS CURRENTLY ON THE MARKET?

- Is the testing and authorization system adequate?
- Have there been any cases of harmful effects on health caused by the consumption of genetically modified foods?
- In the long term may there be effects on health which we are not aware of at present?
- Is work being carried out to make genetically modified foods available which may play a role in disease prevention?

FOOD FOR SUSTAINABLE GROWTH

CAN GMOs CONTRIBUTE TO TACKLING AND SOLVING PROBLEMS ASSOCIATED WITH ENVIRONMENTAL SUSTAINABILITY AND THE SHORTAGE OF NATURAL RESOURCES? OR, ON THE CONTRARY, DO THEY CONSTITUTE A THREAT TO BIODIVERSITY?

- Can GMOs contribute to tackling and solving problems associated with environmental sustainability and the shortage of natural resources?
- What impact does the extensive GMO monoculture farming model have on the environment?
- Can the use of GMOs create a negative impact on the natural habitat of wild animals and insects?
- Does the use of GMOs decrease the need to resort to pesticides, also taking into consideration the risk of resistance developing?
- Which risks derive from possible contamination amongst GM and conventional plants?



FOOD FOR ALL

CAN GMOs CONSTITUTE AN EFFECTIVE SOLUTION TO THE PROBLEMS OF ACCESS TO FOOD IN THE WORLD? OR, VICE VERSA, MIGHT THERE BE EVEN GREATER INEQUALITY IN DISTRIBUTION?

- Do GMOs make it possible to achieve clear, significant and lasting increases in productivity?
- Might OGMs be an answer to the agricultural problems afflicting developing countries?
- Are there any criticalities linked to the structure of the sector and the business models adopted by companies?

FOOD FORCULTURE

WHAT DO PEOPLE THINK ABOUT GMOs?

- What is people's experience of GMOs?
- How is the topic of GMOs handled by the media?

Legenda

- Not problematic situation / Positive
- Uncertain situation
- Problematic situation
- Critical / Negative situation

1. Why another position paper dedicated on GMOs?

Peter Essick/National Geographic Image Collection

Lynn Johnson/National Geographic Image Collection

1.1 Biotechnologies and their applications in the agro-food sector

The term biotechnology, as defined by the UN convention on organic biodiversity, refers to "*any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for a specific use*"[1].

It is roughly the same construction offered by the European Federation of Biotechnology: "*the term biotechnology refers to the integration of natural sciences, of organisms, of cells, of their parts or molecular analogues into industrial processes for the production of goods and services*"[2].

Additional definitions[3] are basically similar to the above concepts.

In much less accurate, but easier to understand terms, biotechnologies occur every time changes are brought about in the structure and functioning of a living organism or organic process for a practical purpose.

This definition of biotechnology, intended in a broad sense, covers most of the tools and techniques that are common in agriculture and in food production such as "*in vitro*" cultures of cells and tissues (including the micropropagation of plants), the fermentation and leavening of bread, wine, beer, cheese (the so-called traditional agro-biotechnologies). According to a more restricted interpretation – which only considers the new technical interventions on DNA (developed in the past few decades with early knowledge on the genome) – this term refers to a set of highly innovative practices, aimed at identifying, manipulating, and transferring genes of plants and animals[4]: in this case reference is made to modern agro-biotechnologies.

1.2 What are the questions we tried to answer?

The question the BCFN wishes to answer is to what extent this significant improvement in knowledge, which allowed to affect the genetic code of plants in the past few decades, can provide a sustainable (and, as such, persistent) response to the major issues on which its activity is focused, i.e. **food safety** (food for all), **environment** (sustainable development), **health** (food for health), and **lifestyles** (food for culture).

On the other hand, the issue of agro-food biotechnologies concerns, by its own nature, a variety of domains and as such can only be thoroughly understood in a multi-disciplinary perspective.

In short, this first paper, particularly focused on GMOs, is an attempt to answer the following questions:

- Can GMOs provide an effective and persistent solution to **food availability** issues in the world? Or, vice versa, can they enhance inequality?
- Can GMOs help address and solve the **environmental sustainability** issues tied to the shortage of natural resources? Or, rather, do they pose a threat to **biodiversity**?
- Does the consumption of existing commercial genetically modified foods imply any **risks**?
- What is the **attitude of people** towards biotechnologies and GMOs? And how is this issue addressed by the **media**?

1 www.cbd.int/
2 www.efb-central.org/
3 The Italian Ministry of the Environment provides a more punctual, and as such perhaps more exhaustive definition: biotechnologies can be defined as a set of technical processes aimed at changing the structure and functioning of living organisms for: a) the production of goods obtained through the use of new organisms (micro-organisms, plants, animals) and/or their products (e.g. enzymes), mostly resulting from the focused implementation of genetic engineering techniques; b) the provision of new services (e.g. diagnostics, therapy, prevention, transplant) resulting from a better understanding of physiology, genetics, and molecular biology." See also the Websites and official papers of the US Food and Drug Administration (www.fda.gov/food/biotechnology/default.htm) and of the US Biotechnology Industry Organization (www.bio.org/about_biotech).
4 www.fao.org/BIOTECH.

Our analysis has tried to integrate different perspectives in order to come up with a brief but well-defined judgement, based on a review of the different positions and on the facts supporting them.

This is the traditional approach of the Barilla Center for Food & Nutrition: based on data, aimed at the search of the most reliable sources, built on a multidisciplinary rationale.

1.3 Methodology and structure of the analysis

This position paper was aimed at understanding and describing the state of the art of the role of biotechnologies and GMOs in the agro-food sector – problems, possible solutions, opinions, and the prevailing assessments.

The work described in this paper is based on a methodological approach that provides for the following:

- organizing our reasoning according to a logical sequence of questions allowing a punctual definition of the issue;
- performing a significant number (more than twenty) interviews with high-level experts in the fields of biotechnologies, agronomy, economy, intellectual property rights protection, medicine, and politics;
- implementing an *ad hoc* analysis of the behaviour of the national and international media in their approach to the issue of agro-biotechnologies, in order to understand its impact on the public opinion;
- ensuring the supervision of the Scientific Committee of the Advisory Board of the Barilla Center for Food & Nutrition, which validated the guidelines of the survey and followed the detailed development of the activity step by step;
- implementing qualified discussion forums among experts, at present only in place to a limited extent but bound to expand, in view of ensuring the involvement of the civil society in its entirety,[5] and enhancing the available knowledge base.

Paul Sutherland/National Geographic Image Collection

5 The first of these meetings is the International Forum on Food & Nutrition organized on November 30 and December 1, 2010 by the Barilla Center for Food & Nutrition in Milan

2. Biotechnologies in the agro-food sector: developments and applications

Lynn Johnson/National Geographic Image Collection

The millennia-old history of agriculture is thus characterized by gradual improvements in plant characteristics, to which farmers devoted through the on-going selection of the desired traits. The introduction of recombinant DNA techniques, also known as genetic engineering, brought about a radical change

Estimates that 70% of soybean, 46% of cotton, 24% of maize, and 20% of rapeseed in the world are GM

2.1 The birth of biotechnologies and their development so far

The decisive steps of the birth and development of modern biotechnological techniques can hardly be traced back due to the broad field of study and to the significant number of contributing scientists. We will therefore just highlight the main milestones, while referring to specialist papers for further details[1].

The term *biotechnology* was created in 1917 by Karl Ereky, a Hungarian agronomist.[2] However, only in 1953 did James Watson and Francis Crick describe the double-helix structure of DNA. Research continued in the 1970s, and in 1975 Georg Köhler and Cesar Milstein launched the production of monoclonal antibodies, and received the Nobel Prize for this[3].

In the same years, the potentials of the new technologies started to be tested also in agriculture. The first vegetal GMO was a tobacco plant created in 1983 for scientific purposes.

The recombinant DNA technology was developed in the 1980s: *Escherichia coli* bacteria were engineered to produce such molecules as insulin in its human form (about 5% of diabetic patients are allergic to the animal insulin formerly in use).

In 1983 Kary B. Mullis (also a Nobel Laureate for chemistry in 1993) defined the Polymerase Chain Reaction (PCR) technique, bound to revolutionize the world of biotechnologies. It is a molecular biology technique that allows the multiplication (*amplification*) of nucleic acid fragments, whose initial and terminal nucleotide frequencies are known[4]. This allowed to copy or change a single DNA sequence in a pre-set way (millions of time), and thus to quickly obtain *in vitro* the amount of genetic material required for subsequent applications.

This laid the foundations for translating scientific discoveries in the field of biotechnologies into a profitable business.

The industry of genetically modified organisms in agriculture started to develop in the mid-1980s. The skyrocketing costs associated with the production of GM varieties (estimated between US$100 and 200 million for a single variety[5], including R&D, intellectual property rights protection, technological transfer, and fulfilment of approval requirements) resulted into close concentration in the sector, now dominated by few global companies (Bayer Cropscience, Dupont, Monsanto, and Syngenta own or co-own 80% of the patents for all the commercial traits[6]).

It was only in 1994 that the US Food and Drug Administration (FDA) approved the first genetically modified food – the "Flavr Savr" tomato. While it was an utter failure from the commercial viewpoint, its attempted commercialization officially marked the birth of the GMO industry.

In the late 20th century, the international scientific community devoted growing interest and efforts to genetics and molecular biology, achieving a whole set of unique initiatives and successes: in 1997 the work team headed by Ian Wilmut cloned sheep Dolly using the DNA of two adult sheep cells[7]; in 2000 the decoding of the Human Genome was completed, and in 2002 the genome of rice was sequenced (this was the first completely sequenced crop)[8]; in 2007 patent number 20070122826 "Minimal bacterial genome" was filed with the US patent & trademark office, referring to the living organism with the smallest genetic makeup, capable to live autonomously[9]; this year (2010) the production of the first artificial cell, controlled by a synthetic DNA and capable to split and proliferate like any other living cell, has been announced[10].

At the same time, agro-food applications have increased enormously, combined with the need to gain a more in-depth understanding of the benefits and risk profiles associated with this technology.

Brian Gordon Green/National Geographic Image Collection

1 *History and Trends in Bioprocessing and Biotransformation (Advances in Biochemical Engineering Biotechnology), Various authors, 2002.*
2 *Biotechnology of Meat, Fat and Milk Production in an Agricultural Large-Scale Farm, Karl Ereky, 1917.*
3 *Nobel Lecture, Georg Köhler, 1984.*
4 *Nobel Lecture, Kary Mullis, 1993.*
5 *Edoardo Ferri, Monsanto Italia, in Senate Hearing 2009.*
6 *Genetically Engineered Plants and Foods: a Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, The Annual Review of Plant Biology, 2009.*
7 *The Second Creation: Dolly and the Age of Biological Control, Ian Wilmut, Keith Campbell, and Colin Tudge Genome News Network, 22 September 2000.*
8 *A Draft Sequence of the Rice Genome (Oryza sativa L. ssp. indica), J. Yu et al., Science, 2002.*
9 *United States Patent Application Publication, 31 May 2007.*
10 *Researchers Say They Created a 'Synthetic Cell', Nicholas Wade, New York Times, 20 May 2010.*

2.2 Biotechnologies in the agro-food sector and GMOs

Lots of efforts in agriculture have been focused on improving crops through cross-breeding and the selection of the best varieties. The start of farming activities, roughly 10thousand years ago, was characterized by the cultivation of grains and legumes, also allowed by the recognition of the natural mutations of plants that turned out useful for man and by their reproduction, thus defining their features across generations. The millennia-old history of agriculture is thus characterized by gradual improvements in plant characteristics, to which farmers devoted through the on-going selection of the desired traits.

In the early 20th century seeds gradually became the object of scientific genetic improvement, first empirically, then with more and more experimental purposes. As early as in the 1920s, on the rising market of seeds, the first commercial hybrids of maize started to appear, and in the early aftermath of the second World War 90% of US maize was estimated to originate from hybrids. These seeds, obtained by crossing two pure lines, show a potentially higher yield: this is the so-called "hybrid vigour" (or heterosis), a natural man-driven phenomenon[11].

One additional intervention on the plants' genome is the triggering of mutations by means of chemical (e.g. cobalt) or physical (X, Y, and UV-rays) mutagenic agents, known as induced mutagenesis (a technique developed in Italy particularly between the 1950s and 1970s). The nature of the induced mutations is substantially the same as for spontaneous mutations, i.e. an alteration of the genetic material. These techniques resulted into the selection of varieties that were then commercialized, including the *creso cultivar* of wheat and pink grapefruit.

The introduction of recombinant DNA techniques, also known as genetic engineering, brought about a radical change by allowing gene transfer from an organism to another (thus changing its genetic makeup[12]).

The recombinant DNA technique, based on the structural and functional characterization and on the transfer of the involved genes, allowed to create genetically modified organisms, including transgenic plants, where one or more genes are introduced to generate or enhance certain characteristics (traits) of interest. The universal language of DNA, in fact, allows the host organism to decode, i.e. read, the introduced transgene, as well as to ignore the biological species-specific barriers by grafting genes that can even originate from different domains: this is the case of most existing commercial transgenic plants, whose DNA was processed through the introduction of bacteria-derived genes.

11 *In this respect it should be noted that hybrids (as well as GMOs) are not sterile. In the case of hybrids, farmers simply do not find it profitable to re-sow part of the crop, in that the seeds' power declines at the following generation, with significant yield losses. On the other hand, in the case of GMOs, legal patent protection prevents re-sowing*

12 *"Genetics: what is a gene?", Pearson H, 2006, Nature*

Three interventional techniques, in particular, have allowed in facilitated, the introduction of new plant varieties, with specific traits of interest, in agriculture:

- The production of genetically-modified organisms (GMOs). According to the European Union's definition (directive 2001/18/EC), *"Genetically Modified Organism (GMO) means an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination";*
- MAS (Marker Assisted Selection)[13]. A process by which a marker (morphological, biochemical, or based on DNA/RNA modifications) is used for indirect selection of a genetic determinant or of the determinants of a trait of interest (productivity, disease resistance, abiotic stress, etc.). In other words, the DNA test is used for the selection of specimens bound to become the "parents" of future generations. The information obtained from the DNA test, combined with an observation of the individual performance, improves the accuracy of selection and increases the possibility to identify organisms with desirable traits at an early stage of the selection process;
- Induced mutations (mutagenesis, tilling, ecotilling)[14]. An induced mutation is caused by the action of mutagenic agents. The type of induced mutation can often be predicted, in that mutagens have some sort of mutational specificity. It is, however, impossible to predict where such mutations will occur and, thus, which consequences they may have on the organism.[15]

While this is obviously an extraordinarily valuable scientific progress, not all its technical implications have been solved.

For example, the artificial insertion of a transgene can interfere with the expression of the genes near the insertion site in that, once introduced into the cell nucleus, the transgene is randomly spliced into the genome. This is due to the fact that genetic engineering techniques (including the "biolistic" technique, which consists in shooting gold or tungsten microbullets coated with the transforming DNA into the cells to be transformed), imply the insertion of multiple copies of the transgene and do not allow focused insertion into the host genome. The structure (and thus the functionality) of the endogenous genes may thus be disrupted by selection, silencing, or rearrangement processes.

Insertion can thus prevent, depress, or stimulate the expression of the genes associated with the host's active DNA regions, and can therefore cause the appearance of unexpected substances or the suppression of some of those that are usually expressed. These genetic dynamics require thorough research and development by the molecular biologists engaged in plant engineering and represent part of the scientific foundation for risk assessment processes.

13 *Marker Assisted Selection - Current status and future perspectives in crops, livestock, forestry and fish, Elcio Guimarães, John Ruane, Beate Scherf, Andrea Sonnino, James Dargie, 2009.*

14 *Targeting Induced Local Lesions in Genomes, a molecular biology technique that allows direct identification of mutations in a specified gene.*

15 *What is a gene mutation and how do mutations occur? US National Library of medicine®, (http://ghr.nlm.nih.gov).*

On the other hand, GMOs represent one of the areas of investigation and biotechnological manipulation in the agro-food sector. Modern biotechnologies provide new instruments for the study and improvement of genomes, promoting classical genetic advancement. One important progress in knowledge is provided by genomics, which allows to characterize the germplasm (i.e. biodiversity) through the identification of the genes of interest and the study of their behaviour and interaction with other components of the genetic makeup: this allows, for example, to classify the genetic resources more accurately and manage the genetic heritage through seed banks, where the natural genetic diversity of a farming interest is preserved.

The integration of classical genetic improvement with technological innovation in molecular genetics also allowed to develop variety improvement techniques, including Marker Assisted Selection (MAS), based on the acquisition of information on the position of the genes that control the characteristics of interest in the genome. The use of molecular markers speeds up the implementation of breeding schemes by allowing a more accurate and effective selection of genotypes of interest.

Lynn Johnson/National Geographic Image Collection

THE FLAVR SAVR TOMATO

In 1994 the Flavr Savr tomato became the first GM food to be granted authorization for human consumption. Through genetic engineering techniques, Calgene, the Californian company which obtained the patent, succeeded in slowing down the process of ripening and rotting so that tomatoes could retain their color, consistency and original taste for longer. In 1994 the Food and Drug Administration (FDA) authorized sale of the tomato, claiming that the tomato in question was "as safe as tomatoes bred by conventional means". Furthermore, the FDA established at the time that there was no need for special labeling of the tomatoes as their nutritional characteristics had remained unchanged and there was no evidence for health risks. The Flavr Savr gene was the copy of a well-studied fruit gene - which coded for an enzyme known as polygalacturonase (PG for short) - involved in the ripening process. The main difference between the PG gene in non-modified tomatoes and the one in the genetically engineered fruit was that, in the Flavr Savr version, the genetic information responsible for the production of a protein had been inverted and turned upside down. The resulting antisense PG gene suppressed production of the native PG gene in the engineered plants and this suppression, in the modified tomato with the Flavr Savr gene, prolonged the shelf-life of ripe tomatoes16[1].

The Flavr Savr tomato was launched on the market in 1994, but production ceased just a few year later in 1997. Over the years this failure has been attributed to a number of reasons 17[2], mainly: Calgene's inexperience in supporting the farming processes involved in tomato growing resulted in rather moderate yields to a point where farmers were quickly discouraged from adopting the variety; the difficulties encountered in the management of packaging and shipment costs, as these processes turned out to be far more critical than for traditional tomatoes harvested while still green; added to this was the simultaneous launch on the market of conventionally bred products which succeeded in guaranteeing good results in terms of shelf-life. The truth is, the benefits associated with the consumption of genetically engineered tomatoes turned out to be pretty insignificant from the consumers' point of view and did not suffice to overcome the mounting distrust in GM products which in the meantime was becoming more and more apparent. This very critical start in the direct relationship with consumers represents a constant as yet unsolved for GMOs which still haven't found a way of convincing consumers of the advantages which could be had from choosing GM products, given the perceived risk aspect, when there are no directly ascertainable and tangible benefits.

So, despite getting off to a good start, also thanks to curiosity aroused by scientific innovation, sales very soon began to dwindle. When Monsanto acquired the company in 1996, it became immediately apparent that they were far more interested in Calgene's technological skills concerning cotton and oil-seed crops and research on tomatoes was soon abandoned. A few years later in Great Britain, in 1996 Zeneca (AstraZeneca today) launched a tomato paste made using similar technology to the Flavr Savr tomato. It was an innovative product, capable of guaranteeing savings of 20% for the consumer and was clearly labeled as genetically modified.

The product, sold in a number of large chain outlets including Sainsbury's and Safeway, met with considerable success in the first two years. However, a climate of growing suspicion towards GM products quickly led to a dramatic fall in sales until production finally ceased all together in June 1999.

16 The story is very well told in the book "First Fruit: The Creation of the Flavr Savr Tomato and the Birth of Biotech Food" (Published in Italy as "Il Primo Frutto" by Sironi Editore, Milan, 2003, 284 pages, €18). The book was written by Belinda Martineau, one of the researchers involved in the creation of the genetically engineered tomato and in the rigorous safety tests carried out on the product for obtaining approval from the very strict US Food and Drug Administration in 1994.

17 [2] The case of the FLAVR SAVR tomato G.Bruening & J.M.Lyons, California Agriculture 54(4):6-7.

2.3 What GMOs, now and in the future?

The existing commercial GM plant varieties were created to obtain resistance to parasites (*Bacillus thuringiensis* - Bt), tolerance to herbicides (*Herbicide tolerant* - HT), and resistance to viruses. The production of the Amflora potato (EH 92-527-1), characterized by high starch contents, was recently approved for the paper industry in Europe in view of enhancing the productivity of the concerned supply chain.

While in the near future virus and herbicide resistance will remain by far the main reason for commercialization, a growing demand for plant species capable to adapt to adverse environmental and climatic conditions has emerged. Studies were launched, in fact, to develop plants capable to adjust to the shortage of water or to significant temperature changes, or to grow on soils rich of certain minerals or metals.

Significant benefits might be achieved from plants ensuring a reduced impact on environmental resources:[18] reduction of greenhouse gas emissions (lower fuel consumptions following a reduced number of treatments, carbon sequestration, reduced use of fertilizers), crop adjustment (particularly to draughts), increase of yields. GM rice and tolerance to draughts are currently seen as the two main subjects of research and development in the field of genetically modified crops.

At the same time, the US announced that a draught-resistant GM maize will be introduced by 2012.

Every year China, the world's main rice producer, suffers from severe crop losses due to pyralid moths. Certain moth-resistant GM rice varieties could increase productivity by as much as 8%, while reducing the use of pesticides by 17 kg per hectare. In 2009 China officially certified the bio-safety of some types of insect-resistant rice, thus paving the way for their cultivation: these are estimated to reach the market within two or three years.

At the same time, the US announced that a draught-resistant GM maize will be introduced by 2012, while Sub-Saharan African countries will only manage to start its development in 2017[19]: however, the subsequent time to market will be much longer (and thus the practical impact on the agriculture and economy of such regions can only become visible between 2015 and 2020, provided that schedules are complied with).

18 *Green Biotech & Climate Change, EuropaBio, June 2009.*
19 *Global Status of Commercialized Biotech/GM Crops: 2009, Clive James (ISAAA).*

Below is a table summarizing the state of the art in the sector.

Figure 1: Commercial or pipeline GM crops in the world per trait[20]

Trait category	Commercial in 2008	Commercial pipeline	Regulatory pipeline	Advanced R&D pipeline	Total by 2015
Insect resistance	21	3	11	22	57
Herbicide tolerant	10	4	5	13	32
Crop composition	0	1	5	10	16
Virus resistance	5	0	2	3	10
Abiotic stress tolerance	0	0	0	5	5
Desiase resistance	0	0	1	3	4
Nematode resistance	0	0	0	1	1
Fungus resistance	0	0	0	1	1
Others traits	2	0	0	11	13

Source: "The global pipeline of new GM crops", JRC, 2009

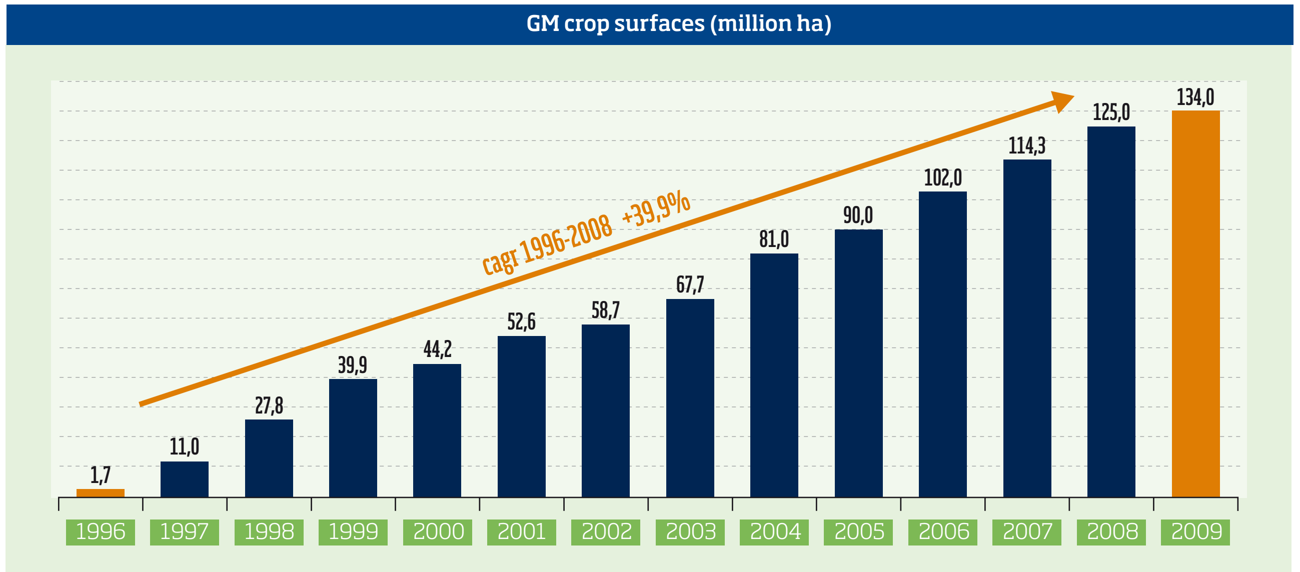
A close look at the present situation, rather than at the future, highlights a different picture, in that the available GM varieties have not been able to provide undisputed benefits to the environment so far.

2.4 The existing commercial products

One important consideration with respect to the GMO phenomenon concerns the scale of adoption of this technology. In this respect, no studies of international organizations, such as UN Agencies, are available, and the only data included in the whole literature on the subject, which will be mentioned in this work, is disclosed every year by the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), a foundation whose purpose is to promote the dissemination of agro-biotechnologies in the world, and whose financial sources include the main companies in the sector.

The ISAAA estimates that 70% of soybean, 46% of cotton, 24% of maize, and 20% of rapeseed in the world are GM. These figures are obviously significant: 134 million hectares of crops were obtained from GM plants in 2009, about 80 times as many as in 1996, when their commercialization started. In terms of average growth, this means that transgenic crops increased by an average compound annual growth rate (CAGR) of 39.9% in the world in the past 14 years and of 10.46% in the past 5 years.

20 *Legend: commercial crop (commercial GM variety), commercial pipeline (GMOs approved for sale at least in one Country), regulatory pipeline (GM products for which the relevant approvals have been already applied for at least in one Country), advanced R&D pipeline (GMOs not subject to approval processes, but at the final stage of development), other crops (GMOs approved at least in one Country, but not marketed or marketed in the past, and not available on the market today).*



Source: "Global Status of Commercialized Biotech/GM Crops: 2009", Clive James (ISAAA)

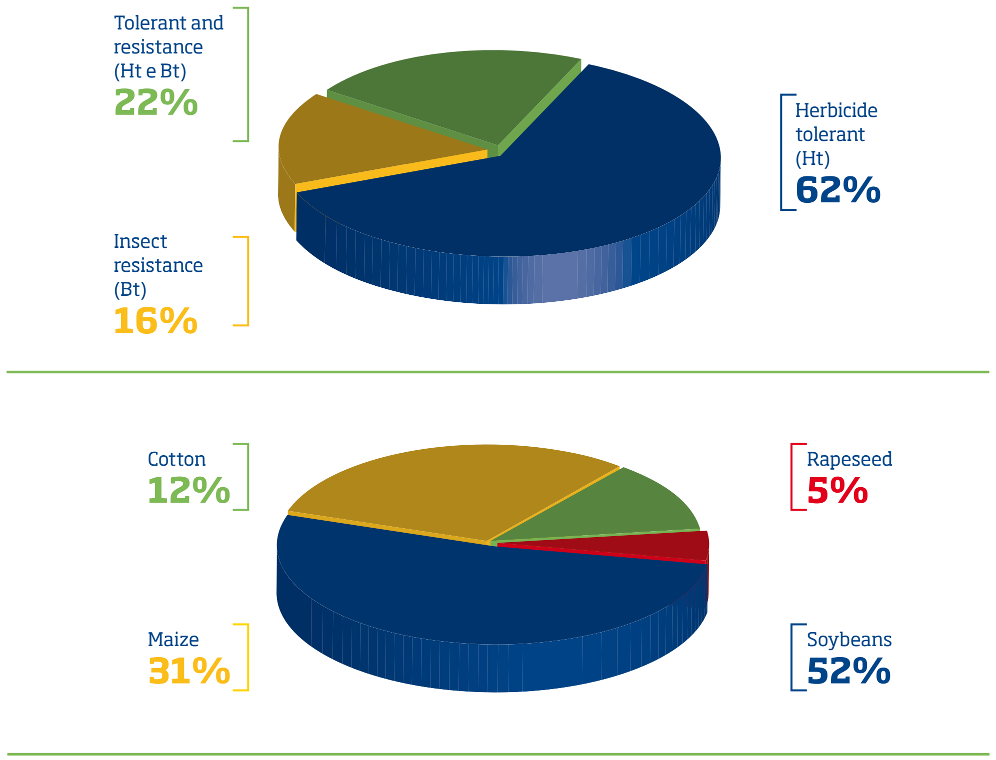
A very significant medium-term increase is thus recorded, combined with an equally significant decline in the past few years: the annual growth rate of crop surfaces was 12% in 2007, 9.4% in 2008, 7% in 2009. In 2009, 60% of the total increase was due to the increase of transgenic crops in Brazil, and another 10% was due to the increase of Bt cotton in India, where meanwhile the commercialization of Bt egg-plants was discontinued.

The most popular GM plant varieties include soybean (52% of the total transgenic crop surface), maize (31%) and cotton (12%). If rapeseed is included (5%), the amount is close to 100% of the total GM crop surface, also considering the more limited crop surfaces of transgenic sugar beet, alfalfa, and papaya.

David Boyer/National Geographic Image Collection

In terms of technological properties, tolerance to herbicides is the prevailing trait with 62% of the transgenic crop surface, whereas insect-resistant plants cover 16% of the surface, and their combination in the same crop, the so-called "stacked genes", covers the remaining 22%.

Figure 2: Trait category commercialized



Source: Joint Research Centre - European Commission

2.5 The producing Countries

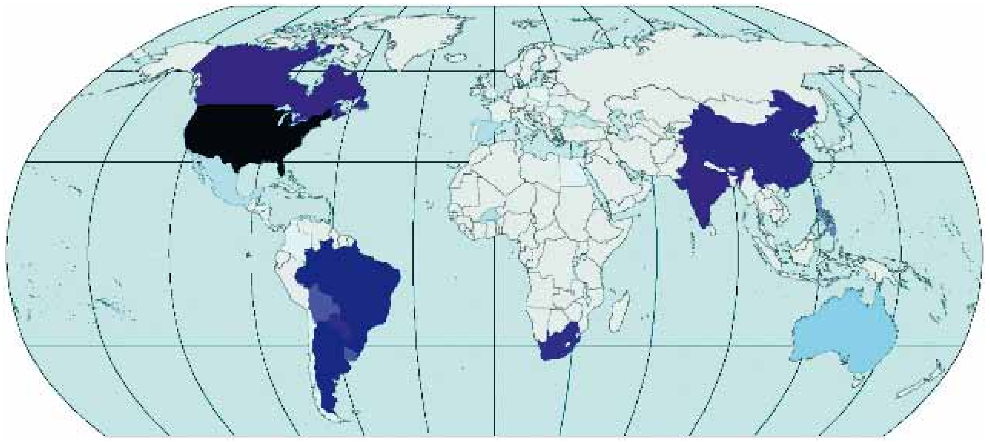
In 2009, 8 Nations planted more than 1 million ha of GM crops. These were: US, Brazil, Argentina, India, Canada, China, Paraguay, and South Africa.

The remaining countries include: Uruguay, Bolivia, Australia, Burkina Faso, Chile, Colombia, Costa Rica, Czech Republic, Egypt, Honduras, Mexico, Spain, Poland, Portugal, Romania, and Slovakia, in some cases with surfaces limited to few hundreds hectares.

In Europe, six countries planted a total of 94,750 ha of GM crops in 2009 (80% in Spain) vs. 107,719 ha planted in 2008 (-12,04%).

Of the 25 Countries around the world that grow GMOs, 16 are developing economies, while the other 9 are developed economies. Based on ISAAA data, 13 million farmers, out of 14 million (90%) that used GM plants, are located in the south of the world.

Figure 3: Distribution of GM crops in the world (millions of hectares), 2009

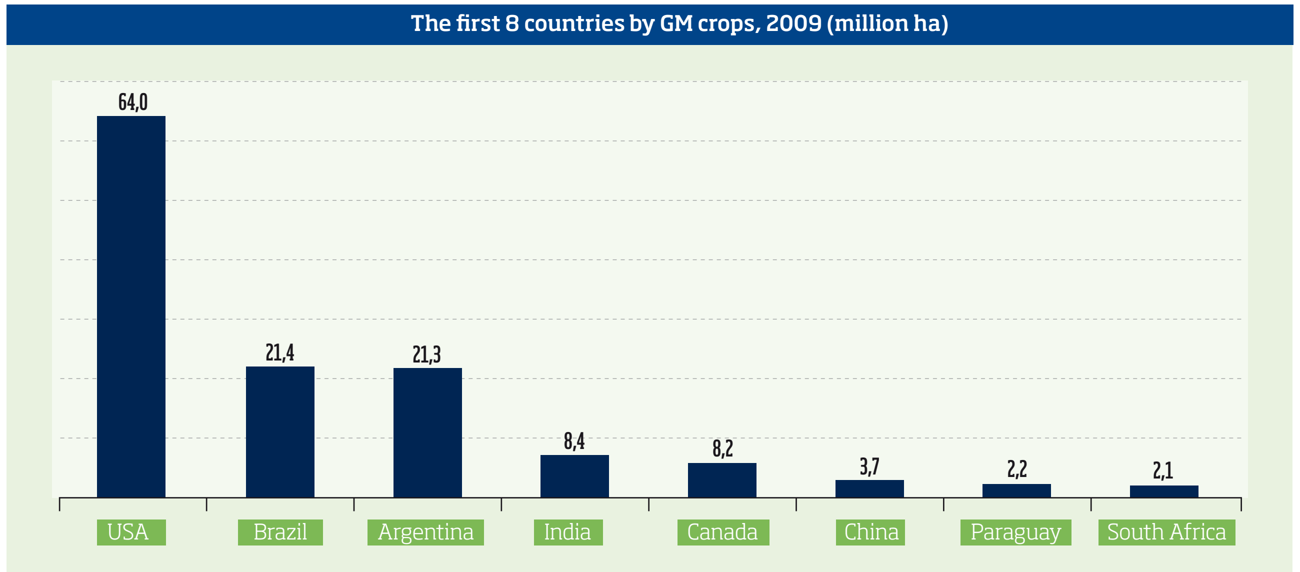


*Note: The diffusion of GM crops is represented with a colour scale that includes **blue** (high GMO prevalence), **green** (medium-high GMO prevalence), **red** (relatively low GMO prevalence), and **yellow** (low GMO prevalence); in general terms, the brightest hues correspond to a higher prevalence of GM crops.*

Source: processed ISAAA data, "Global Status of Commercialized Biotech/GM Crops in 2009"

Actually, 6 States (US, Brazil, Argentina, India, Canada, China) account for 95% of GM crop surfaces in the world, with a mere 5% left to the remaining 19. The American continent alone accounts for 89% of the total.

Figure 4:The first 8 countries by GM crops, 2009 (million ha)



Source: "Global Status of Commercialized Biotech/GM Crops: 2009", Clive James (ISAAA)

Probably the most significant and popular example of such GM expansion in the world's poorest regions is provided by cotton in India (which will be further described below through a detailed review of the advantages and disadvantages of such crops for developing countries). At this stage, suffice it to observe that biotech cotton in India definitely brought about a significant (albeit "controversial") change for the local production: 5.6 million growers planted 8.4 million ha. in 2009, equal to a record 87% rate of adoption.

Jim Richardson/National Geographic Image Collection

3. The answers to the questions of the Barilla Center for Food and Nutrition

Michael Poliza/National Geographic Image Collection


Annie Griffiths Belt/National Geographic Image Collection

This section contains an attempt to provide at least some useful keys for interpretation, rather than comprehensive responses (as we will see, not all the themes offer the opportunity to take a clear, non-controversial stance), to improve understanding of the issue.

FOOD FOR HEALTH

ARE THERE HEALTH RISKS TIED TO EATING GENETICALLY MODIFIED FOODS CURRENTLY ON THE MARKET?

Is the testing and authorization system adequate?

Have there been any cases of harmful effects on health caused by the consumption of genetically modified foods?

In the long term may there be effects on health which we are not aware of at present?

Is work being carried out to make genetically modified foods available which may play a role in disease prevention?

FOOD FOR SUSTAINABLE GROWTH

CAN GMOs CONTRIBUTE TO TACKLING AND SOLVING PROBLEMS ASSOCIATED WITH ENVIRONMENTAL SUSTAINABILITY AND THE SHORTAGE OF NATURAL RESOURCES? OR, ON THE CONTRARY, DO THEY CONSTITUTE A THREAT TO BIODIVERSITY?

Can GMOs contribute to tackling and solving problems associated with environmental sustainability and the shortage of natural resources?

What impact does the extensive GMO monoculture farming model have on the environment?

Can the use of GMOs create a negative impact on the natural habitat of wild animals and insects?

Does the use of GMOs decrease the need to resort to pesticides, also taking into consideration the risk of resistance developing?

Which risks derive from possible contamination amongst GM and conventional plants?

FOOD FOR ALL

CAN GMOs CONSTITUTE AN EFFECTIVE SOLUTION TO THE PROBLEMS OF ACCESS TO FOOD IN THE WORLD? OR, VICE VERSA, MIGHT THERE BE EVEN GREATER INEQUALITY IN DISTRIBUTION?

Do GMOs make it possible to achieve clear, significant and lasting increases in productivity?

Might OGMs be an answer to the agricultural problems afflicting developing countries?

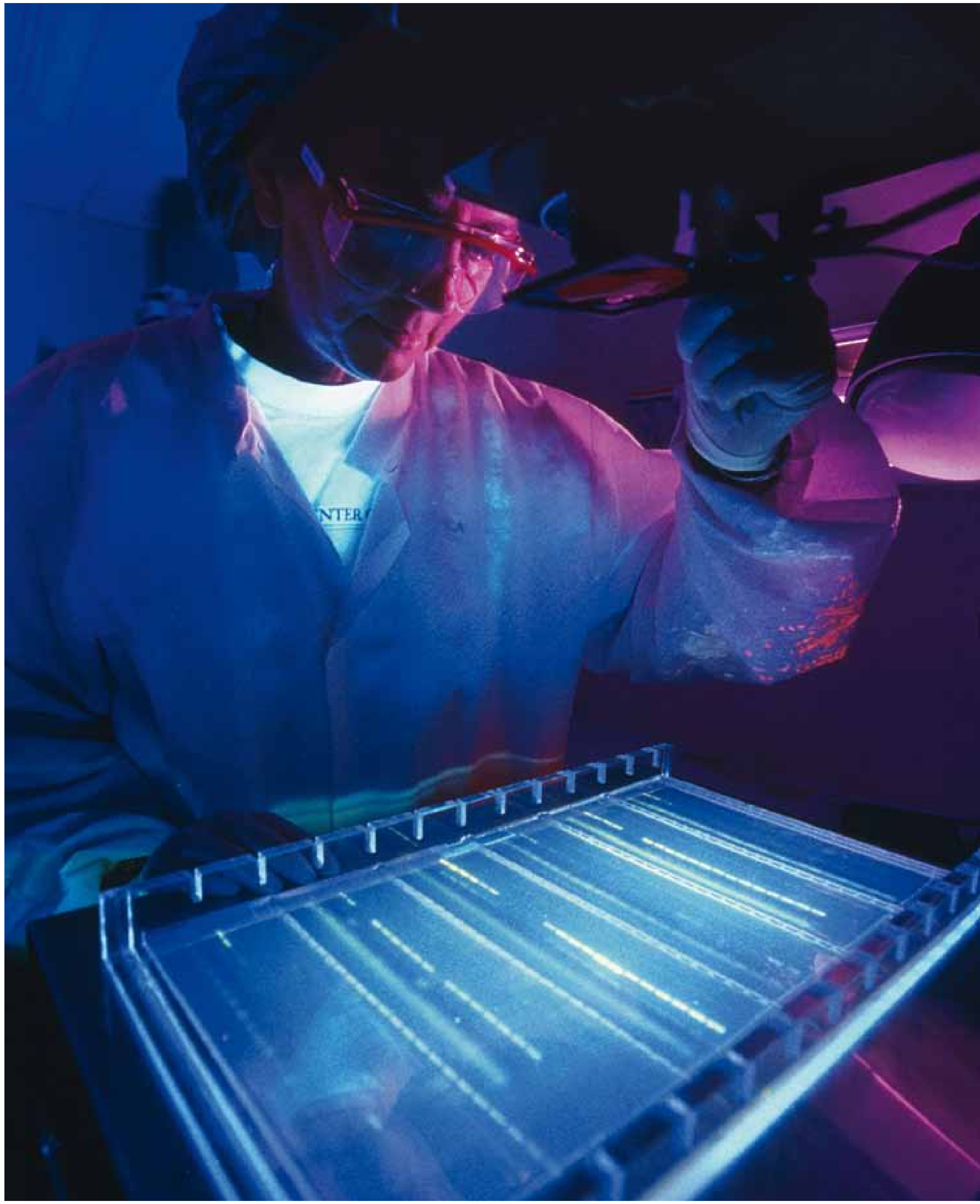
Are there any criticalities linked to the structure of the sector and the business models adopted by companies?

FOOD FORCULTURE

WHAT DO PEOPLE THINK ABOUT GMOs?

What is people's experience of GMOs?

How is the topic of GMOs handled by the media?



Jim Richardson/National Geographic Image Collection

3.1 Are there health risks tied to eating genetically modified ingredients currently on the market?

Genetically modified foods have a genetic make-up heritage modified by man using genetic engineering techniques, which allow to add, remove, or change gene elements, something that can be seen as a non-natural process.

This implies a real concern (however not confined to GMOs, but also including conventional and organic products meant for human and animal consumption) about whether food checks on genetically modified products are duly performed.

3.1.1 Is the testing and approval system appropriate?

As mentioned, genetically modified plants approved for human or animal consumption in Europe (about thirty different varieties of maize, soybean, sugar beet, and rapeseed[1]) are mostly grown in non-EU countries[2] and imported and used primarily as feed for livestock in all EU Member states.

On the other hand, the production and sale of 52 types of transgenic products meant both for human and animal consumption is now approved in the US.

The presence of new proteins in genetically modified organisms poses a potential risk of undesired effects in man and in animals.

The risk derives from the proteins codified by the inserted gene, as well as from the potential changes to the plant's metabolism, possibly due to an interaction with the other genes, which leads to the production of substances not found in conventional plants.

This is why the assessment of GMO safety is based on several aspects, including an evaluation of the individual gene-codified proteins, chemical analyses that allow to identify the presence of substances in quantities different from the corresponding conventional produce and, particularly, tests performed on animals fed the concerned organism to search for the possible onset of undesired effects.

The food safety of GMOs is ensured by a strict legal framework specifying the tests required to identify potential risks for man's health and for the environment.

In particular, before approving the introduction of these foods and feeds in Europe, the EU provides for a safety evaluation process of that is among the strictest now in place.

The US operates an approval system that is utterly different from the European one and solely implemented on a voluntary basis with respect to health risks. From the conceptual viewpoint, in fact, the US process is based on the concept of **substantial equivalence** (a product is deemed safe until it is proved to be hazardous), whereas the European one adopts the **precautionary principle** (a product should be considered as hazardous until it is proved to be safe). This difference originates from the historical diversity of both continents

In particular, the genetically modified food assessment and approval procedures are provided for by (EC) Regulation No. 1829/2003 concerning genetically modified food and feed, which came into force in April 2004, and by directive 2001/18/EC on the deliberate emission of genetically modified organisms into the environment, in force since March 2001[3].

1 *See:* http://ec.europa.eu/food/dyna/gm_register/index_en.cfm
2 *The cultivations in EU are maize and potato GMO*
3 *EFSA – European Food Safety Authority*

This regulation calls for the performance of several kinds of tests, as well as for a set of controls whose implementation may take as long as 5 years.

These assessments are performed in Europe by the European Food Safety Agency (EFSA) that, based on the reports drafted by companies, expresses a positive or negative opinion or requests further studies. Moreover, it should be noted asessment that checks are always of a documentary, rather than experimental character.

In December 2008, the European Environment Council[4] recognized that the EU has adopted a legal system for GMO authorization ensuring high-level protection of the environment and of human and animal health, but concluded that the implementation of the EU legal framework for GMOs should be strengthened. In particular, risk assessment procedures were unanimously judged inappropriate.

Therefore the EFSA, the European Commission, and the Member States, each within its scope, initiated a process aimed at implementing recent scientific acquisitions and advanced evaluation criteria.

Severe criticism has been raised by some experts and organizations against the European testing and authorization system, the most relevant of which being the absence of independent studies as a basis for the EFSA to express its opinions, founded primarily on the risk assessment accomplished recommended by the notifying company.

This criticism was raised, for example, against certain data submitted in support to the safety of a genetically modified maize variety produced by Monsanto, known as MON863, and approved by the European Commission for sale in January 2006 pursuant to Directive 2001/18. The report submitted by Monsanto in 2002 contained, in fact, a 90-day study on Guinea pigs fed MON 863, which highlighted a few differences in blood parameters and in kidney weight vs. the control animals, albeit deemed statistically non significant. This study, later also published in an international review[5], had been positively assessed both by the German expert committee that first reviewed the report and later by the EFSA. Both assessment committees had come to the conclusion that the observed differences were biologically non significant. The French committee CRIIGEN (Committee for Independent Information and Research on Genetic Engineering) disagreed with these conclusions and requested to review the original data of the study. After Monsanto refused to provide such data, Greenpeace brought an action and obtained access upon injunction of the judge in June 2005. Based on the data submitted by Monsanto, the CRIIGEN researchers carried out a new statistical assessment and concluded that, while the performed analyses were formally correct, their results did not allow to exclude a potential kidney toxicity and new studies were required to assess the safety of this transgenic maize appropriately[6]. The EFSA was requested to review the data in the light of this new analysis and, upon completing a further assessment, confirmed its opinion, namely that the products derived from this transgenic maize variety should be considered as safe within the context of the approved use[7].

4 *Council Conclusion on Genetically Modified Organism (GMOs), 2912° ENVIRONMENT Council meeting, Brussels, 4 December 2008*
5 *Hammond B., Lemen J., Dudek R., Ward D., Jiang C., Nemeth M., Burns J., "Results of a 90-day safety assurance study with rats fed grain from corn rootworm-protected corn", Food Chem Toxicol., 2006*
6 *Séralini G., Cellier D., de Vendomois J.S., "New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity", Arch Environ Contam Toxicol, 2007*
7 *"EFSA reaffirms its risk assessment of genetically modified maize MON 863", Press Release, 28 June 2007*

3.1.2 Did any health damage occur as a result of the consumption of genetically modified foods?

The most outstanding international authorities (including the WHO, the FAO, the EFSA, the EU, the FDA, etc.), as well as the international (and Italian[8]) scientific societies, have always claimed that the existing commercial GM foods are safe.

The most outstanding international authorities have always claimed that the existing commercial GM foods are safe.

This belief originates from the findings of the scientific tests performed, none of which concludes that GMOs are toxic and, more precisely, from the absence so far of reported cases of hospitalization or specific medical treatment following the consumption of food containing GMOs. Moreover, lots of people, particularly in the US, have been consuming GM foods for years without showing any harmful effects.

At the end of a 15-year study (1985-2000) promoted by the European Union, which involved 400 public research centres with a total 70 million EUR investment, Philippe Busquin, the European Commissioner for Research, concluded that:*"These studies show that, according to the usual risk assessment procedures, genetically modified plants and the products developed and marketed so far do not pose any risks for man's health or for the environment. [...] The use of a more focused technology and the most accurate assessments upon rule issuing are likely to make these plants and these products even safer than conventional ones."*[9]

The parties in disagreement with the findings of the study pointed out that commercial GMOs at the time were still very limited, particularly in terms of trait variety, and investigations on the products' harmlessness can, by their own nature, be performed case by case only, and cannot be expanded to the future products of technology for reasons of scientific rigour. Moreover, they also pointed out that the broad range of funded studies did not fall within the framework of such an integrated design as to represent an investigation of consistent and coordinated aspects.

Indeed, some concerns still persist about any possible effects on man's health. These include:

- **allergies**;
- **resistance to antibiotics;**
- **gene transfer.**

Allergies

Gene introduction into an organism implies a possible production of allergens, i.e. compounds that cause an immune response in susceptible individuals, thus triggering an allergy.

It is still unclear, though, whether GMOs can cause short and long-term allergies (not least because even the mechanisms that cause allergies to non transgenic foods are still largely unknown). Moreover, while most traditional foods are rich of allergens, no preventive analysis for allergenicity is provided for these kinds of food. However, when a transgenic plant is assessed, one preliminary check concerns its allergenic potential.

8 *"Sicurezza alimentare e OGM. Consensus document" document signed by all the main Italian Scientific Academies and Societies in 2004*

9 *European Union, "Review of results of 15 years study on GMOs", 2000*

In fact, while no absolute tests exist for the purpose, the allergenic potential is tested by means of chemical and physical tests and immune assays *in vitro* and *in vivo*, which allow to measure it before and after inserting the transforming gene into the plant[10].

The FAO and the WHO have excluded the existence of allergenic effects in the genetically modified products now available on the market.

By means of these tests, the FAO and the WHO have excluded the existence of allergenic effects in the genetically modified products now available on the market, and have already actively stopped the market launch of certain varieties that posed risks of onset of allergies instead[11].

However, studies performed on Guinea pigs reported the onset of some inflammatory and allergic reactions in individuals fed exclusively genetically modified feed[12].

Resistance to antibiotics

Certain commercial GMOs contain, in addition to the gene of interest, a gene ensuring their resistance to an antibiotic agent (90% kanamycin, 10% ampicillin and hygromycin). The reason is that, in order to select the cells that have actually assimilated the foreign gene into their DNA, a gene (known as marker) is also inserted to ensure resistance to a given antibiotic agent: if a cell culture is exposed to such agent, only the transformed cells survive, and can thus be recognized.

The antibiotic agents at issue are already seldom used for therapeutic purposes due to their toxicity or poor efficacy[13] (kanamycin and hygromycin are toxic, whereas ampicillin is actually still in use, even if most micro-organisms, e.g. soil micro-organisms, have by now developed resistance to it).

Concerns exist that the consumption of transgenic foods may promote the transmission of resistance to a specific antibiotic agent from food to non-pathogenic bacteria that live in our digestive tract, and from these to pathogenic bacteria capable to infect man, making them resistant to treatments with such agent.

The consumption of transgenic foods may promote the transmission of resistance to a specific antibiotic agent.

With respect to this problem, the EFSA published an opinion in 2004, admitting the existence of this risk and mentioning several risk levels tied to the individual resistance genes, based on which it issued guidelines to limit their use[14].

While the use of these genes was gradually discontinued (upon suggestion of the WHO/FAO and upon recommendation of the EU rules), most of the approved transgenic plants have a gene that is resistant to some types of antibiotics.

However the risk looks quite remote and a pathogenic bacterium is more likely to acquire the gene for resistance to an antibiotic agent from bacteria resident in the human gastrointestinal tract or in the soil than from GMO-derived foods.

10 *According to Recommendation EC 97/618 regulating the use of toxicity and allergy tests and resistance to antibiotics*

11 For example, in the course of development of a soybean variety genetically modified with the insertion of the gene of Brazilian nuts to improve its sulphur aminoacid contents (methionine, cysteine), the protein codified by the inserted gene (Albumin 2S) was found to be an allergen of walnuts. Therefore research on this variety was discontinued

12 *See, for example, Finamore A., Roselli M, Britti S., Monastra G., Ambra R., Turrini A, Mengheri E., "Intestinal and Peripheral Immune Response to MON810 Maize Ingestion in Weaning and Old Mice", 2008*

13 *"Safety of Genetically Engineered Crops," VIB, 2001*

14 *"Opinion of the Scientific Panel on Genetically Modified Organisms on the use of antibiotic resistance genes as marker genes in genetically modified plants", Question N° EFSA-Q-2003-109), adopted on 2 April 2004*

Gene transfer

One concern associated with the introduction of GMOs in crops refers to the possibility for transgenic DNA fragments to be absorbed by the tissues of animals or men consuming genetically modified foods.

However, according to the European Commission, no GMO residues are found in the meat or milk that we consume, due to degradation mechanisms in the animal and human gastrointestinal tract.

In this respect, the EFSA stated in a notice that: "*After ingestion, a rapid degradation into short DNA or peptide fragments is observed in the gastrointestinal tract of animals and humans. […] "To date a large number of experimental studies with livestock have shown that no rDNA fragments or proteins derived from GM plants have been detected in tissues, fluids, or edible products of farm animals*"[15].

Notwithstanding this, it should be noted that some studies[16], including very recent ones[17], have demonstrated the presence of modified DNA in the blood and milk of certain animals fed genetically modified feed, and that the cells of the stomach and intestine may absorb DNA fragments whose size is such as to contain whole genes (even if this characteristic is not peculiar to transgenes, in that all the ingested DNA undergoes the same process).

3.1.3 Can now unknown health effects occur in the long term?

Despite – as anticipated – the encouraging results of the scientific tests and the fact that no damage to man's health was ever reported following the consumption of genetically modified foods, it should be noted that no true epidemiological studies have been performed on a target population and a control population, and thus no empirical evidence exists[18], allowing to claim the absence of long-term effects with certainty[19]. The prevalent destination of most GM crops itself makes it impossible to evaluate any impacts of long-term and consistent exposure to transgenic foods on man's health.

The main objection is that, while tests prove the absence of immediate risks, the extent to which ordinary consumption may generate health damage in the long term cannot be established.

The issue of the long-term safety of GMOs is, in fact, quite controversial and widely debated in the scientific community, also at institutional level within the FAO and the WHO. At the end of such discussions, in the light of the experience developed with GMOs and other issues, while no elements are available that point out to long-term adverse health effects attributable to genetically modified organisms, few studies are developed on long enough time periods.

15 "EFSA statement of the fate of recombinant DNA or proteins in meat, milk and eggs from animals", July 2007
16 Duggan P.S. et al, "Survival of free DNA encoding antibiotic resistance from transgenic maize and transformation activity of DNA in ovine saliva, ovine rumen fluid and silage effluent", FEMS Microbiology Letters, 2000; Einspanier R. et al, "The fate of forage plant DNA in farm animals; a collaborative case study investigating cattle and chicken fed recombinant plant material", European Food Research Technology, 2001; Netherwood T. et al, "Assessing the survival of transgenic plant DNA in the human gastrointestinal tract", Nature Biotechnology, 2004
17 For example a recent work studied groups of goats fed traditional and GM feed: Tudisco R. et al., "Fate of transgenic DNA and evaluation of metabolic effects in goats fed genetically modified soybean and in their offsprings", Animal, 2010
18 However, studies on this subject would be very complicated, due to the wide variety of man's diet and to the multiple concomitant risk factors that should be considered
19 Domingo J., "Toxicity Studies of Genetically Modified Plants: A Review of the Published Literature", 2007

The absence of compulsory labelling in the US and the prevalent destination of most GM crops do not make it easy to perform epidemiological studies.

No elements are available that point out to long-term adverse health effects attributable to genetically modified organisms, few studies are developed on long enough time periods.

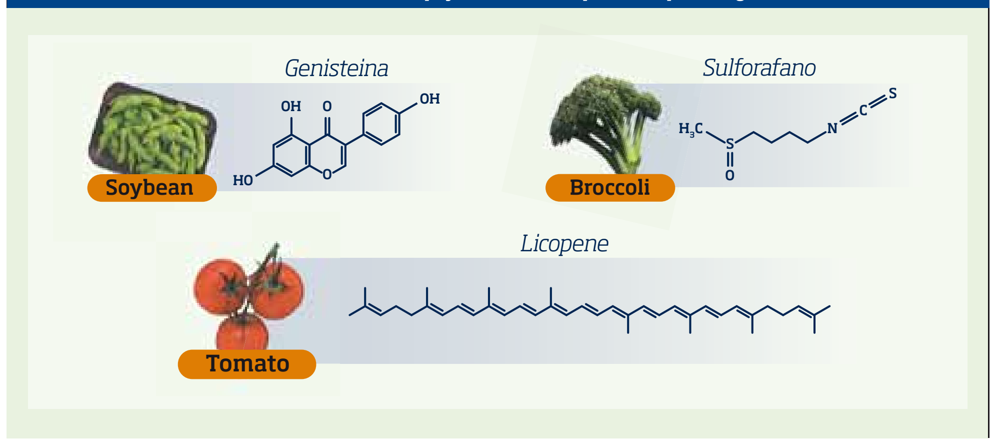
This is why the joint FAO/WHO consultation in 2000[20] stressed the need to carry out long-term toxicological and monitoring studies to ensure more safety for any food. The progress of scientific research itself could provide useful instruments to establish whether any long-term adverse effects may occur..

3.1.4 Are any efforts currently under way to obtain genetically modified foods with a role in disease prevention?

In this regard, studies are being carried on in plants to test the ability to manipulate through genetic engineering, the ability of crops to produce vitamins and other "nutraceuticals".

They include, for example, the introduction of genetically modified foods in order to contain a higher amount of antioxidants, essential amino acids, vitamins (A, B, E), iron and trace elements (Zn, Mg, Se), omega-3, etc

Some anti-cancer phytochemical compounds of plant origin



One existing example of these kinds of products is Golden Rice, a rice whose grains develop a golden due to their carotenoid contents (pro-vitamin A), which could be an option to manage the problem of blindness in Third-World Countries.

20 Safety aspects of genetically modified foods of plant origin, Report of a Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology, World Health Organization, Headquarters, Geneva, Switzerland, 29 May – 2 June 2000.
21 Newell-McGloughlin M., "Nutritionally Improved Agricultural Crops", University of California, American Society of Plant Biologists, 2008

GOLDEN RICE

One crucial issue – at present and, particularly, for the future – is the so-called "hidden hunger" that, according to the World Food Programme's estimates, affects more than two billion people. "Hidden hunger" refers to a condition in which, upon equal calorie intake, a deficiency – often dramatic – of one or more fundamental micronutrients for the well-being of the human body is observed. The World Food Programme stresses that the diseases and physical disorders related to such deficiency represent one of the most severe causes for socioeconomic discomfort in developing Countries.

Micronutrients include, in particular, Vitamin A, whose deficiency – according to the World Food Programme – causes about 800,000 deaths a year among women and children. In fact Vitamin A, contained primarily in vegetables and cereals, helps regulate a number of fundamental biological processes, including growth, sight, reproduction, and cell differentiation. The FAO regularly calculates the availability of Vitamin A (retinol) for human consumption around the world by converting the estimated food available for consumption into retinol equivalent (RE) micrograms (mcg). The available data – for the 2003-2005 period – show that Vitamin A deficiency is particularly significant in most developing Countries.

This was the background for the *Golden Rice* initiative, aimed at developing a rice variety rich of beta-carotene to help make up for Vitamin A deficiency in most developing Countries.

Research on *Golden Rice* started in 1982 as an initiative of the Rockefeller Foundation. After some years of study, in 1999 Peter Beyer and Ingo Potrykus demonstrated that genetic engineering could be used to make rice grains produce beta-carotene (which is not found in traditional rice): the rice obtained through genetic engineering has a golden grain, due to its carotenoid contents (hence the name *Golden Rice*). The beta-carotene consumed with food can be converted by the body into the necessary Vitamin A amount.

At first, while the discovery aroused widespread hope about an immediate remedy for the severe consequences of Vitamin A deficiency, it turned out that the amounts of beta-carotene that could be taken through an assumed consumption of the original version of *Golden Rice* (GR1) were too low to achieve the daily pro-vitamin A targets deemed appropriate for populations suffering from Vitamin.

The research efforts that followed resulted into the identification of a second-generation *Golden Rice* variety (GR2), whose beta-carotene content was 23 times higher than in the original variety. According to estimates, at such levels of beta-carotene, a daily consumption of 72 grams of *Golden Rice* is both in line with the average consumption recorded in the target developing Countries (about 100 grams of rice per day per child) and capable to provide the minimum amount of Vitamin A (after conversion by the body) required to live a normal and healthy life.
The most popular studies on the possible impact of an actual use of *Golden Rice* were carried out by Roukayatou Zimmermann and Matin Quaim with reference to the Philippines, using simulation techniques. Results were encouraging and led to conclude that, while a practical use of *Golden Rice* in the Philippines could actually help reduce the incidence of VAD (Vitamin A Deficiency), this cannot be the final and only solution to the problem.

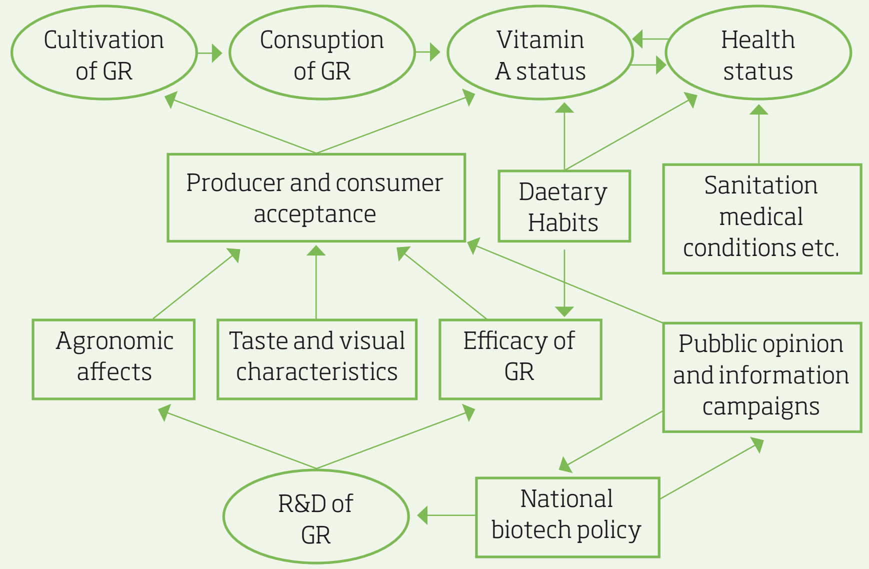
Zimmermann and Quaim recognized that the introduction of *Golden Rice* should not discontinue the struggle against the causes of poverty and discomfort in developing Countries. *Golden Rice* can provide significant help, particularly in rural communities. But this help would and will not make up for the need to ensure a significant improvement of the existing infrastructure, of education levels, and of all the other factors hampering the development of such countries.

As for any innovation in the agro-food sector in such complex and fragile environments, the impact of *Golden Rice* needs to be mediated by a broad set of factors (as noted by Zimmermann and Quaim), strictly concerning both the implementation of farming practices and the nutritional and social acceptance of innovation, as well as related to the regulating and R&D sphere and referring to the overall hygienic and health conditions in the regions where *Golden Rice* would be introduced. At present, it is impossible to provide a final judgement on what has been known for many years as the GMO of hope,

Some of the criticism against the development of the existing commercial GMOs was partly overcome in the case of *Golden Rice*: its development is also promoted by the efforts of a private multinational company, Syngenta, but without any commercial purposes (at least not in developing Countries, which would be its main recipients); it was created and developed in an utterly "public" domain and has been aimed at social purposes from the outset; its development is shared in view of spreading to several developing Countries, in order to identify any context-specific varieties of rice and thus try to overcome at least part of the criticism against other existing commercial GMOs – i.e. not being developed for context-specific purposes.

While the positive approach of this project is remarkable, criticism is mostly directed against the unstable nature of any major experiments, rather than against speculating intentions to the detriment of the weaker populations.

Another example concerns tomatoes enriched with anthocyanins, colour pigments contained in a variety of common flowers and fruits, such as blackberries and blueberries, with a generally strong antioxidizing and protective action against certain kinds of tumours, including colon cancer[22]. The efficacy, in terms of extension of the average life expectancy, of administering to Guinea pigs tomatoes containing high amounts of anthocyanins, obtained through gene modification, was tested experimentally[23]. Last but not least, studies are now at different stages to obtain GMOs capable to produce antibodies for diagnostic or therapeutic use (e.g. for cancer antigens) or antigens (e.g. for vaccines).



22 Umberto Veronesi, 1st International Forum on Food and Nutrition, Rome, December 3, 2009
23 Butelli E., Titta L., Giorgio M., Mock H. P., Matros A., Peterek S., Schijlen E., Hall R. D., Bovy A. G. "Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors", October 2008

3.1.5 Summary remarks on the Health Area

The issue of the safety of genetically modified foods is the one on which there is most agreement between the various opinions in this area.

The European authorization system for selling genetically modified ingredients would seem to be the most restrictive of those adopted by countries. However, some aspects of risk assessment must be further improved, for example, through the introduction of evaluations of tests made by independent bodies.

To-date, scientific studies undertaken on an international level have not shown evidence of serious effects on human health, at least not in the short-term. Over the long-term, there is nothing to give rise to the fear of negative effects, although there are no studies which would provide definitive confirmation of this.

Among the areas of attention for human health are:

- the onset of allergies, but which the current authorization system seems able to detect;
- resistance to antibiotics, even if the use of gene markers resistant to antibiotics[1] was the subject of a recommendation of the European Commission;
- the risk of gene transfer, regarding which the results of scientific studies still differ.

The most positive aspects of scientific research in this area is the creation of genetically modified foods with nutritional characteristics superior to traditional ones or even protective characteristics against some pathologies.

Lynn Johnson/National Geographic Image Collection

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3.2 Can GMOs help address and solve the issues of environmental sustainability and shortage of natural resources? Or do they rather pose a threat to biodiversity?

The introduction and growing adoption of GM plants have opened up a long-standing debate on the possible environmental impact of these crops.

More specifically, the public debate and the political approach are focused on the impact of transgenic crops on environmental sustainability, on the preservation of biodiversity, and on the protection of ecosystems.

3.2.1 Can GMOs contribute to tackling and solving problems associated with enviromental sustainability and the shortage of natural resources?

The varieties of existing commercial GM plants were developed for two main purposes: resistance to parasites (*Bacillus thuringiensis* - Bt) and to viruses on one hand, and tolerance to herbicides (*Herbicide tolerant* - HT) on the other. GM plants are thus created with the intention to provide farmers with a solution to problems that have always affected crops (first and foremost parasites and weeds) and to preserve, at the same time, crop integrity in terms of quality and quantity.

In a context characterized by climate changes and the shortage of natural resources, GM plants will also be requested, in the near future, to fulfil other practical functions[24]. In the medium term, in fact, farmers have great expectations about the ability of commercial plants to resist to adverse environmental and climatic conditions,[25],[26] including:

- high or low temperatures (or sudden changes thereof);
- high or low light exposure;
- water shortage;
- unbalanced nutritional properties of soils (minerals / metals);
- soil salinity
- etc.

In this respect, the future of GM varieties is by far at stake. To date, however, no GM products are available capable to cope effectively with adverse environmental and climatic conditions.[27].

To date, no GM products are available capable to cope effectively with adverse environmental and climatic conditions.

In fact, despite frequent announcements of successful experiments, the development of new useful traits continued at quite a limited pace in the past few years, definitely below the much more optimistic expectations expressed during the 1990s, when the excitement following the market launch of the first products pointed out to much more brilliant perspectives

24 Commission of the European Communities, "Adapting to climate change: the challenge for European agriculture and rural areas", 2009.
25 "The global pipeline of new GM crops", Joint Research Center - European Commission, 2009.
26 ISAAA, "2009 ISAAA Report on Global Status of Biotech-GM Crops", 2009.
27 CTIC, "Facilitating Conservation Farming Practices and Enhancing Environmental Sustainability with Agricultural Biotechnology".

3.2.2 What is the impact of the extensive single-culture GM farming model on the environment?

One of the hottest themes in the debate on the use of GMOs in agriculture is simplified crops, inevitably associated with the risk of a possible reduction of biodiversity[28].

Biodiversity is intended as the set of genetic resources available in a given region; the broader and more diversified these genetic resources, the higher the potential for new crops and new food[29].

The debate on the preservation of biodiversity has been going on for several years in agriculture. Large pre-GMO monocultures, associated with some methodologies typical of the so-called "green revolution", have implied a risk of suppression of agro-biodiversity and of wildlife. However, while traditional farming practices as a whole induce a selection of crop species, which generated, in turn, a reduction of the genetic heritage in time, they do not seem to pose a serious threat to biodiversity.

However, the growing popularity of GM plants resulted into the farmers adopting a specific farming model, based on monocultures on extended land surfaces. The reasons for this choice refer to economic considerations and are associated with the pursuit of economies of scale and cost savings[30].

The growing popularity of GM plants resulted into the farmers adopting a specific farming model, based on monocultures on extended land surfaces.

This aspect is reflected in the numbers describing the size of GM crop surfaces in the world[31]. 85,9% of such surfaces are geographically located in developed Countries or in countries characterized by extensive crops[32] (85,4% of the world crops are in the US, Brazil, Argentina, and Canada), whereas only 14,1% reside in developing or recently industrialized countries[33].

In that part of the world that is worth 85.9% of the total crop surface, the average size of farming lands is more than 110 hectares, vs. about 1.5 hectares in the remaining 14.1%.

While the analysis can be further differentiated taking into account the different product types to come up with more detailed results, a close association between a farming model based on single crops on extended land surfaces and the use of GM seeds is very clear.

While concentrating a limited number of crops on extended surfaces seems to give life to an effect of substitution of previous crops, some claim that genetic engineering plays a role in the protection of plant species at risk of extinction. One case in point concerns the GM papaya, briefly described below.

28 Graham Brookes, Peter Barfoot, "GM crops: global socio-economic and environmental impacts 1996-2007", 2009.
29 Rio de Janeiro Convention on Biological Diversity, 1992.
30 Graham Brookes, Peter Barfoot, "GM crops: global socio-economic and environmental impacts 1996-2007", 2009.
31 Global Status of Commercialized Biotech/GM Crops: 2009, Clive James, ISAAA.
32 US, Brazil, Argentina, Canada, Australia, Spain, Czech Republic, Portugal, Romania, Poland, and Slovakia.
33 India, China, Paraguay, South Africa, Uruguay, Bolivia, Philippines, Burkina Faso, Chile, Mexico, Colombia, Honduras, Costa Rica, and Egypt.

THE PAPAYA OF HAWAII

Papaya is a widespread crop in most parts of the world, including Brazil, Mexico, India, and Indonesia, and has come into the limelight as an international "case" for its happenings in Hawaii, where it is a typical produce.

Papaya is susceptible to attacks by the RingSpot virus (PRSV), transmitted by aphid, against which no treatment exists. Papaya plants can be "vaccinated" using a process similar to human vaccination, which provides for the inoculation of an attenuated culture virus into the plants to make them "ready" to fight the virus, in case of occurrence. However, one contraindication to this generally effective technique is the damage caused to the fruits in case of virus attack: the plants appear technically healthy, but the commercial value of the fruits declines significantly. Moreover, there is no hereditary transfer from the "vaccinated" plants to their offspring.

In order to overcome these critical factors, a team of public researchers from the Hawaii University, the Cornell University, and the USDA, independent of private multinational companies, led by Dennis Gonsalves (photo), decided to promote an experimental project aimed at creating papaya varieties genetically resistant to the virus: the study was launched in 1986 and completed successfully in 1991 with the creation of the papaya variety known as *Sunset*, which was promptly field-tested for efficacy.

The time of the final check of the effectiveness of the study came, unfortunately, quite soon: in the spring of 1992, the virus spread to and destroyed all the papaya crops on the island. Until 1994, traditional containment techniques were implemented, albeit unsuccessfully, basically founded on the destruction of the infected plants. At the same time, following the direct field observation of optimal resistance of the *Sunset* plants to the virus, two varieties of papaya were developed for commercial purposes, namely *SunUp*, directly derived from *Sunset*, and *Rainbow*, born from cross-breeding *Sunset* and the traditional local variety. In 1995, the process for the approval of the Food and Drug Administration (FDA). Enviromental Protection Agenzy (EPA) and the Ministry of Agriculture for sale started. In the spring of 1998 the licence was obtained, and the free distribution of GM papaya seeds to the farmers could thus start.

The production of papaya in 1992 amounted to 26thousand tons. Later, due to the virus, it gradually fell to 19thousand tons in 1995 and to 12thousand tons in 1999. In 2001, following the commercial launch of the GM papaya, a 23thousand ton production was recorded. It should be noted that not all of these were derived from GM plants: according to 2006 data, the GM papaya variety only accounted for 58% of the total. Not all the merits of the revival of local production can thus be attributed to the introduction of GM varieties, which played an important role anyway, also in terms of containment of the virus' spreading to traditional, still unharmed, crops.

Following a number of checks, in 2003 the GM papaya varieties produced in Hawaii were deemed acceptable by Canada. However, despite this commercial opening, Japan and Europe do not allow their sale on their domestic markets and only import the traditional variety: the commercial closing to the Hawaiian papaya resulted, as recognized by all observers, into a significant decrease of the total turnover for local growers, something that was harshly criticized by some observers – including Greenpeace – stressing that the local economy did not draw any significant benefits from the introduction of the GM varieties, and claiming that the use of non-GM techniques to rescue and re-introduce papaya crops would have ensured that the local population could go on accessing the previously served outlet markets.

This observation, while founded on a long-term basic logic, does not seem to take into due account the positive impact that several observers attribute to the discovery of the researchers led by Dennis Gonsalves.

While, on one hand, the protection of the local crops appeared at severe risk, and thus the introduction of GM varieties produced immediate benefits, on the other the international acceptance of GM products caused a relative economic and commercial worsening of the local economy.

Gerry Ellis/Minden Pictures/National Geographic Image Collection

3.2.3 Can the use of GMOs generate negative impacts on the natural habitat of insects and wildlife?

An additional object of debate concerns the possible effects of GM plants on the protection of ecosystems. The introduction of GM plants can, in fact, have a negative impact on insects and wildlife and on their habitat. Several theoretical simulations based on mathematical models[34] point out to the risk for the survival of animal organisms following the introduction of GM plants. The causes for this are mostly attributed to a more limited availability of food, particularly for bird populations. This appears more severe in Europe than in other regions of the world, due to the more limited availability of non-farming lands.

Several studies were carried out on the impact of the introduction of GM crops on the natural habitat.

Several studies based on direct observation were carried out on the impact of the introduction of GM crops on the natural habitat of wildlife species[35]. One of the most comprehensive of these, somehow summarizing the state of the art of the matter, is an independent survey commissioned by the UK Department for Environment, Food and Rural Affairs (DEFRA)[36].

This study, which started in 1999 and continued for five years, is based on 266 direct observations, both in spring and in autumn. The impact of HT crops (sugar beet, maize, and rapeseed) was quantified vs. conventional varieties in terms of abundance and diversity of wildlife in farming lands.
No univocal results were obtained for all the crops. Significant differences were, in fact, recorded within each, making the possible interpretation of phenomena quite controversial.

In particular, in 2003 researchers observed the existence of significant differences between GM and conventional varieties (in favour of the latter) in the abundance of wildlife with reference to spring rapeseed, sugar beet, and maize crops. More recent results also point out to differences for the winter rapeseed variety. In short, growing non-GM sugar beet and spring rapeseed creates a more favourable habitat for several animal populations compared to the corresponding GM varieties: there were more insects (including butterflies and bees) in the fields, also thanks to a higher amount of wild herbs offering food and shelter.

Moreover, seeds of weeds were more abundant in conventional spring rapeseed and sugar beet crops than in the corresponding GM crops. Such seeds are important for the diet of certain animals, particularly the birds that live near farming lands.

On the other hand, GM maize was more favourable than conventional maize for several wildlife populations. There were more weeds, more butterflies, and more bees at some times of the year, along with more weed seeds. Winter rapeseed, instead, created utterly comparable conditions for GM seeds and conventional seeds. However, GM crops saw a more limited blooming of broadleaves, particularly beneficial for wildlife, and more Gramineae weeds, along with a lower number of bees and butterflies. On the other hand, no significant differences were found in the total number of other insects, snails, and spiders.
The study also stresses that the differences among crops are not caused primarily by the genetically modified nature of plants, but are rather tied to the specific properties of HT varieties and to the different options available to farmers in terms of supporting chemical agents.

Based on the above and according to the mere results of measurements, the findings of the study stress that the use of genetically modified seeds may have implications on biodiversity. However, other factors are involved in terms of medium or long-term impacts, including the allocation of crops in farming lands, the adopted farming techniques, and the management of crop rotation. This makes it impossible to isolate a single factor to come to undisputable conclusions.

3.2.4 Does the use of GMOs decrease the use of pesticides, also considering the risk of onset of resistance?

Pesticides are considered as an integral part of modern agriculture. They are usually chemical compounds used to manage parasites and other organisms that may cause harm to man, animals, or plants (including insects, mites, fungi, rodents, or nematodes). The most popular types include herbicides and insecticides.

Herbicides are substances used to control weeds. They are most often synthetic chemical compounds that may cause damage to the farmer's health or to the environment.

Significant differences occur in the use of herbicides according to plant varieties. HT GM plants, such as maize, sugar beet, soybean, and rapeseed, are resistant to broad-spectrum herbicides. The latter, usually sold in association with the GM plant, allow the farmer to protect crops more effectively.

At the same time, farmers have to manage plant parasites, something they usually do by means of chemical insecticides, which have a strong environmental impact and a high cost. Their large-scale use can, in fact, generate consequences on the ecosystem, such as killing beneficial insect species, while causing damage to the farmer's health.

Bt GM plants protect themselves from the attack of target insects thanks to the toxin produced by bacteria that are lethal for certain insect species, but not for man.[37]

Due to the different nature and type of existing commercial transgenic plants, whether the use of chemical pesticides has grown or declined should be evaluated case by case, also taking into account short-term development (both of GM and of conventional crops). A recent study[38] launched in the US upon the introduction of GM plants (1996) and completed in 2008 offers interesting results with respect to the use of pesticides. In fact, in the performed tests, GM plants caused a 318 million Psi increase in the use of pesticides in the period under study.

More specifically, HT GM plants caused a 382 million Psi increase in the use of herbicides, whereas Bt GM plants reduced the use of insecticides by 64 million Psi. In terms of plant types, HT GM Soybean caused 92% of the recorded increase in the use of herbicides for all HT GM plants.

These results also show that the use of HT plants caused a reduction in the use of herbicides in the first 3 years (-1.1% in the first year and -2.3% in the second and third year) since their market launch, but at the same time caused a significant increase in the annual use of glyphosate (the active ingredient of the most popular herbicide) starting at year four.

34 Naranjo SE, "Impacts of Bt crops on non-target invertebrates and insecticide use patterns", 2009. Pilcher CD, Rice ME, Obrycki JJ, "Impact of transgenic Bacillus thuringiensis corn and crop phenology on five nontarget arthropods", 2005. Raybould A, "Ecological versus ecotoxicological methods for assessing the environmental risks of transgenic crops", 2007.
35 Martha Mertens, "Assessment of Environmental Impacts of Genetically Modified Plants", 2008. Agne`s Ricroch, Jean Baptiste Bergé, Marcel Kuntz, "Is the German suspension of MON810 maize cultivation scientifically justified?", 2009. Anderson PL, Hellmich RLII, Prasifka JR, Lewis LC., "Effects on fitness and behavior of monarch butterfly larvae exposed to a combination of Cry1ab-expressing corn anthers and pollen", 2005.
36 Dep. Environ. Food Rural Aff. (DEFRA), 2007. Environmental protection–genetic modification (GM)–farm scale evaluations, (http://webarchive.nationalarchives.gov.uk/20080306073937/http://www.defra.gov.uk/environment/gm/fse/results/fse-summary-05.pdf)

37 Man's stomach neutralizes Bt toxins completely.
38 The Organic Center, "Critical Issue Report: The First Thirteen Years", November 2009.

The overall results of this study allow to conclude that GM plants have certainly brought about an increase in the use of pesticides. However, if the figure is correlated with the expansion of farming lands, such results – though confirmed – appear less negative. However, they allow to state that Bt GM plants have so far provided benefits in terms of reduced use of insecticides.

As to the use of pesticides, recent studies of the USDA[39] (U.S. Department of Agriculture) produced somewhat different results.

A more in-depth review of this phenomenon, in fact, demonstrates that the different crops produce a wide variety of scenarios and results. For example, the use of insecticides in cotton crops has been reduced. In fact the use of Bt Cotton plants has brought about a 4-10% reduction (or even 14% for other agencies[40]) in weight of the active ingredient and a 22% reduction in the average number of treatments.

As to herbicides, also according to the USDA, it all depends – even more specifically – from the type of GM plant in use. For example, HT Maize reduces the use of herbicides, whereas the amount of herbicide used for HT Soybean is widely varying.

For some GM plants has been a sharp increase in the use of pesticides for others a simple reduction.

In short, the debate on the relation between GM plants and the amount of used pesticides is still open.

However, despite the overall increase in the use of pesticides, GM crops provide some benefits: Bt GM plants ensure a reduced use of insecticides, and HT GM plants offer more options to manage harmful species, such as watering during full vegetation and seeding on firm (unfurrowed) soils, with positive impacts in terms of preservation of soils subject to erosion and of reduced fuel consumption.

Resistance is an additional reason for concern. This phenomenon originates from the possibility for weeds to acquire the ability to survive to herbicides in time.

The case of resistance to RoundUp, a glyphosate-based herbicide used in association with most of the GM HT plant, is reported in several studies[41]. In this case, in fact, certain weeds (such as perennial *Lolium* in Australia, Eleusine Indica in Malaya, *Conyza canadensis* and *Amaranthus palmeri* in the US) developed specific resistance to the product[42].

An exception is the Bt cotton that reduced the use of insecticides.

39 USDA, "Agricultural Resources and Environmental Indicators", 2006.
40 USDA, "The First Decade of Genetically Engineered Crops in the United States", 2006.
41 Gerald M. Dill, Claire A. CaJacob, Stephen R. Padgette, "Glyphosate-resistant crops: adoption, use and future considerations", 2008.
42 Stephen O. Duke, Stephen B. Powles, "Mini-review Glyphosate: a once-in-a-century herbicide", 2008.

ROUNDUP AND RAISE GLYPHASATE - RESISTANCE

Roundup is the trade name of a broad-spectrum herbicide introduced by Monsanto in 1974. Its active ingredient is glyphosate, no longer patent covered and now at the basis of several alternative generic products.

Roundup is still the most popular herbicide in the US, as well as the best seller in the world since 1980. In 2009, 30% of the revenues of Monsanto originated from the sale of glyphosate-based herbicides, while the whole product line – including herbicide-resistant GM seeds (the so-called *Roundup Ready*) – accounted for about half of its turnover[43].

Upon entering the field of genetic engineering back in the 1980s, Monsanto focused all its efforts on the development of an integrated business model capable to enhance its existing products. The creation of glyphosate-resistant varieties was one of its most successful economic ventures.

Today, the competition of low-cost products particularly from China, combined with the market challenges affecting some of the new product launches, is causing some trouble to the company, which is going through a critical period, as shown by the reduced value of its stocks and its short-term economic perspectives[44].

Moreover, more and more glyphosate-resistance forms are emerging, with growing environmental concern. The first reported case occurred in Australia, but this phenomenon is now widespread, particularly in the US. Resistance reduces the effectiveness of the herbicide and calls for the adoption of new strategies, with the predictable risk of higher use of chemical agents.

A recent report of the US National Research Council, along with a positive evaluation of the adoption of genetically modified products, describes the acquisition of resistance traits by as many as nine different plant varieties in the US and raises the issue of the use of appropriate strategic actions, in order to preserve the claimed benefits for farmers and for the environment[45]. At world level, fifteen varieties suffer from the same problem.

A number of growers' associations believe that this phenomenon can become even more severe in the future[46].

The fact that this issue has become so utterly evident to the media and has been investigated in the past twelve months makes it extremely difficult to evaluate it and its related risks.

While the issue of resistance is not new, and is in most respects unrelated with genetically-modified products[47], the latter are directly involved, in that their use – which enables farming strategies that are quite aggressive for the environment, if not carefully managed – has accelerated a process that was anyway already in place.

In general, a variety of approaches were designed to address this problem. The most popular one is the combined use of herbicides of different kinds, as well as the use of herbicide rotation forms. It should also be noted that certain herbicide supplements or substitutes now available to farmers to address the issue have higher toxicity levels.

43 The parable of the sower, The Economist, 19 November 2009.
44 Harvest casts doubt on Monsanto's strategy, Andrew Pollack, Herald Tribune, October 2010.
45 The impact of genetically modified crops on farm sustainability in the United States, National Research Council, April 2010.
46 Resisting Roundup, The New York Times, 16 May 2010.
47 Altieri, M.A. (2009). "The Ecological Impacts of Large-Scale Agrofuel Monoculture Production Systems in the Americas". Bulletin of Science Technology & Society 29: 236

Another risk factor, in this respect, is the transfer of resistance from the HT GM plant to the weed, as already observed in some cases (hybridization between transgenic Canola, *Brassica napus*, and *Brassica rapa*)[48].

Resistance is one of the most awkward issues in the introduction of GMOs, and as such the object of great attention at this stage, also by the promoters of this technology that see it as a severe barrier to marketing.

Similar resistance-related issues occur with Bt crops: individuals resistant to the Bt toxin have appeared in the past few years in India and China among parasitic cotton Lepidoptera, capable to attack the crop and reproduce themselves by transferring the resistance trait to their offspring.[49] In order to manage and delay such phenomenon, the US American Corn Growers Association (gathering US maize growers) has developed guidelines, upon agreement with the federal Department of Agriculture, which provide for growing at least 20% non-transgenic maize or cotton, and up to 50% in some southern states, as buffer zones, in order to reduce the speed of onset of resistance to the noxious Bt toxin by butterfly larvae.[50] The onset of resistance to the Bt toxin in Lepidoptera poses a potential environmental issue, while stressing an intrinsic limit of the technology in terms of medium-term efficacy, and also affecting the non-transgenic farmers that use organic pest management and treatments with insecticides based on *Bacillus thuringiensis*.

The transfer of resistance from the HT GM plant to the Weed is one the most emerging issues.

48 *Rosa Binimelis, Walter Pengue, Iliana Monterroso, "Transgenic treadmill: Responses to the emergence and spread of glyphosate-resistant johnsongrass", 2009.*

49 *Fengyi Liu et al. Evidence of Field-evolved resistance to Cry1Ac-expressing Bt cotton in Helicoverpaarmigera (Lepidoptera: Noctuidae) in northern China; Pest Mnag Sci 2010; 66:155-161; BRUCE E. TABASHNIK et al. Field-Evolved Insect Resistance to Bt Crops: Definition, Theory, and Data; 2009 Entomological Society of America.*

50 *See: http://www.ncga.com/biotechnology/insectMgmtPlan/index.htm*

3.2.5 What are the risks of possible contaminations between GM and conventional plants?

No matter how ordinary it may sound, it should be noted that commercial transgenic crops occur in open environments, and that these are living organisms that reproduce themselves in time and space using all the adjusting strategies developed in the course of evolution. These include the ability to convey their pollen towards plants that belong to different varieties of the same species or to sexually compatible species, either cultivated or wild, which can hand down the acquired transgenic traits to the following generations. If gene modification provides a competitive advantage in the reference environment, the plants incorporating it in their genome may turn into weeds and spread in turn, to the detriment of others.

Gene contamination thus acquires a great ecological meaning if the introduced gene provides a selective advantage over other plants, but is also specifically relevant for the management of farming systems and food supply chains. This is a risk that needs to be carefully considered,[51] particularly in a fragmented farming context (such as the Italian one[52]).

It is nothing new for the farmers, who constantly strive to limit the impact of production and processing techniques. The risk for seeds of varieties other than the adopted one, as well as for organic and inorganic matter (insects, plastic residues, gravel, and more) to spread to neighbouring lands, and the relevant prevention are quite common.

The ability to convey their pollen towards plants that belong to different varieties of the same species or to sexually compatible species, either cultivated or wild, which can hand down the acquired transgenic traits to the following generations.

In other words, no product is 100% pure in agriculture. The AOSCA (Association of Official Seed Certifying Agencies) allows, for example, for 0.5% genes of other varieties and 2% undesired inert materials to define maize hybrids as pure seed. However, in the case of GMOs, which are contaminations that can be reproduced in the environment and give new traits to plants, with both ecological and economic implications, the principle of zero-tolerance in seed batches is enforced in Italy. The supervisory activities carried out by the customs and seed institutions have demonstrated in time that seed contaminations can be easily controlled by the companies that reproduce and sell them, and only occur – if at all – as residues in the batches that in case can not be sold in our Country.

Genetic contamination in agriculture is anyway a structural fact, and its measurement is at the focus of all considerations. But we will come back to that later in this section, with special reference to GMOs.

51 *Conference of autonomous regions and provinces, "Investigation on genetically modified organisms for use in the Italian farming sector for vegetable produce, with special focus on agro-food economy and on scientific research," June 2009. European Commission, "The bigger picture: GM contamination across the landscape", December 2008. Senate of the Republic, "Investigation on Genetically Modified Organisms for use in the Italian farming sector for vegetable produce, with special focus on agro-food economy an on scientific research," November 2008.*

52 *Consensus Document, "Co-existence of traditional, organic, and genetically modified crops", March 2006. Giancarlo Moschini, "Pharmaceutical and Industrial Traits in Genetically Modified Crops: Co-existence with Conventional Agriculture", 2006.*

For GMOs, in particular,[53] recent investigations confirm the risk of contamination in the absence of appropriate cautionary measures.[54] One example of carefully analyzed contamination is rapeseed resistant to three different herbicides. Ever since the earliest tests carried out on the genetically modified plant, this variety was assumed to involve risks of accidental pollination, something that indeed occurred[55].

Another quite famous study concerns a HT variety of *Agrostis stolonifera*, a perennial herb whose seeds are currently not available on sale, which relies on an airborne pollination system. In this case a transfer of the transgene to some correlated species of *Agrostis* could be observed[56].

Jim Richardson/National Geographic Image Collection

53 This will happen in next May.
54 See, among others: Long-term persistence of GM oilseed rape in the seedbank, Tina D'Hertefeldt, Rikke B. Jørgensen and Lars B. Pettersson, 2008; Report on the separation distances required to ensure GM content of harvested material from neighbouring fields is below specified limits in non-seed crops of oilseed rape, maize and sugar beet, Research Strategy and Support Unit, NIAB, Cambridge, DEFRA, 2006
55 Cathcart RJ, Topinka AK, Kharbanda P, Lange R, Yang R-C, Hall LM. 2006. Rotation length, canola variety and herbicide resistance system affect weed populations and yield. Weed Sci. 54:726–34
56 Hall L, Topinka K, Huffman J, Davis L, Good A, Allen A. 2000. Pollen flow between herbicide-resistant Brassica napus is the cause of multiple-resistant B-napus volunteers. Weed Sci. 48:688–94; Belanger FC, Meagher TR, Day PR, Plumley K, MeyerWA. 2003. Interspecific hybridization between Agrostis stolonifera and related Agrostis species under field conditions. Crop Sci. 43:240–46

THE CASE OF LIBERTY LINK RICE 601

In August 2006, the USDA (the U.S. Department of Agriculture) announced the contamination occurred in a part of U.S. crops of rice due to a rice genetically modified to resist a herbicide. Genetic contamination was detected at an early stage in Arkansas and in the adjacent States.

The LibertyLink 601 was the subject of research and experimentation in open field in Louisiana in 2001, but its commercialization was never approved.

In the days after the announcement, the European Union, Japan and other countries blocked the imports of U.S. rice. The situation took on such a scale that in the following few months the European Union made the request for certification of the absence of traces of LL601 in long grain rice imports from the USA, prior to export, with the requirement to test against the importer upon receipt of the goods. Despite these measures, the contamination was detected in Europe, Africa and the world at large in the months that followed, imposing withdrawals of products from the Philippines to Ghana.

Despite the fact that a federal investigation was not able to accurately determine the causes and modes of contamination, in 2008, following the adoption of more stringent control measures by the Authority and U.S. farmers, the Standing Committee on the Food Chain & Animal Health of the European Union decided to suspend the strict regime of controls in place.

The economic implications of the case were very significant. Greenpeace estimates that it has caused a total loss for the U.S. rice industry between 741 million and 1.29 billion dollars (2006-2008), due to difficulties of commercial nature. This estimate does not take into account either the additional costs faced by companies in Europe and the rest of the world, nor the claims drawn against Bayer. The same report shows that, at the end of the story, contamination has been detected in at least 30 countries worldwide. Other sources, show that - in addition to causing a loss so important to U.S. industry – the contamination has also caused between 50 and 110 million euro of additional costs to European counterparts.

What still has not been fully understood, and that leaves open a number of questions, is why a trial has been able to interfere with the cultivation of other varieties and contaminate the crops.

One case in point in this respect was debated before the US Supreme Court with sentence of June 21, 2010,[57] disputing the fairness of a position of a District Court that had resolved not to request a thorough examination of the possible environmental risks posed by a variety of GM alfalfa (Roundup Ready Alfalfa, RRA).

Another significant issue concerns the huge difference in the approach and attitudes of the US vs. the EU supervisory authorities: while the former tend to be more casual, the latter are more cautious.

An extremely significant case, with reference to the issues discussed in this section, concerns Monsanto vs. Geertson Seed Farmset, debated before the US Supreme court, which issued its judgement on June 21, 2010.[58] The case concerned a dispute over a verdict of a District Court on the decision of the APHIS (Animal and Plant Health Inspection Service) to approve some form of unconditional deregulation of Roundup Ready Alfalfa (RRA), a variety of alfalfa genetically modified for tolerance to the Roundup herbicide. The APHIS had ruled that there was no need to issue an EIS (Environmental Impact Statement), i.e. an in-depth study on the possible environmental risks.

The District Court, invited to judge on the dispute by a group of farmers, had come to the conclusion that the APHIS had infringed the rules in force with its decision to adopt a broad deregulation of the RRA without completing a detailed EIS, in the belief that the involved farmers had demonstrated that the conventional alfalfa crops were reasonably likely to be contaminated if RRA had become available for sale. It had therefore issued a permanent injunction preventing product marketing.

Another controversial issue concerns not so much the possibility for accidental contaminations, as the reversibility of the choice to introduce genetically modified crops.

The US Supreme Court adjusted the previous judgement of the District Court and subjected marketing of the GM plant to the performance of a detailed investigation of its environmental impacts. In short, the issue of the environmental impacts of genetically modified crops is quite controversial based on the present knowledge. What is particularly striking upon reading the paper of the US Supreme Court is the statement referred to the challenges the district court had met in issuing its judgement: "the parties' experts disagreed on virtually all factual aspects related to possible environmental damage, including the likely occurrence of genetic contamination and the reasons at the basis of such risk of contamination".

As noted by judge Stevens, member of the Supreme Court (who ruled in favour of the sentence issued by the District Court), in the 6 months during which the APHIS admitted receiving public comments for the purpose of a mere environmental assessment (EA), the agency had received 663 accredited comments of scientists and farmers, 520 of whom expressed their contrary opinion, based on the risks of contamination.

However, in the light of the literature collected and only partially referred to here, we think we can state confidently that no solid and unique basic references exist on the issue. While a risk of contamination does exist, with consequences that are not easy to predict, its severity should be assessed for each individual case.

In order to confine the risk of genetic contamination within a safe threshold (even if the debate is lively also in this respect: some claim that contamination is critical if observed in 0.1% of cases, others appeal to the EU labelling rules that go for 0.9%), several strategies can be adopted – from co-existence rules, discussed below, to controversial bio-containment projects developed by the same biotechnological companies. These include the GURT (Genetic Use Restriction Technologies), adopted to protect the proprietary technology owned by the company through a mechanism that allows to "lock away" the gene ensuring seed characterization, thus preventing its expression.

Examples of GURT plants include the so-called "terminators", whose seeds are sterile, thus named because this technology forces the farmers to buy seeds every year, in that the saved seeds cannot be replanted. The possible market launch of 'terminator' seeds triggered an international wave of claims, which forced Monsanto and other biotechnological companies (holders of some terminator patents) to give up their use. In February 2005, the UN proposed an international moratorium, adopted unanimously on a global scale.

Another controversial issue concerns not so much the possibility for accidental contaminations, as the **reversibility** of the choice to introduce genetically modified crops. In this field too, several studies exist, but no univocal results are available. In its well-known monitoring of the StarLink™ maize – a GM maize variety meant for animal feeding, which proliferated uncontrollably and was therefore withdrawn from the market – the EPA, the US environmental protection agency, came to the conclusion that, in the few years after the variety was withdrawn from the market, the persistence of modified genetic traits was not observed in other crops[59].

In this case too – apart from individual cases – no consistent historical data sets are available to provide a reliable scientific base. What is sure is that reversibility, if ascertained, can mitigate the risks of genetic contamination significantly. No fond hopes, though: once eradicated, a farming model can hardly be restored. And this is the additional risk, in perspective, for subsistence farming systems, typical of most developing countries.

It is interesting to note how cautiously and carefully the Chinese Authorities are performing a broad range of thorough studies on various potential environmental criticalities tied to GMOs before approving them for widespread use in the Country.[60]

One relevant aspect for the purpose of the analysis concerns **co-existence strategies**. In short, a clear overview of the overall situation can still hardly be provided, but the issue of genetic contamination is surely relevant. This is why information should be collected continuously on field facts, in order to design more effective co-existence strategies.

In view of ensuring co-existence between transgenic crops, conventional agriculture, and organic agriculture, in 2003 the European Commission issued specific guidelines (recently updated) for the development of individual national strategies and, at the same time, promoted the adoption of best farming practices[61].

The rules of the European Commission are based on the "principle of co-existence". In short, farmers are free to choose among the three types of crops (transgenic, conventional, or organic), but should take containment measures to keep accidental pollination below the legal threshold of 0.9% (a threshold that is now being reviewed based on a proposal of the European Commission issued in July 2010, now assessed and negotiated among the EU institutions – the Commission, the Council, and the European Parliament).

57 http://www.supremecourt.gov/opinions/09pdf/09-475.pdf.
58 http://www.supremecourt.gov/opinions/09pdf/09-475.pdf.

59 Monitoring for StarLink™ Corn to End, EPA, 2008.
60 Is China ready for GM rice?, News Feature, 2008
61 European Commission, "Report from the commission to the council and the European Parliament on the coexistence of genetically modified crops with conventional and organic farming. Implementation of national measures on the coexistence of gm crops with conventional and organic farming", April 2009.

In the European Union, only 15 Member States have developed their own co-existence strategies in compliance with the EU guidelines so far. Hence a significant fragmentation of legal and economic conditions within the European Union.

In conclusion, the proper definition and the strict enforcement of co-existence measures provide a necessary answer to minimize the risk of contamination among different crops, within a picture that deems GM crops acceptable and viable. To date, however, the different national legal approaches and the limited experience with GMOs (something that needs to be duly considered) make it hard to achieve convergence towards a unitary legislation on the issue, and exacerbate opposition and reluctance to adopt genetically modified seeds in Europe. On the other hand, more studies should be carried out on the issue to provide a more and more scientific response to specific risks.

Last but not least, **market issues**, not to be confused with regulation issues. The latter face a persistently critical attitude of consumers in most regions of the world[62] and are, in some respects, even more serious. In the US, for example, the existence of limited adventious presence of genetically modified matter in produce is not necessarily a breach of the rules enforced by the National Organic Program (NOP), nor is a reason to lose the relevant accreditation, provided that the farmer can demonstrate not having deliberately planted genetically modified seeds and having taken all the necessary measures to prevent cross pollination. If, however, the trade agreements governing product sale are particularly strict, the same farmer will suffer an economic damage.

The same is true in the European Union with reference to organic crops, where the rules in force extend the 0.9% contamination threshold provided for by the labelling rules to the sector, except that, in this specific case, certification is denied beyond this threshold, also subject on the principle of non-intentionality. Moreover, it should be noted that most organic crops are aimed at full exclusion of GMOs from the output, as well as from the production process.

This example clearly accounts for the complexity of this phenomenon. It is not enough, in fact, to find the tools to manage co-existence at best, in a world where end consumers have no final positive perspective on the issue. Unless these, who have in most respects taken a rational approach so far, become convinced that the benefits offered by the introduction of GMOs can offset their risks, the issuing of rules and procedures will not suffice to overcome the existing barriers.

Other themes are affected by the ecological issues related to the release of GMOs into the environment, which we are not going to discuss here for reasons of space and complexity. These concern: the possible invasiveness of the GM plant, horizontal transgene transfer, the negative impact on non-target organisms, including pollinators, predators, etc., the negative impact on the soil and on biogeochemical cycles, intraspecific contamination in the centres of origin or diversification of species.

To prove their importance, some of these are specifically studied for the purpose of the assessment of the environmental impact that the EFSA (the European Food Safety Agency based in Parma) is considering within the framework of the updated guidelines for the assessment of the environmental risks of genetically modified organisms[63], with respect to which specific approaches are recommended to develop effective impact assessments.

62 A detailed review in section …….. will focus on this issue

63 Guidance on the environmental risk assessment of genetically modified plants, EFSA Panel on Genetically Modified Organisms, 2009.

THE CONTAMINATION IN MEXICO

In September 2001 the Mexican government, via its Inter-Secretarial Commission on Biosafety of Genetically Modified Organisms (CIBIOGEM), announced that some of its scientists had found cases of native maize being contaminated by transgenic varieties imported from the USA. The seriousness of the case derived from the geographical datum: the contaminations were discovered in the Mexican state of Oaxaca, one of the centers of origin and diversity of maize.

In November of the same year the prestigious scientific magazine "Nature" published an article64[1] which lead to great scientific controversy and not only.

The article exposed recorded cases of contamination, underlining the fact that introgression of the transgenic character had occurred (in other words it had integrated in the genome of the "contaminated" plant), data which was also later confirmed by other research institutes. Despite the fact that truth of contamination having occurred was never questioned, the publication was the object of violent scientific attack, so much so that "Nature" negated its validity and one of its authors, Ignacio Chapela, saw his teaching post at the University of Berkeley threatened, which was however ultimately confirmed.

That concern was genuine is confirmed by the document drawn up by a mixed scientific commission established in the framework of the NAFTA treaty between Canada, the USA and Mexico, in which the conclusions recommended keeping a moratorium on commercial cultivation of transgenic maize in Mexico (moratorium later revoked by the government) and the milling of imported GM maize to prevent any from being intentionally or accidentally cultivated65[2].

The hypothesis of genetic pollution in the centre of origin of maize generated and still attracts a great deal of attention. A vast inventory of diversity has in fact been put together in the southern states of Mexico by collecting a multitude of ecotypes and local varieties (called criolle) found in the whole of Central America in thousands of genetic variants.

Such biological diversity is essential in terms of food safety: Jack Harlan, a famous United States botanist, has claimed that genetic diversity is what stands "between us and catastrophic starvation on a scale we cannot imagine". Drawing from genetic information relative to important characteristics such as resistance to pathogenes and parasites, nutritional quality, tolerance to abiotic factors, such as those generated by shifting climatic events, are in fact of fundamental importance for breeders making preservation of the integrity of genetic resources crucial.

64 [1] David Quist & Ignacio H.Chapela (29 NOVEMBER 2001) Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico; NATURE; vol 414

65 [2] Comisión para la Cooperación Ambiental de América del Norte (31 de agosto de 2004) Maíz y biodiversidadefectos del maíz transgénico en México; Informe del Secretariado conforme al Artículo 13 del ACAAN

3.2.6 Summary remarks on the Environment Area

This is the question in which there seems to be the lowest agreement between scientists and the highest level of uncertainty.

On the other hand, the difficulty in obtaining reliable data is due to two factors:

- the very nature of scientific research in the field which makes it extremely difficult to isolate causes and effects and establish related correlations, within a complex biological context;
- reference data from the past which is still too recent;

However, analysis of available scientific studies does reveal a number of environmental risks connected with the introduction of GMOs into the environment. Specifically:

- loss of biodiversity;
- risk of contamination (especially in the areas involving species origin);
- increased use of pesticides/herbicides;
- increase in the phenomenon of resistance to herbicides;
- damage to the natural habitat of wild fauna.

With the exception of the emerging phenomena of resistance to herbicides, to-date, no clear consensus within the scientific community exists for any of these risks.

Some recent episodes demonstrate that the mere introduction of GMOs, even if only within experimentation of limited scope, can be the cause (including years later) of unexpected and widespread contamination which not only impacts on the local market, but also exports.

This explains the heated debate on an institutional level regarding key regulatory criteria and control of the coexistence of genetically modified and traditional crops.

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3.3 Can GMOs provide an effective solution to the problem of food availability in the world? Or, vice versa, can they enhance inequalities?

Referring to **food availability** – and food security in a broader sense – means giving joint consideration to a number of parameters, including the provision, stability, accessibility, and use of food. An analysis of the issue addresses the demographic, environmental, economic, social, political, and institutional sphere. This complicated picture provides the basis for the debate on the role that transgenic crops can play in making appropriate food amounts available.[66]

The analysis of world demographic trends until 2050 clearly points out to a demographic increase in the most fragile regions, where food production and procurement are already vulnerable, such as Africa.

On the other hand, a slowing down of productivity growth was clearly observed in the farming world in the last two decades after the miracle of the green revolution of the 1970s (the mean annual growth of the world wheat production in the 1990-2008 period amounted to 0.7% vs. a 3.1% growth in the 1960-1990 period).

Such a world scenario – burdened by food stocks at the lowest level since the 1960s – was the context for the 2007-2008 crisis of food prices. The FAO calculated that the food price index rose from 122.4 to 190.9 points from 2006 to 2008. The fastest increase in the prices of produce from 1970 to the present day occurred over few months. The year 2010 sees new tensions with respect to prices and an enhanced volatility of markets.

The food crisis highlighted a severe failure of agro-food market mechanisms. Today, the true challenge for globalization is thus the definition of new rules for those markets, including food raw materials, that cannot be governed – if the world's sustainable development is recognized as a priority – by means of logics and instruments borrowed from the financial and capital markets.

In this context, economic problems, first and foremost, affect food availability: three-quarters of the people suffering from food shortage live in rural areas and produce food. The same producers (and their families) allocate a significant share of their income to the purchase of food.

There follow, to a growing extent, environmental problems, such as the impact of climate change, estimated to be responsible for a possible 5 to 25% reduction of the world crops by 2050.

The change of climate and environmental conditions seems to imply a broader diffusion of diseases and contaminations in farming and food products.

Demographic growth, the use of inefficient irrigation systems, and growing competition for the use of water resources, combined with the impact of climate change, will make a 15 to 35% water consumption rate unsustainable in the future.

Along with environmental issues, food safety is closely associated with the living and social stability conditions of populations, particularly where the shortage of food, water, and natural resources is combined with inborn basic socioeconomic instability. Poverty and the risks tied to the availability/use of natural and agro-food resources are turning into significant risk factors for the onset of international conflicts, particularly in the form of civil wars in the individual countries, including developing ones. According to the UNEP, at least 18 domestic conflicts have been generated/ promoted by the exploitation of natural resources since 1990.

66 See the paper on the subject drafted by the Barilla Center for Food & Nutrition in 2009 for a more detailed discussion.

A strong urbanization process is also under way. According to UN forecasts, the urban population in Africa will grow from 32% in 1990 to 55% by 2030, with a 72% increase in 40 years.

In addition, the analysis of world demographic trends to 2050 clearly points out to a further demographic increase in regions that are already fragile and characterized by vulnerable food production and procurement levels, such as Africa. On the other hand, the countries where the living standard of citizens is improving significantly, also record negative consequences on the food consumption level and composition, with a sharp increase in livestock product consumption and the adoption of new dietary approaches.

From an economic viewpoint, the increase of the world population, the appearance on the market of populations that used to be excluded, and the persistent structural gaps in world revenue distribution have a strong impact on food security, and make the identification of an appropriate sustainable development process a tough challenge.

The food crisis highlighted a severe failure of agro-food market mechanisms.

If data from 1980 onwards is considered, the per capita income differential between the G7 countries and the developing countries (particularly in Africa) is continuously and gradually expanding, with large groups of the population growing poorer and poorer, being unable to draw benefits from economic reforms and liberalization processes. At the same time, in recent years the emerging use of certain kinds of produce for the production of biofuel reduced their availability for traditional use in crops, thus generating a market distortion and physically subtracting food resources from primary consumption. This resulted into a price increase that came as a consequence of a more competitive demand: the risk of "substitution" effects for the future appears concrete and significant.

This is, in other words, a complicated scenario, characterized by a set of complex and not easily managed variables.

With respect to the relation between the use of GMOs and the solution to the problems of developing Countries, two issues are addressed in this paper:

- the ability of GMOs to improve farming productivity,
- the possibility to transfer the GM farming model from the countries of origin (US, Argentina, Brazil) to developing ones.

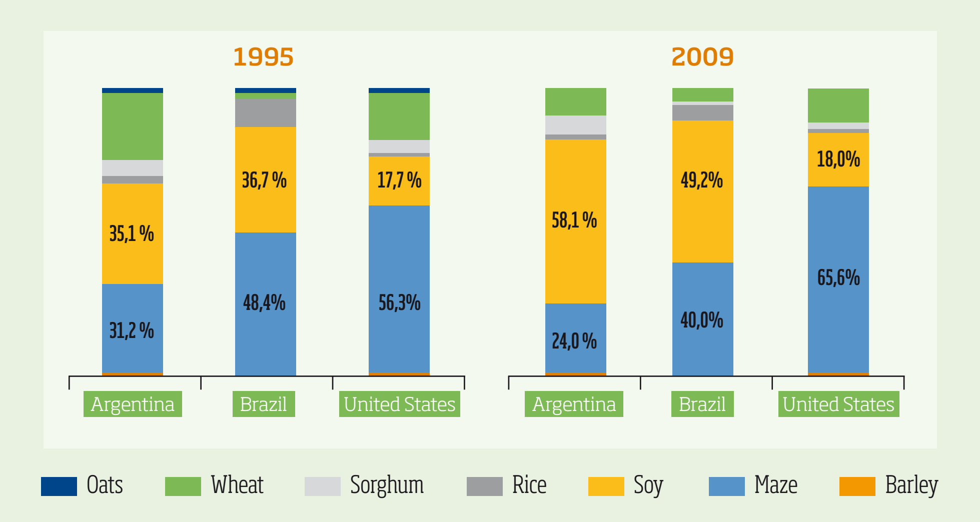
We still need to be aware that mere technological innovation, whatever its potential and its contraindications, can only provide a partial response to the above described problems.

THE INCREASE IN SOYBEAN PRODUCTION IN THE AMERICAS

Over the last fifteen years, alongside the advent of genetically modified crops, some countries have seen an assertion in the increase of GM soybean production (even taken into consideration expansion of farming on an overall scale), which has had the effect of modifying the composition - in percentage terms - of the basket of agricultural products.

The data provided in the table below, from this point of view, speaks for itself.

Percentage breakdown of the annual production of a selected basket of agricultural products, 1995 and 2009



Source: The European House-Ambrosetti re-elaboration of USDA data, 2010

In Argentina, above all, the phenomenon has reached extremely significant proportions with a shift from maize to soybean crops. The same can be said of Brazil

In both cases the overall share of the two predominant crops has increased significantly: in Argentina there has been a rise from 66.3% of total production to 82.1 %, whereas in Brazil the figures have shifted from 86.1% to 89.2%.

In other words we are witnessing further strengthening in these two countries of their traditional focus on just a few crops and associated with this we have the phenomenon - the object of bitter discussions in the respective countries - of an expansion in the average size of managed farm plots, with consequent modifications to the underlying economic and social structure . From this point of view, we are assisting quite a marked change in the relations between the land owners and land management, with subsequent high job losses due to the process of amalgamating farming estates

3.3.1 Do GMOs allow to achieve clear, significant, and persistent productivity gains?

A preamble is needed at this point. "Productivity" is a complex concept: in fact the ability to obtain higher volumes per hectare of crops is an easily understood and intuitive aspect, but only represents one side of the matter.

Productivity gains are also achieved when the production techniques in use allow to reduce the inputs (labour, time, chemical agents…) required to obtain the same production volumes.

A "productivity" gain in general terms is also a possible reduction of the volatility of yields per hectare, which represents an historical challenge for the farming sector.

The input of farming innovation in terms of productivity is not easy to measure, in that the factors that generally help determine (or just influence) it are numerous and not all dependent on man and on the quality of the farming technologies/practices in use.

Agriculture is not an industrialized and sterile production process: the varying climate conditions, soil characteristics, and production techniques used in different crops have a significant impact on productivity estimates.

Based on this assumption, a few considerations can be made on the results achieved through the use of the existing commercial GM seeds.

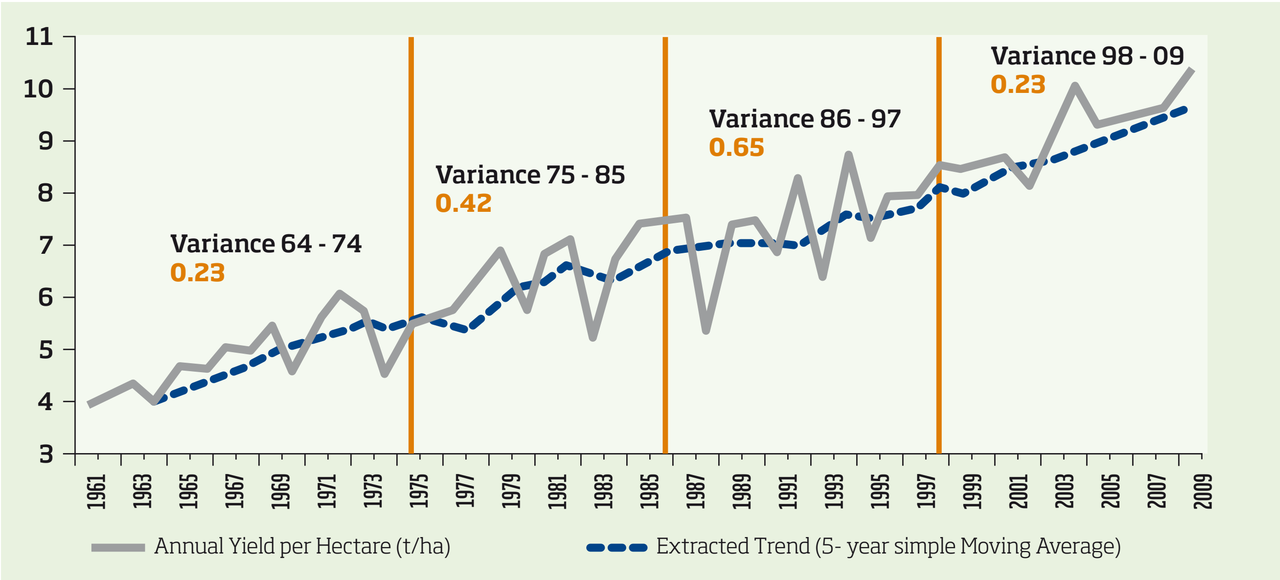
The spreading of the GM technology in the regions subject to extensive agriculture (particularly the US and Latin America) seems to respond to the historical problem of yield volatility. All experts agree that the use of GM seeds produces a positive "assurance effect" on crops.

The use of GM seeds produces a positive "assurance effect" on crops.

Let us analyze the case of maize in the US. Considering the historical data on annual maize yields in the US (Y_i), the trend (T_i) can be extracted and the variance of yields around it can be estimated: the results confirm the existence of an assurance effect starting in 1998, when the GM maize share in the US first became significant (more than one-fourth of the total).

From 1998 onwards the recorded volatility was about 65% lower compared to the values recorded in the mid-1980s and mid-1990s, and settled on values comparable to those measured between 1964 and 1997.

Figure 5: Yield per hectare of maize, US $ per ton (1961 - 2009)



Source: US Department of Agriculture data 2010. Note: the yield per hectare is calculated as the ratio of the production output to the crop surface for each individual year under study; the trend was identified using a 5-year mobile average.

For further check of the existence of such effect, the volatility of maize yields recorded in the US was analyzed for all the considered years, from 1964 to 2009. Based on annual yield deviations from the extracted trend $(Y_i - T_i)^2$, three large groups of years were identified: low-volatility years (with $0.0 \leq (Y_i - T_i)^2 < 0.2$), medium-volatility years (with $0.2 \leq (Y_i - T_i)^2 < 0.6$), and high-volatility years (with $(Y_i - T_i)^2 \geq 0.6$). From 1998, 10 years out of 12 fall into the low-volatility group.

Despite the efficacy of genetic engineering technologies applied to agriculture in terms of reduced uncertainty of annual crop yields, such technologies do not seem to produce significant and persistent increases of yields per hectare, except for cotton, which experiences a significant increase in yields per hectare, instead.

The use of GM technologies – in optimal "technological context" conditions (availability of water, herbicides, fertilizers…) and subject to the occurrence of the phenomena for which the GMOs were first designed (e.g. attacks by a given insect) – allows to achieve greater yield stability, bringing actual productivity close to intrinsic productivity (which can also be obtained from traditional plants in non-adverse conditions).

It therefore turns out that GM technologies are not – always and in all circumstances – more "productive" in terms of yield per hectare: therefore, there seems to be no evidence of a unique cross "development effect" connected with the use of existing commercial GMOs.

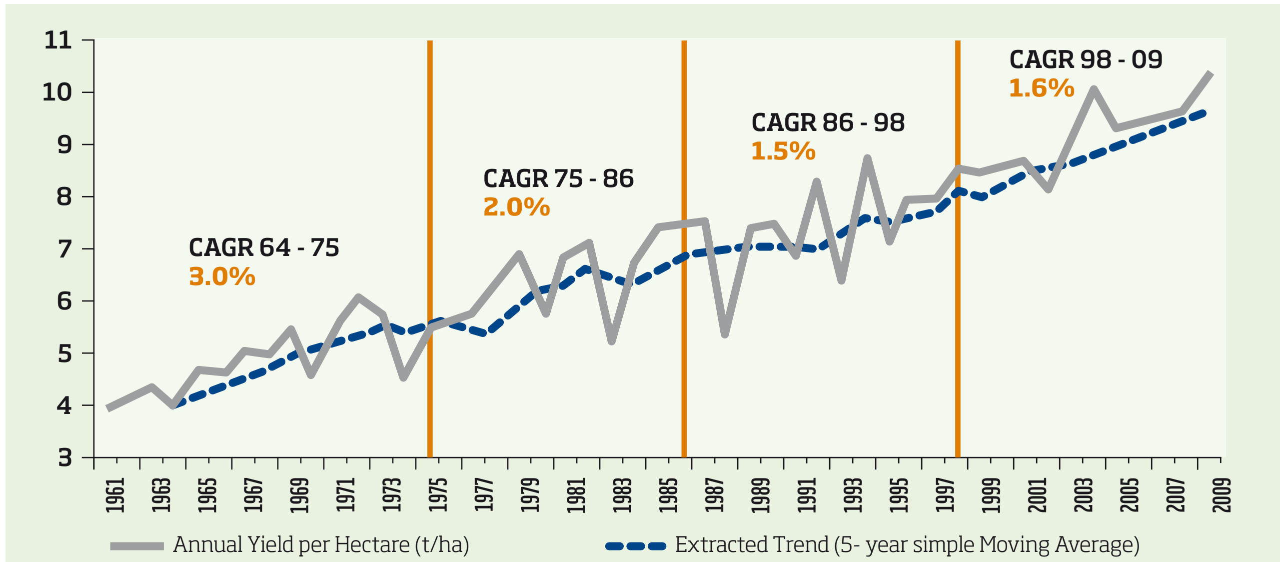
An analysis of the dynamics of the yield per hectare of maize in the US highlights a decreasing trend of the mean compound annual growth rate (using in this case trend T_i extracted from the historical data set in order to eliminate the effect of consistent variability of this phenomenon).

This decrease stopped in 1998, however without any significant "rebound": yields grew at a mean annual 1.6% rate from 1998 to date, vs. a 1.5% rate in the 1986-1998 period and higher rates in the previous years.

In the US, the gradual slowing down of the dynamics of crop yields – associated, among other things, with a mitigation of the effects of the green revolution – does not seem to be counterbalanced by a significant expansion effect related to the introduction of GMOs. It should be noted that the trends recorded in the past few years could very well have continued to persist also after 1998, with further significant declines of the mean yield per hectare: the introduction of GMOs could have had an "anti-cyclic" effect. However this theory is not easy to prove. On the other hand, one hint for thought is the absence of an observed "boost" effect on yields, in this case of maize.

One point seems clear (except for some remarkable exceptions, including cotton): it does not seem possible to claim that a "second green revolution" is under way. The introduction of GMOs in agriculture seems to be an "incremental" innovation, rather than a "radical" innovation. And this without discounting the positive potentials of the former vs. the latter.

Figure 6. Trend of the yield per hectare of maize – US (tons per hectare, 1961-2009)



CAGR=Compound Annual Growth Rate (Average annual compound growth rate)

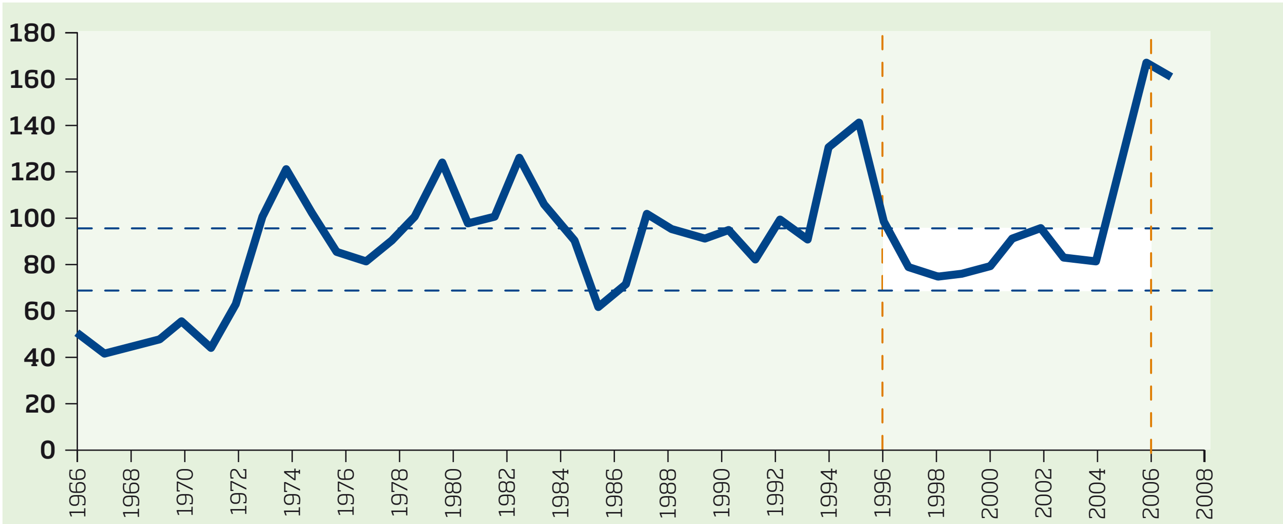
Source: US Department of Agriculture data 2010. Note: the yield per hectare is calculated as the ratio of the production output to the crop surface for each individual year under study; the trend was identified using a 5-year mobile average.

With regard the productivity the introduction of GMOs in agriculture seems to be an "incremental" innovation, rather than a "radical" innovation.

According to the trend of the main farming commodities in the past few years, prices – on average – did not follow a course attributable to a possible "productivity effect" resulting from the use of GM technologies: the international food crisis in the 2007-2008 period is the most significant example (see, in this respect, the analysis of the BCFN in the Position Paper *"The challenges of Food Security"*, published in 2009). In the light of the absence of significant effects on yields, it is not surprising to see that no clear impacts occur on the grain's price.

In particular, by way of example, consider the production price of maize in the US: as shown in figure 7, during the 1996-2006 period (thus excluding the 2007-2008 period, characterized by great speculations on farming raw materials), the maize price level remained within a value range in line with the historical trend, without any obvious connections with changes under way in the supply of the farming sector in the US (where GM seeds were gradually becoming established in those years).

Figure 7. Price of maize in the US, US$ per ton (1966-2008))



Source: FAO data 2010

3.3.2 Can GMOs provide a response to farming problems in developing Countries?

The second major theme tied to the productivity of GMOs in agriculture concerns their **possible ability to help solve the problems of developing Countries**.

One thought of **Amartya Sen** (nobel prize in economics) could be applied to the debate on the use of genetic engineering techniques in agriculture in developing Countries: *"It is sometimes thought that those who study can predict the future, but unfortunately this is not the case. Study is important but it does not endow us with powers of divination. It may however help us find the best solutions to problems, once we have fully understood the causes".*

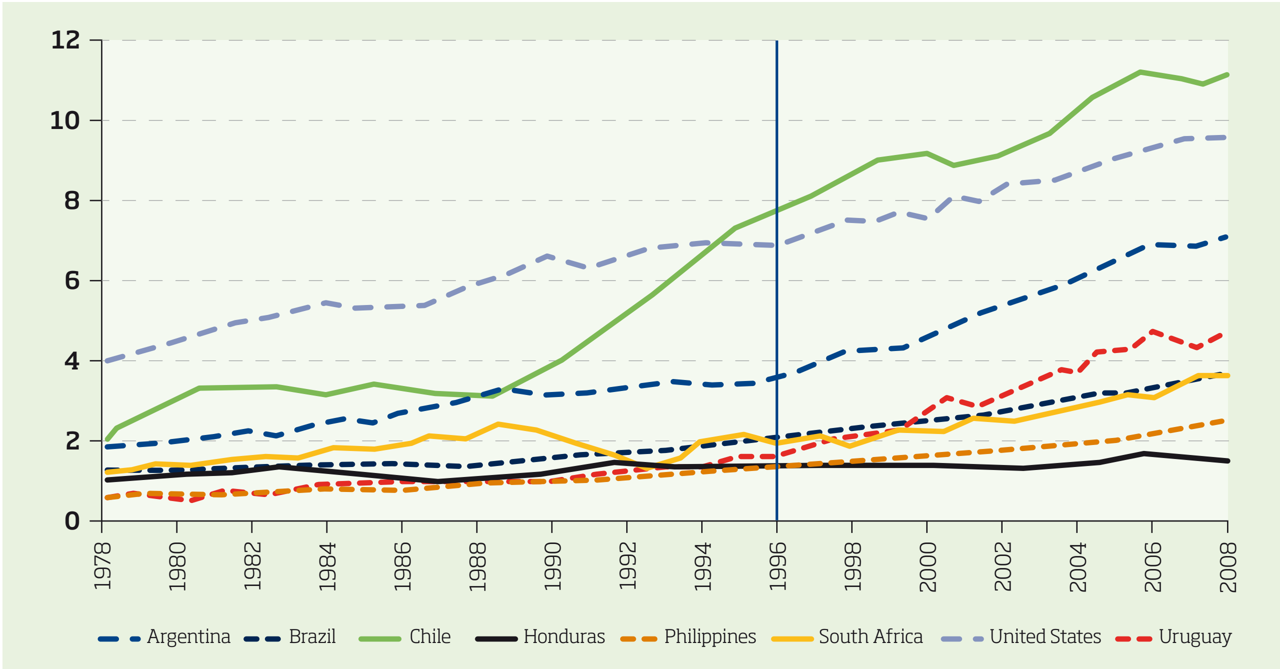
In this respect, one point can be reasonably stressed: a schematic debate on "yes to GMOs / no to GMOs" with reference to developing Countries is an extreme and inappropriate simplification of a complex theme. Assessments should certainly start from the current status of the available technologies and their usage opportunities/ criticalities. On the other hand, new fascinating scenarios can be assumed, albeit still to be outlined. Finally, while it is wrong to consider biotechnologies and GMOs as one thing, it is equally misleading to treat "developing Countries" as a single macro-group, in the light of the different economic, climatic, social, and political characteristics of each.

Existing GMOs have been designed in – and for – the farming system characterized by large land lots tilled by means of modern intensive techniques, which make abundant use of fertilizers and chemical agents with significant economies of scale.

More precisely, existing GMOs have been designed in – and for – the farming (and agro-food trade) system of the US and of Latin America, characterized by large land lots tilled by means of modern intensive techniques, which make abundant use of fertilizers and chemical agents with significant economies of scale and consolidated national and international outlet markets.

Back to yields, discussed in the previous section, and observing the yield of maize in tons per hectare on a 5-year mobile average, some farming contexts clearly seem to benefit to a greater extent from the use of the new technology.

Figure 8. Yield per hectare of maize - US (tons per hectare, 1961 - 2008)



Source: FAO data 2010

But the other agro-food systems, particularly in developing Countries, cannot find an appropriate solution to their needs in the GM farming model. In fact, small-scale growers in developing regions (often engaged in subsistence agriculture) have:

- no availability of the necessary funds to start and maintain "chemistry-intensive" crops in the long term;
- no availability of land parcels suited for optimal scale yields;
- no average mechanical farming level;
- no opportunity to access outlet markets.

In rural contexts of developing Countries where about 70% of the seeds used by farmers are estimated to originate from re-use or exchange between farmers, the adoption of GM seeds appears unlikely.

The IAASTD clearly stressed the existence of potential problems (both of a farming and socioeconomic kind) involved in the "non-critical" export of the GM farming model to developing countries.[67]

In this case too, there seems to be an exception, which shows how meaningless an ideological debate is – namely, cotton in India.

67 See www.iaastd.org

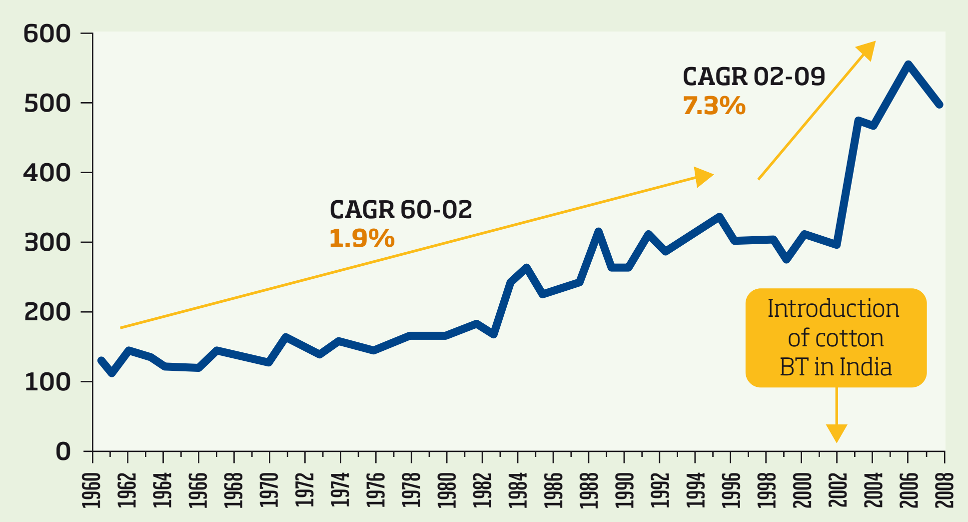
COTTON BT IN INDIA

The introduction and subsequent spreading of Bt cotton in India is one of the most often mentioned and controversial cases with reference to the use of genetically modified crops in developing Countries. A mere analysis of yields per hectare seems to draw a picture that – as simple as it is – appears utterly positive.

As of 2002, the year of introduction of Bt cotton in India, the yield per hectare (expressed in terms of kg per hectare) grew at an average compound annual rate almost **4 times higher** than in the 1960-2002 period (7.3% vs. 1.9%), as shown in the figure below[68]. This observation is clear and represents the most positive factor related with the introduction of such cotton variety in India. However, from 2008 to 2009 the **first significant decline of yields per hectare** since the introduction of this variety (8 years later) was recorded: this figure should be duly considered, because it could point out to a future, steady decline of yield growth, perhaps due to the achievement of the potentials of this crop. But at present it is impossible to express a detailed judgement on the matter.

However, as stated on other occasions, the evaluation of the effects of the introduction of agro-food innovation in fragile and complex contexts such as those of developing Countries cannot be limited to a mere recording of the effects intrinsically tied to the adjustability of the new variants to the local soil and to their actual enhanced productivity.

Figure 9. Yield per hectar of cotton - India (kg per HA, 1960 - 2009)



CAGR=Compound Annual Growth Rate (Average annual compound growth rate)

Source: FAO data 2010

An **overall, well-meditated judgement** must include an answer to a number of key questions: how do new crops, that lead to the adoption of farming models other than the traditional ones, affect the farming sector in a strict sense, as well as the **social and cultural conditions** of the rural populations adopting them? What effects, in terms both of productivity and of overall economic and social dynamics can be expected in the **long term**? Can the introduced innovation help **improve the overall living standard** of populations in developing Countries in a **stable, permanent, and sustainable manner**?

68 Source: processed data from the United States Department of Agriculture Database, 2010

In the light of the studies carried out on the case of cotton in India – whose reliability and accuracy are not judged here – there seems to be room for further investigation and marginal improvement for the entire technological, economic, agricultural, and legal system connected with the large-scale diffusion of such radically invasive and innovative farming models in contexts similar to the Indian one. While some positive traits are clear and undisputable (see, for example, the increase of yields per hectare), certain aspects tied to the economic and social structure of the rural communities raise some concern, which will hopefully turn out unfounded at last.

Time will tell whether – net of **some "adjustments"** that **always occur upon the introduction of radical farming innovations** – the spreading of Bt cotton in the Indian agro-economic sector was the first evidence of a possible positive role of genetic engineering technologies for the development of economically disadvantaged Countries.

Michael S. Quinton/National Geographic Image Collection

In conclusion, however, while on one hand the present GM farming model should be "reviewed" to make it truly useful for developing countries, on the other an honest and organized debate on the potentials of biotechnological applications other than genetic engineering, still largely unexplored for such Countries, appears necessary.

In this respect, an interesting paper (*"Socio-economic impacts of non-transgenic biotechnologies in developing countries: the case of plant micropropagation in Africa"*) was recently published by the FAO, demonstrating that non-GM biotechnologies tested in certain developing Countries appeared effective to solve the productivity and poverty issues of these Countries, provided that:

- "specific" techniques and solutions, suited for the local conditions (soil, climate, society, economic structure,…) are designed and implemented;
- the existing entry barriers (access to technology by the local populations, know-how transfer, provision of the necessary resources, definition of market access modes for local produce, albeit obtained on a small scale) are removed;
- broad diffusion schemes are implemented, also with the practical involvement of the national and supranational public institutions (private companies alone, even if "committed", could hardly obtain significant results in developing Countries).

3.3.3 ARE THERE ANY CRITICAL ISSUES LINKED TO THE STRUCTURE OF THE SECTOR AND THE BUSINESS MODELS ADOPTED BY COMPANIES?

To answer this question in the following paragraphs will analyze the main aspects of the structure of the agrochemicals and seeds, will identify characteristics of the common business models adopted by firms operating in this area, will refer briefly the main aspects of the discipline of protection of intellectual property rights regarding GMOs, as well as those relating to industry concentration.

A) The structure of the agro-chemical and seed sector: highlights

What the Anglo-Saxons refer to as the seed industry (the sector of seeds for agriculture) first acquired productive and commercial relevance in the late 19th century. The breeding activity – originating from the opportunity to obtain cross-breeds meant to improve the quality of the available plant varieties – became gradually more defined, until it acquired the dynamics of a typical economic and industrial sector[69].

For the most part of the 20th century, thousands of small and medium independent seed companies operated all over the world according to the prevailing logic of proximity to the main outlet markets. In those years, the sector was modernized and rules were implemented in consideration of the special nature of the goods concerned, which affect the availability of food to the served populations.

In order to understand the rationale that directed the approach to farming activities for centuries, it should be noted that, until the first decade of the 20th century, the State was often involved in the free distribution of seeds[70]. As the sector was consolidated, the State's direct initiative was reduced all over the world, and was only limited to regulation and research, leaving the opportunity to private citizens to operate freely.

But this situation was not bound to last. The 1970s saw the establishment of the consolidation that is now one of the main peculiarities of the sector. A first wave concerned the acquisition of seed companies by firms operating in chemistry and in the production of pesticides and fertilizers. This dynamic approach was driven by the benefits available through the rationalized management of integrated distribution channels, combined with the opportunity to establish a closer and more profitable relation with customers.

69 *International Seed Federation, Marcel Bruins, 2009.*

70 *The distribution and research schemes supported by the United States Department of Agriculture (USDA) are particularly renowned in this respect.*

But it was only in the two following decades that the sector's physionomy radically changed at an unprecedented speed, thanks to the unique progress of biotechnologies and genetics. The significant investments in research required to support the development and sale of the new agro-industrial products promoted the sector's concentration: the convergence between chemistry, biotechnologies, and seed production gave life to some large multinational groups that held a significant share of the high-quality farming seeds market.

In order to convey an idea of the stunning pace of growth and concentration in the sector, just consider the process initiated by some of its players. In 1996 Monsanto acquired a share of DeKalb (owner of a large share of the maize seed market) for US$177 million, took over the soybean and maize unit of Asgrow for US$240 and, in 1997, acquired Holden (owner of high-quality maize varieties) for US$1 billion. In 1998 DeKalb was wholly acquired for US$2.3 billion and Delta & Pine followed for US$1.8 billion. It was then the turn of Plant Breeding International (a leader in the wheat seed sector) for US$0.5 billion, and finally, the acquisition of the seed branch of Cargill, for US$1.4 billion[71].

The process resulting from mergers and acquisitions among giants in the agro-chemical and seed sector did not involve Monsanto alone: in 1999 Pioneer, a leader of hybrid maize seeds, was taken over by DuPont; Novartis merged its farming unit with the same unit of Zeneca and gave life to Syngenta; Rhône-Poulenc merged with Hoechst to form Aventis Crop Science, acquired by Bayer in 2001 for US$7.25 billion[72].

The acquisition of seed companies was also aimed at acquiring the broad proprietary germplasm held by these, as well as their patents, know how, market shares, and sales networks, and at generating significant financial advantages.

The assumptions for this consolidation were created by legal decisions, particularly with reference to intellectual property rights, as described below.

A summary of the present seed production scenario is provided here. This obviously refers to the official market, considering that a very high share of seed exchange and use occurs outside official systems.

According to a study of the international seed federation (ISF),[73] the practice of reusing part of the crop for re-seeding is widespread, like exchanges (whether for free or against payment) among farmers, and these activities are not limited to developing Countries or to so-called backward systems: while the use of certified seeds (i.e. industrial seeds recorded in an official catalogue of varieties) in China amounts to 27% for rice, 24% for maize, 22% for wheat, and 13% for beans, in western agriculture, where industrialization processes are historically established and the rules on intellectual property rights are stricter and more closely complied with, higher values are recorded, albeit not too different. In France, 58% of wheat seeds are purchased on the official market vs. 65% in the US, but this rate falls to 17% in Canada (and to 21% for barley). In Germany, this market amounts to 54% for all cereals (including maize that is almost always hybrid, in that re-seeding practices are inhibited due to the loss of vigor in the generation following the first crop) and to 44% for potatoes. In this particular ranking, Italy stands out for its compliance with the rules and its respect for the markets: 90% of soybean, 80% of barley, 90% of durum wheat, and 70% of common wheat are sown following purchase on the formal market. The corporate practice of reusing the seeds amounts to 67.5% for the 14 countries considered by the ISF study for cereals, with a US$6.7 billion revenue loss in sales for the industry, plus US$470 million lost royalties on patents.

71 *La guerre secrète des OGM, Hervé Kempf, Seuil, 2003.*

72 *Luca Colombo, working paper, 2010.*

73 *International Seed Federation (October 25, 2005), Meeting on enforcement of plant breeders' rights; International Union for the Protection of new Varieties-UPOV; UPOV/Enforcement/05/3.*

Since the main companies have adopted integrated business models, the analysis of the official seeds market should be performed also considering the farming chemicals market.

The six main agro-chemical industries involved in the production of pesticides[74] (including, by market share size[75]: Bayer, Syngenta, BASF, Dow AgroScience, Monsanto, DuPont) also play a crucial role in the seed business. Their market share, held either directly or through controlled or participated companies, amounts to about 75% of agro-chemical production[76] and to around 60%[77] of seed production[78].

World's Top 10 seed firms (share of market; 2007)	
Monsanto (US)	23%
DuPont (US)	15%
Syngenta (CH)	9%
Groupe Limagrain (F)	6%
Land O' Lakes (US)	4%
KWS AG (G)	2%
Bayer Crop Science (G)	2%
Sakata (J)	<2%
DLF-Trifolium (D)	<2%
Takii (J)	<2%
Top 10	**67%**

Source: ETC Group.

World's Top 10 pesticide firms (share of market; 2007)	
Bayer (G)	19%
Syngenta (CH)	19%
BASF (G)	11%
Dow AgroSciences (US)	10%
Monsanto (US)	9%
DuPont (US)	6%
Makhteshim Agan (IL)	5%
Nufarm (AUS)	4%
Sumitomo Chemical (J)	3%
Arysta Lifescience (J)	3%
Top 10	**89%**

Source: ETC Group

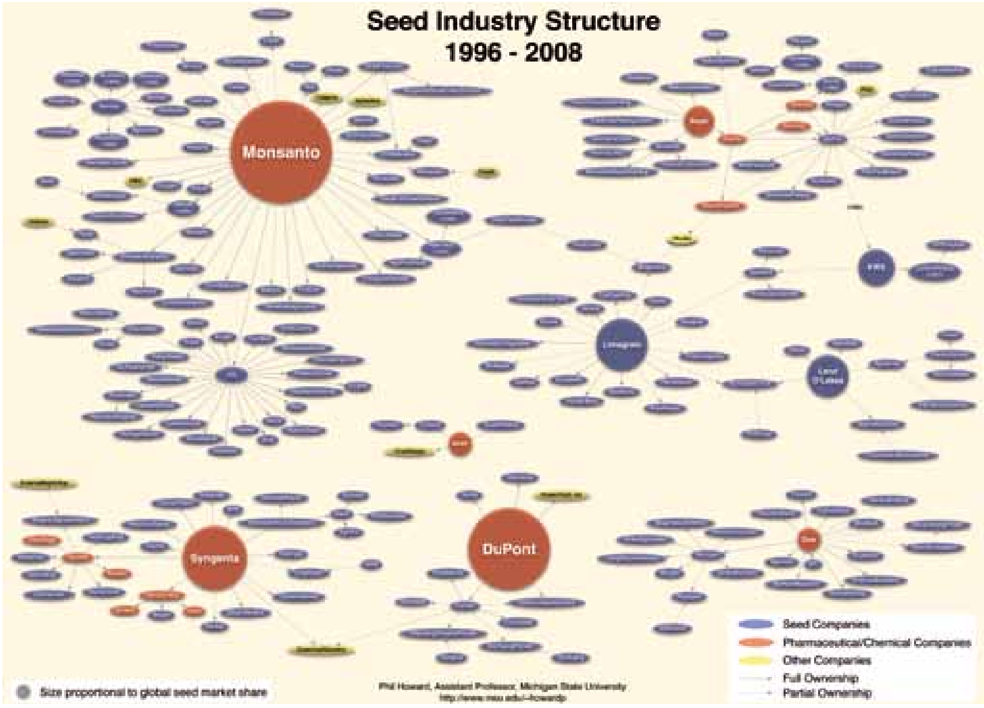
74 The fertilizer business currently follows different logics and sees the involvement of different players.
75 Agro World Crop Protection News, 2008.
76 The global market is worth approximately US$40 billion. ETC data.
77 ETC Group
78 The global market is worth approximately US$23 billion. ETC data

It should further be noted that over 80% of the genetic traits approved in the world are owned (and often co-owned) by four companies or their participated companies (Bayer Cropscience, Dupont, Monsanto, Syngenta)[79]. An additional element, which will be discussed in more detail below, is the thick web of agreements based on the granting of licences for the use and marketing of new transgenic varieties, which the main players have signed with smaller companies and which further increase their actual influence. This depends on the ownership of the intellectual property rights they hold on the products they created, as well as on the patented production techniques.

In short, farming seed production today is a highly concentrated industry. By way of comparison, while the market share of the 10 main seed companies in the world is about 90% of the total, the share of the 10 main pharmaceutical companies is just above 50%. This recently drew the attention of the authorities in charge of regulating competition in the US[80].

The scheme below, drafted by Phil Howard of the Michigan State University, provides an updated picture of the level of concentration following gradual acquisitions and mergers on the world seed market as of 2008[81].

Figure 10. Seed industry structure (1996 - 2008)



Source: Michigan State University

B) GM products and business models

A business model is, in short, a method for an organization to generate, distribute, and capture value[82]. The business models of companies operating in an industry and the interaction among them define their overall structure and determine a degree and cost for consumer access to the potential benefits offered by the company's activities.

79 Genetically Engineered Plants and Foods: a Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, The Annual Review of Plant Biology, 2009.
80 Monsanto: the parable of the sower, The Economist, November 2009.
81 Phil Howard, Michigan State University, Sustainability, 2009.
82 Business Model Generation, Alexander Osterwalder e Yves Pigneur, 2010.

A few common traits emerge from a preliminary analysis of the main global companies, which could be described as follows[83]:

- these companies operate in at least two different, closely related business areas: a) seeds (production of seeds, mostly GM) and b) crop protection (production of herbicides, insecticides, and fungicides). Most importantly, a company's profitability largely depends on its ability to manage the connections between both areas effectively;
- they are focused on the research and development of products covered by intellectual property rights. The patent portfolio is, in fact, a prerequisite for competitive advantage;
- their original business is the production of agro-chemical products, combined with an investment in biotechnologies at a later stage;
- they have been capable (at least so far) to produce significant economic returns for the investors;
- they invest (sometimes significantly) in the protection of their intellectual property rights;
- they invest significantly in customer relations, focusing on loyalty strategies that leverage on the provision of complementary and general management and farming services;
- they have a global reach, particularly in the regions where an extensive agriculture model prevails, implemented on wide land lots, typical of the American continent;
- they are mostly listed companies, which makes them particularly exposed to the pressures of financial market expectations;
- they have established a thick web of scientific relations among them, due to the fact that the techniques required for development are protected by patents held by different parties.

Diversities, on the other hand, mostly concern specific product types (traits and varieties) and the served geographies.

C) Intellectual property rights

Since 1980 genetically organism can be patented, infact, a judgement of the US Supreme Court in 1980 (within the framework of the case Diamond vs. Chackrabarty) ruled that a **genetically modified organism can be patented**. Ananda Mohan Chackrabarty, a researcher for General Electric, had developed a bacterium capable to "break up" and then "eat" petroleum, to be used in case of random leaks. The patent, applied for in the US, had been denied at first, because according to the law living beings could not be patented[84].

This was a decisive judgement to start the industrial exploitation of genetic engineering, a business that is fully based on the use and protection of industrial patents.

Since 1980 genetically organism can be patented.

With a hint of the huge economic and research opportunities offered by this decision, back in 1981 Monsanto set up an in-house team of experts in molecular biology, and biotechnologies became the strategic focus of its research activity.

The way to patent protection is mandatory in consideration of the costs associated with the development of a new GM variety. From genetic engineering to marketing, a US$**100-200 million** investment is estimated for R&D, intellectual property right protection, technological transfer, and legal compliance costs[85].

In order to ensure the protection of their intellectual property rights, GM producers in some Countries ask the farmers to sign a commitment not to reuse or sell the seeds, thus forcing them to buy new ones every year.

83 A comparative analysis was carried out based on official papers of some of the main companies operating in the seed and agro-chemical industry (Monsanto, DuPont, Syngenta, Bayer, BASF).
84 Actually, natural chemical substances, including the DNA sequences of living organisms, cannot be patented. In order for a gene to be patented, a new use, nonexistent in nature, should be found for it.
85 preferably Monsanto source

Patents can cover seeds, as well as the techniques and the processes required to obtain them.

This request for intellectual property rights protection in the sector of biotechnologies applied to seed production, albeit legitimate, has resulted into the appearance of **barriers to entry**, which are almost insurmountable both for other private individuals, unless endowed with significant resources, and for the public institutions.

In fact, no public institution in western Countries owns the full set of patents required to develop a new vegetable GM variety today[86].

A recent study[87] estimated that the public institutions have developed one-fourth of the patented inventions applicable in agriculture, but this figure does not take into account that the private sector only grants the use of technologies required to develop these patents upon the subscription of restrictive clauses on the use of the end products.

The institutions seem to have given up playing an active role in scientific research. One of the few implemented attempts to strengthen the role of public research in the study of biotechnologies for agriculture, was the establishment of the PIPRA (Public Intellectual Property Resource for Agriculture) in 2009 by more than 40 universities, public agencies, and no-profit institutions, followed by the creation of a data base of intellectual property rights, the definition of best practices for development and research, and the implementation of humanitarian projects[88].

An intellectual property right, or IPR, is a legal protection applied to products of the intellect, including literary, artistic, or scientific works, industrial processes, inventions, production methods.

Multiple instruments are used to protect intellectual property rights, the most popular being patents, copyrights, and registered trademarks. A patent is a right to the exclusive use of an invention for a limited time (typically 20 years). The holder of a patent for an industrial invention has the exclusive right to implement and use the invention within the limits and at the conditions set by the law. The right is also extended to include the sale of the product the invention refers to[89].

The patent system is aimed at protecting both the interests of individuals and companies (more specifically their investments, often significant) and those of the community (that sees the invention published and described in detail). If such kind of protection cannot be implemented, an alternative option is offered by the industrial secret.

The debate on the extent to which property rights protection can reach is still open, as shown by the recent WHO review in the field of genetic sequences in medicine, susceptible – according to the FAO – to influence the GM products sphere as well[90].

Meanwhile, the attitude of major corporations in the industry seems to aim at more openness to the problems of developing Countries. Monsanto, for example, has donated its intellectual property rights on seeds and production techniques for the development of draught-resistant genes to Water Efficient Maize for Africa (WEMA), a public-private partnership which receives aids from, among others, the Bill & Melinda Gates Foundation.

The five beneficiary Countries are Kenya, Mozambique, South Africa, Tanzania, and Uganda.

86 *Intellectual property resources for International development in agricolture, Delmer, Nottenburg, Graff, Bennett, Plant Phisiology, 2003.*
87 *The public-private structure of intellectual property ownership in agricultural biotechnology, Graff, Cullen, Bradford, Zilberman, Bennett, Nature Biotechnology, 2005.*
88 *www.pipra.org.*
89 *Italian Civil Code, arts. 2575 – 2591.*
90 *20 Questions on genetically modified (GM) foods, FAO, 2009.*

D) The level of industry concentration

One significant aspect of the controversies fueling the public debate on GMOs concerns the level of sector concentration where the so-called life science companies operate.

In view of the framework described in detail in the previous headings, authoritative commentators – starting with the prestigious American Antitrust Institute[91] - have been denouncing for some time the existence of a situation in which competition in the sector appears distorted. According to the judgment expressed, this depends not only on the degree of concentration but, in particular, on the presence and the role of certain players therein.

The most important fact which has occurred to date concerns Monsanto against which the United States Department of Justice, the competent authority for enforcing the antitrust discipline, opened proceedings last year[92 93]. In-depth investigations into the case are still underway [94]. The doubt being raised is that the company is holding a dominant position and that, to some degree, it is abusing this position for its own ends, generating negative consequences on customer choice options and on the capacity to express adequate rates of innovation by the entire sector. Such misgivings are also adamantly expressed by some of the American giant's competitors.

In this regard, it is interesting to mention the document published by DuPont /Pioneer last year concerning this very topic. Not only does DuPont/Pioneer underline the differences in terms of views and concrete approach, highlighting its own choice, in the logic of improvement, to place itself at the service of pre-existing farm models in Asia and Africa, it also denounces the supposed monopoly that the American competitor has in various genetic traits[95].

As is known, the Guarantor Authorities for Competition are called in to safeguard the correct operation of markets, in order to guarantee a variety of offers for the consumer, high levels of innovation and sufficiently competitive prices, given the contextual situation. The decisions taken are the result of extremely complex analytical investigations which go from defining the size of the market to evaluating the impact the structural arrangement of the sector has on the processes of innovation.

Without going into the specific aspects on which the US authorities will have to pronounce a verdict, we will merely limit ourselves to highlighting the importance of the lawsuit underway. In fact, a large part of future developments in the sector and its long term physiognomy will depend very much on the decision made.

91 Diana L. Moss, The American Antitrust Institute, "Transgenic Seed Platform: Competition Between a Rock and a Hard Place?", October 23, 2009. See also "Addendum to White Paper on Transgenic Seed", April 8, 2010.

92 Dow Jones Newswires, "US Senators Urge DOJ To Complete Monsanto Anti-Trust Review", 2010.

93 Claudio Gatti, Il Sole 24 Ore, "Indagine Antritrust su Monsanto", 11 December 2009.

94 Of the activities underway, please see: Department of Justice and USDA Announce Updated Schedule for Agriculture Workshop, March 2010.

95 Respectively 98% for soybean traits and 79% for maize, not least 60% of the maize and soybean germplasm covered by license in the USA.

Ted Spiegel/National Geographic Image Collection

3.3.4 Summary remarks on the Food Security Area

Food security is a complex problem involving a range of economic, social and political variables intertwined into an overall picture that is difficult to interpret, even before deciding on the proper actions. Within this context, it is unthinkable that a single technology, alone, be able to play a role in taking on the problems still facing us.

In order to provide a concrete contribution to this problem, genetic engineering products must be coherent with the nature of the challenge and, as a result, capable of adapting to the local characteristics of each regional context.

In reality, the GMOs on the market today were designed and developed "within" and "for" capital-intensive industrialized agricultural models with large surface areas under cultivation, massive mechanization and intensive use of agro-chemical products. The benefits they provide are connected to the "insurance" effect than the possibility of decisively increasing crop yield. They also tend to reinforce the commitment to single-crop production in vast regions of the world.

In addition, it should be remembered the GMOs on the market today are primarily for zootechnical, energy or textile use in which direct human consumption is very limited. They involve a low number of variants of vegetal species, primarily limited to just two types (Ht and Bt), in line with highly-integrated business models in which the sale of agro-chemical products plays a fundamental role in insuring profitability of the enterprise.

On the other hand, it is easy to understand the low interest of the sector in products and technologies aimed at marginal areas but which are, in fact, those in which lack of food security is greatest.

Completing this picture is the marginal role of public institutions in developing research on GMOs, not only as a consequence of political choices, but also through systems of protecting the property rights currently in the hands of a select group of multinationals.

To summarize, GMOs–as we know them today–do not seem to play a significant role in alleviating hunger in the world, for one simple reason: they were not developed with this goal in mind. On the contrary, concerns are high over the risk of imbalances deriving from the introduction of the intensive farming model in rural areas characterized by subsistence farming.

Changing this picture would require substantial change in the normative structure and incentives in this sector in order to promote the development of initiatives specifically aimed at developing countries..

Gordon Gahan/National Geographic Image Collection

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3.4 What do people think about GMOs?

3.4.1 What is people's experience of GMOs?

A review of the perceptions and attitudes of people, in Europe and beyond, towards the use of biotechnologies in the food sector outlines quite a clear picture of trends, which seem to consolidate within a substantially **univocal interpretation scheme**[96].

Starting from the data submitted by Eurobarometer for the last fifteen years, integrated with a number of independent studies on the food industry, a **structural cognitive scheme** strongly oriented towards **naturality** seems to be in place.

In other words, whatever the specific contents of the performed surveys (on biotechnologies, GMOs, industrial food processing), a vast majority of people are more inclined towards whatever appears natural. The respondents cannot always explain punctually what they mean by naturality, which is mostly defined as negative: **a shortcoming or a reduced processing intervention** by man.

Most of the European population is opposed to GMOS.

In other words, a sort of taboo with respect to industrial activities in the food sector seems to have emerged in the past few years. Moreover, a highly significant correlation between **naturality and health** is observed; what is natural is perceived as necessarily healthy, or anyway healthier.

The second, very interesting finding is that this cognitive scheme has a cross-cultural character. A thorough reading of results, in fact, does not reveal any significant differences between the Anglo-Saxon Countries and continental Europe[97]. The variability of results, whatever the relevant cultural context, is not substantial: the majority of the population is anyway against the introduction of GMOs into human nutrition (also in the US and in the UK), and the reasons for opposition are the same: GMOs are unnatural by definition, also in their original structure. In particular, the transmission of genes between different species is perceived as unnatural. Products modified by means of cisgenic techniques are more acceptable than the corresponding transgenic varieties.

96 *The contents of this section are published courtesy of Claude Fischler, sociologist and member of the Advisory Board of the Barilla Center for Food & Nutrition, who provided a significant input to the critical interpretation of the issue.*

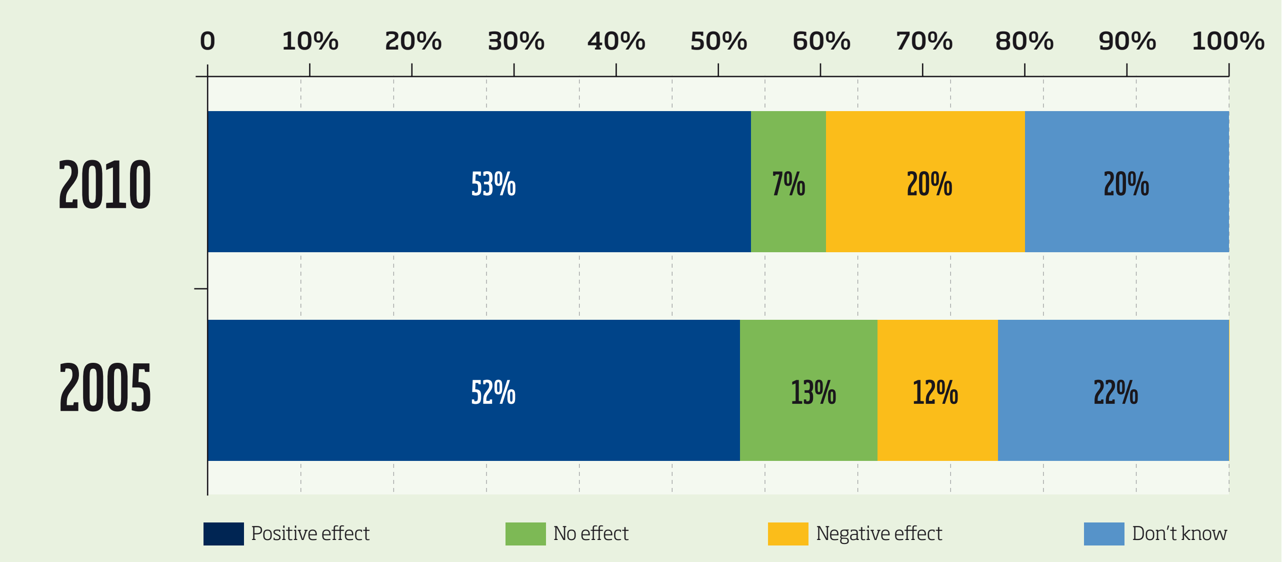
97 *It is scientifically demonstrated that, by working on an assessment scale, respondents in sample-based surveys in the Anglo-Saxon Countries favour the extremes of the scale, whereas in Europe intermediate values are most often selected.*

Analysis of the Eurobarometer survey 2010

The results of the 2005 and 2010 Eurobarometer survey[98] are particularly helpful to understand whether this attitude reveals an ultimate position characterized by rationality or is just the outcome of fear, of an undefined awe. Such results point out to deep mistrust towards the possible benefits, such as to upset the risk/benefit ratio in general (as well as irreversibly).

From the data of the survey, in fact, we learn that almost half of European citizens struggling to recognize the benefits of the - more general - such as biotechnology and genetic engineering.

Optimism and pessimism regarding biotechnologies



An interesting precedent in this respect concerns studies on **mobile phones**. In this case the majority of people believed they could pose risks for health, but would not give up their use. At best, they would take precautions (including the use of headsets).

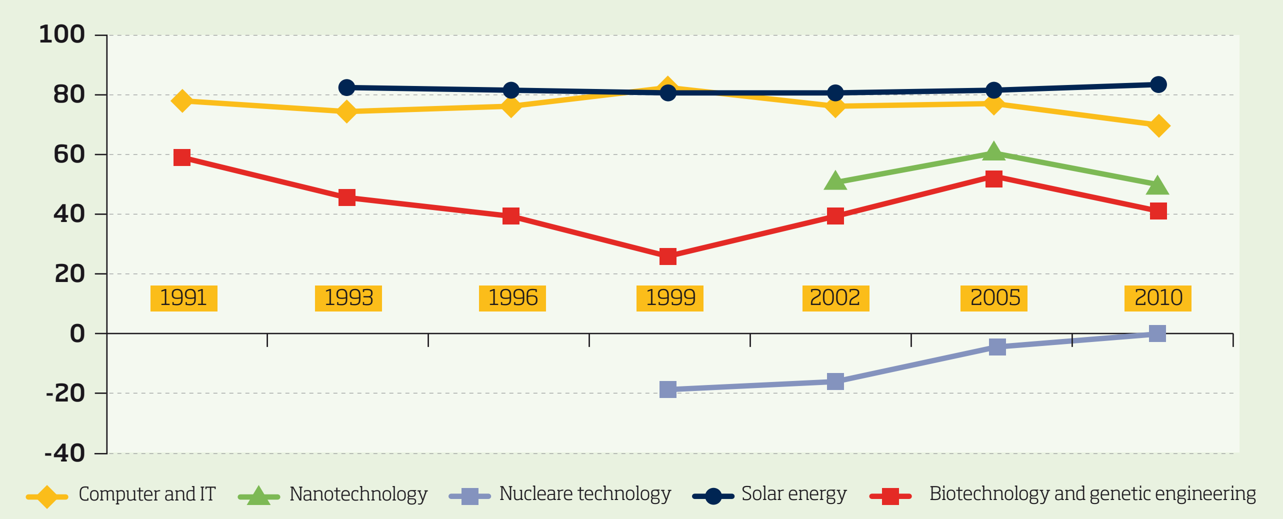
If the benefits tied to the introduction of a new technology are significant, people are prepared to put up with risks, which are sometimes even underestimated. People are not irrational then, but weigh risks against the practical perceived benefits.

The Eurobarometer survey allows to analyze other important aspects for our analysis. The **European citizens are generally optimistic** with respect to the future input of **technologies** to the quality of life. **The picture drawn from the 2005 and 2010 survey shows a non risk-averse public, fond of technological innovations, provided that these promise tangible benefits.**

98 *European Commission, "Europeans and Biotechnology in 2005: Patterns and Trends", Eurobarometer, July 2005; European Commission, "Europeans and Biotechnology in 2010", Eurobarometer, November 2010*

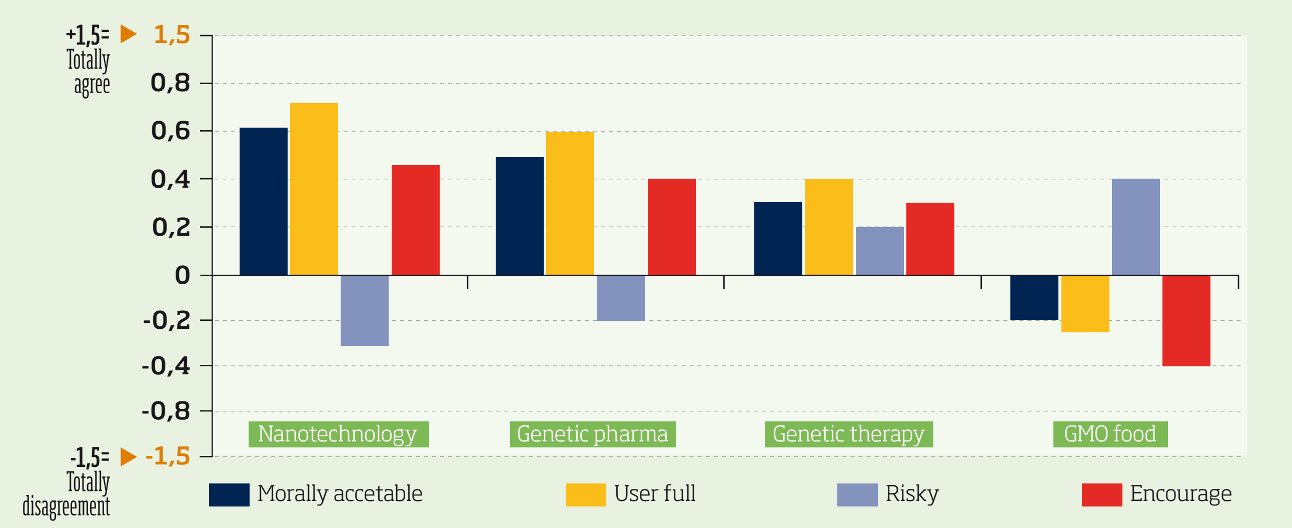
The indexes for optimism show high and stable levels for information technology and solar energy. Nanotechnologies experienced a "boom" as of 2002, and pessimism vis-à-vis nuclear power has also declined. Optimism with respect to biotechnologies, however, constantly declined from 1991 to 1995, then rose to the original 1991 level in 2005 and decline again in 2010.

Index of optimism for 5 technologies



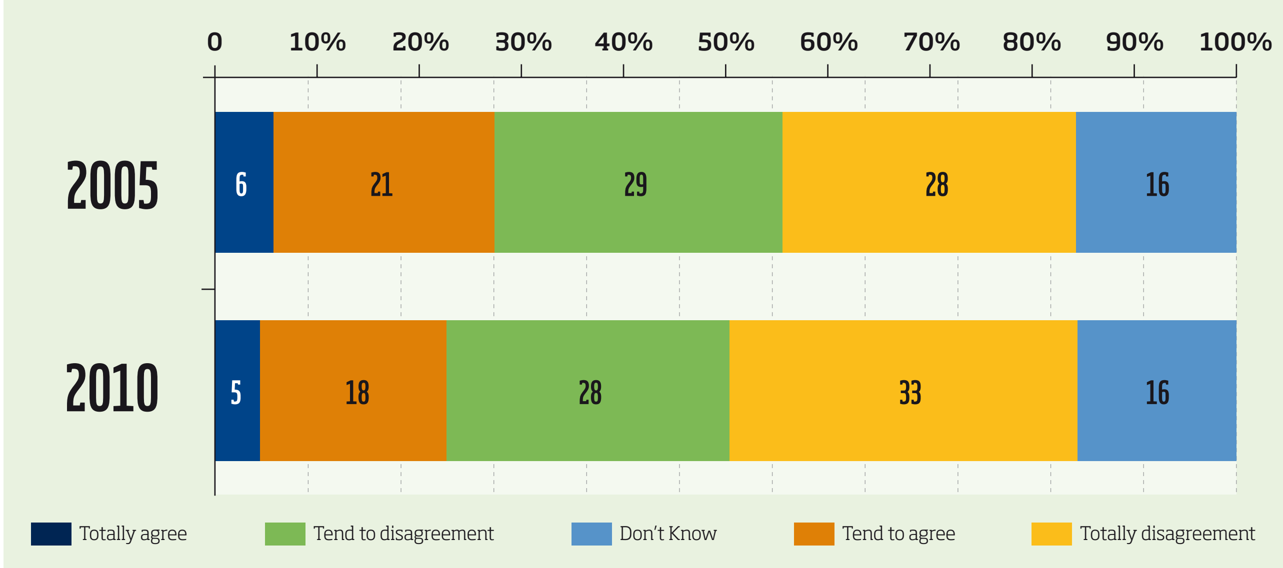
Of the technologies considered, **nanotechnology, pharmacogenetics, and gene therapy** are perceived as useful, morally acceptable and - in the case of nanotechnology and pharmacogenetics - risk free. On the other hand, gene therapy is though to pose non-marginal risks for society, but the value of its possible benefits makes further investments in research anyway desirable.

Degree of agreement/Disagreement for 4 technologies



Genetically modified food is a different matter. The majority of the European citizens believe, in fact, that such technological advance should not be encouraged. It seems to be **not too useful, harmful for society, and morally inacceptable**.

Degree of agreement/disagreement for GMO food



One more subject deserves mentioning, also as an introduction to the next sections - namely, the role of the media. What is the role of the mass media in contributing to generate or influence ideas, hints for analysis, logics, or cognitive processes?

% respondent who agree or totally agree that GM food should be encouraged

	1996	1999	2002	2005	2010
UNITED KINGDOM	52	37	46	35	44
IRELAND	57	45	57	43	37
PORTUGAL	63	47	56	56	37
SPAIN	66	58	61	53	35
DENMARK	33	33	35	31	32
NETHERLAND	59	53	52	27	30
NORWAY	37	30	-	-	30
FINLAND	65	57	56	38	30
BELGIUM	57	40	39	28	28
SWEDEN	35	33	41	24	28
ITALY	51	42	35	42	24
AUSTRIA	22	26	33	24	23
GERMANY	47	42	40	22	22
SWITZERLAND	34	-	-	-	20
LUXEMBURG	44	29	26	16	19
FRANCE	43	28	28	23	16
GREECE	49	21	26	14	10
CZECH REPUBLIC	-	-	-	57	41
SLOVAKIA	-	-	-	38	38
MALTA	-	-	-	51	32
HUNGARY	-	-	-	29	32
POLAND	-	-	-	28	30
ESTONIA	-	-	-	25	28
SLOVENIA	-	-	-	23	21
LATVIA	-	-	-	19	14
LITHUANIA	-	-	-	42	11
CYPRUS	-	-	-	19	10

One final issue deserves to be treated, even in key introduction to the following paragraphs, and the role of the media. To what extent do mass media play a role in helping to generate ideas, ideas of analysis, logic, cognitive processes, or to influence them? The means of mass communication if they can't generally "create" from scratch the most important trends in a cultural context, they can always act as "social amplification" that reinforce trends already in place in society.

In the controversial case of GMOs, the media certainly influence the degree of knowledge and awareness to a significant extent.

3.4.2 How is the topic of GMOs covered by the media?

In order to understand how the mass media (more specifically, in this case, the daily papers and magazines subgroup) present and discuss GMO-related issues, a study was carried out on behalf of the BCFN, based on a number of methodological assumptions:

- the study was based on the use of **framing**, a crucial instrument for the analysis of a narrative structure;
- the development in terms of **storytelling** is the most important vehicle to create an impact and involve a wide audience in media processes. This is definitely the case also for the way the issue of GMOs is now approached by the media, both in Italy and in most other Countries;
- in order to study the "storyboard" of the GMO issue, in particular, a **semiotic-narrative approach** was used - with reference to the French-derived semeiotics (of the so-called *Ecole de Paris*) - which is particularly fit for the purpose;
- the study was founded on **a collection of about 400 press articles** from a number of widely circulating Italian and foreign publications, almost all issued between June 20 and October 20, 2010. The main publications included: Il Sole 24 Ore, Corriere della Sera, La Repubblica, L'Espresso, Panorama, Time, Newsweek, The Economist, Le Echos, Le Monde, El Pais, Suddeutsche Zeitung. Minor publications were also considered.

- **framing**, i.e. the way in which GMO-related matters are defined and outlined, particularly through deliberate language choices;
- **storytelling**, i.e. the **narrative "scripts"** based on which GMO stories are told starting from a given framing.

The results of analysis

The framing of the GMO matter is about the language adopted by the media in tackling the issue, as well as about its implications for the construction of a meaning.

What clearly emerges from the story of genetic engineering products is the establishment of certain phrases that tend to strictly characterize the whole talk, and to give it a negative meaning. These are phrases that have a significant conceptual and symbolic impact – almost catchwords, in certain contexts. The main ones include Frankestein food, Natural vs. Artificial, Contamination, Recombinant DNA, Fish-strawberry, NO GMO (or GMO FREE),

The language choices described – i.e. whether to use certain terms having a framing power – are not made at random, but reflect on one side different ways to provide information and, on the other, different points of view.

At the same time, such choices strongly influence the discussion on GMOs, i.e. their storytelling by the media, or by those whose voice is then reported by the media. The shift from the language to storytelling can be very quick. By saying that GMOs "pollute" other crops, a storytelling dimension and a clearly directed narrative development are offered.

The reason for this is that some words are scripts as such. For example the phrase "*Frankenstein food*" has clear references to cinema, and easily leads to imagine a story where food takes unpredictable and abnormal connotations.

It should be noted that information on GMOs in the Anglo-Saxon world tends to be offered in a more sober and pragmatic way. French, German, and Spanish publications too, despite the cautionary attitude of the Authorities and of the public in the respective countries, usually inform about GMOs using a moderate journalist style, focused on the legal and scientific traits of the issue. Indeed Italy is where information on GMOs is most emphatic and inaccurate.

This stated, it should anyway be noted that the GMO issue – now the object of lively discussions in several countries – tends to solicit conflicting language structures. These different storytelling forms can be highlighted with reference to certain basic principles of semiotics.

The review leads to conclude that the debate on GMOs is carried out in the media starting from largely misleading framing effects, which contributed to frame and influence it from the outset and are still used by the press.

The debate on the major mass media is not paying attention to the complexity and facts.

These terms and phrases, which tend to make emotions prevail over reason, are more often used by the European than by the US media and, in Europe, particularly by the Italian ones.

Starting from framing choices, the GMO issue is developed by the media according to different and contrasting storytelling styles. Anti-GMO and pro-GMO stories diverge in some basic aspects. While the Object partly overlaps (although it changes completely in anti-GMO scripts), a true reversal of other crucial narrative figures is observed.

In general, significant improvements are required in terms of information on the issue. In particular, the debate should make a leap in quality, avoiding catchwords and sticking to concrete and objective references – without losing the ability to talk to the widest possible audience.

3.4.3 Summary remarks on the Culture and Media Area

From analysis of perceptions in Europe (and elsewhere) about the use of biotechnologies and GMOs in the area of food, there emerges a cognitive picture decidedly conditioned by a strong orientation towards natural products (seen as the lack or reduced presence of human manipulation), which is closely correlated to health.

This picture is cross-cultural in nature: in fact, there are no significant differences between Anglo-Saxon and continental European countries. People see GMOs as being essentially "unnatural", even in their original structure, especially when they are created through the transmission of genes between different species. Products modified through cisgenic techniques (genes introduced into the DNA of the plant come from the same species) are more acceptable than corresponding transgenic varieties.

According to the Eurobarometer, the level of GMO acceptance has been decreasing in recent years. In particular, this drop is significant within those countries (Spain, Portugal and the Czech Republic) in which GMO cultivation has been allowed for some time.

This trend also depends on the fact that, faced with risks (still vague and not clearly defined), people do not perceive any advantage from the introduction of this new technology.

4. Synthesis scheme and next steps

This document constitutes a first moment of reflection on the subject of GMOs in agriculture.

Todd Gipstein/National Geographic Image Collection

The theme of biotechnology is much broader and requires further analysis to understand what role they can have other techniques for the development of sustainable agriculture

Rich Reid/National Geographic Image Collection

THE FOLLOWING SCHEME PROVIDES AN OVERVIEW AND SUMMARY OF MAIN FINDINGS OF THE ANALYSIS HIGHLIGHTING THE AREA MOST CRITICAL.

FOOD FOR HEALTH

ARE THERE HEALTH RISKS TIED TO EATING GENETICALLY MODIFIED FOODS CURRENTLY ON THE MARKET?

- Is the testing and authorization system adequate?
- Have there been any cases of harmful effects on health caused by the consumption of genetically modified foods?
- In the long term may there be effects on health which we are not aware of at present?
- Is work being carried out to make genetically modified foods available which may play a role in disease prevention?

FOOD FOR SUSTAINABLE GROWTH

CAN GMOs CONTRIBUTE TO TACKLING AND SOLVING PROBLEMS ASSOCIATED WITH ENVIRONMENTAL SUSTAINABILITY AND THE SHORTAGE OF NATURAL RESOURCES? OR, ON THE CONTRARY, DO THEY CONSTITUTE A THREAT TO BIODIVERSITY?

- Can GMOs contribute to tackling and solving problems associated with environmental sustainability and the shortage of natural resources?
- What impact does the extensive GMO monoculture farming model have on the environment?
- Can the use of GMOs create a negative impact on the natural habitat of wild animals and insects?
- Does the use of GMOs decrease the need to resort to pesticides, also taking into consideration the risk of resistance developing?
- Which risks derive from possible contamination amongst GM and conventional plants?

FOOD FOR ALL

CAN GMOs CONSTITUTE AN EFFECTIVE SOLUTION TO THE PROBLEMS OF ACCESS TO FOOD IN THE WORLD? OR, VICE VERSA, MIGHT THERE BE EVEN GREATER INEQUALITY IN DISTRIBUTION?

- Do GMOs make it possible to achieve clear, significant and lasting increases in productivity?
- Might OGMs be an answer to the agricultural problems afflicting developing countries?
- Are there any criticalities linked to the structure of the sector and the business models adopted by companies?

FOOD FORCULTURE

WHAT DO PEOPLE THINK ABOUT GMOs?

- What is people's experience of GMOs?
- How is the topic of GMOs handled by the media?

Legenda

- Not problematic situation / Positive
- Uncertain situation
- Problematic situation
- Critical / Negative situation

This document constitutes a first moment of reflection on the subject of GMOs in agriculture. Over the next few months the BCFN will analyze both the positive and negative impacts brought about by the introduction of GM crops in those countries (the USA, Canada, Argentina, Brazil) which have adopted them on a vast scale and in emerging countries (Chine and India in particular). This analysis will seek to bring together the experiments and evaluations concerning the use of this technology in the various agricultural systems.

For the purpose of looking into these topics in more detail, as in this first document, in addition to analyses on significant data and publications, a round of interviews will be carried out to collect testimonies directly from the experts and operators working in this sector. Evolution of the debate concerning the use of patents and the consequences of the same in terms of competition, will also be followed.

But the topic of biotechnologies is far wider-reaching and requires further analyses before we can understand the role other techniques may have in the development of sustainable agriculture.

Lastly, but possibly this is the most important aspect, all the comments and observations which we receive as feedback to this first document will be collected and made public (also on the website www.barillacfn.com). With this in mind, readers are invited to give their own thoughts and considerations on this topic.

Annex: Media and GMO

Peter Essick/National Geographic Image Collection

Lynn Johnson/National Geographic Image Collection

A1.1 The media approach to GMOs

As mentioned above, GMOs and their future presence (or absence) in the global scenario, are tackled at multiple levels, non necessarily scientific. These include **geopolitics** (trends in China and India will have a decisive impact on the adoption of the outcomes of genetic engineering in the world), **international trade**, **communication processes**. While the first two themes will be discussed in future papers, our focus is now on the third one[1].

In order to understand how the mass media (or, more specifically, in this case, the daily papers and magazines subgroup) present and discuss GMO-related issues, the study was basically founded on the following:

- analyzing the *framing*, i.e. the way in which GMO-related matters are defined and outlined, particularly using non-random language choices;
- analyzing the *storytelling*, i.e. the **narrative "scripts"** based on which stories on GMOs are told starting from a given framing.

Two methodological assumptions apply in this respect:

- the **framing** is at the basis of the media process that leads to discuss GMOs. As observed by Jim Kuypers, one of the experts most involved in this subject, frames are the general core ideas organizing the narrative development of a phenomenon or a social event (Kuypers, 2009);
- however, development in terms of **storytelling** is the most important vehicle to create an impact and involve a wide audience in media processes. This is definitely the case also for the way the issue of GMOs is now approached by the media, both in Italy and in most other Countries;
- in order to study the "storyboard" of the GMO issue, in particular, a **semiotic-narrative approach** was used – with reference to the French-derived semiotics (of the so-called *Ecole de Paris*) – which is particularly fit for the purpose;
- the study was founded on **a set of about 400 press articles** from a number of widely circulating Italian and foreign publications, almost all issued between June 20 and October 20, 2010. The main publications included: Il Sole 24 Ore, Corriere della Sera, La Repubblica, L'Espresso, Panorama, Time, Newsweek, The Economist, Le Echos, Le Monde, El Pais, Süddeutsche Zeitung. Minor publications were also considered.

John Stanmeyer/National Geographic Image Collection

1 *The analysis was supported by the substantial input of Joseph Sassoon, sociologist and member of the Advisory Board of the Barilla Center for Food & Nutrition.*

A1.2 Framing analysis

The framing of the GMO matter is about the **language** adopted by the media in tackling the issue, as well as about its **implications for the construction of a meaning**. Which are the main choices? And which are their consequences?

What clearly emerges from the story of genetic engineering products is the establishment of certain phrases that tend to strictly characterize the whole talk, and to give it a negative meaning. These are phrases that have a significant conceptual and symbolic impact – almost **catchwords**, in certain contexts.

The main ones include:

A) Frankestein food

There is no doubt that the phrase "Frankenstein food" (or the shorter Frankenfood) has contributed to introduce very special meanings into the general idea of GMOs. Adopted a few years ago, it is still used by the media, particularly by the opponents of transgenic products, and particularly in Italy. The act of defining GMOs as "Frankenstein food" has a number of clear implications:

Frankenstein is the emblem of a science ready to perform illicit and morally reproachable experiments.
→ Frankenstein's experiments were aimed at creating new life, but could only generate e terrifying monster
→ GMO producers also want to create new forms of life, acting on an ethically hazardous level
→ GMOs risk to become the analogues of the monster that escapes control and terrifies the world

The phrase, actually very effective, is often used as a brief description of a negative stance towards GMOs, fraught with mediated and alluding contents.

"The ultimate barrier the FDA should overcome is labelling. A few years ago the administration decided it is not necessary to state whether a food is produced with genetically modified grains, unless these change its nutritional properties. Thus, fish called Frankenstein could end up on our table without any additional specifications. Enjoy your food..." (La Repubblica, 27 June, 2010).

"The approval of transgenic salmon, known as Frankenfish, for human consumption in the US was virtually considered as accomplished, but the expert committee in charge of submitting a report on its safety declared itself unable to come to a conclusion." (El Pais, 22 September, 2010).

B) Natural vs. artificial

As argued above, the theme of **naturality** is now a conceptual discriminant in consumer choices all over the world. After all, the antinomy between the **"natural" character** of conventional (or organic) food and the **"artificial" character** ascribed to GMOs is not always founded on a strong scientific basis: even a modern wheat crop, in fact, is highly artificial and subject to man's intervention. However, there is a clear sense of a limit that seems to be overcome by acting on the structure of life. And this too tends to recur as a framing of the issue, particularly in Italy:

Conventional food		GM food
Natural Good Safe	VS.	Artificial Harmful Risky

Interestingly, an equivalent approach (taking most things for granted) is much more seldom found in the **Anglo-Saxon press**. And in **France** and **Germany**, much more cautious with respect to GMOs, the press carefully avoids such phrases.

C) Contamination

This term is used both by the supporters and by the opponents of GMOs. Having a **scientific origin**, if used by the former or by neutral journalists it is usually referred to possible accidental pollination or mixing.

For example, when discussing about the recent occurrence of a few plants of Amadea, a still unauthorized tuber, in crops of **Amflora** – the transgenic potato of BASF approved by the European Union – Le Monde simply observed that:

"According to the German society this contamination … is due to the mixing of seeds in a deposit where both batches were stored together." (Le Monde, 29 September, 2010).

The term is seldom used by the Anglo-Saxon press and, if ever, usually with similar tones.
The term contamination can, however, take **much more unsettling meanings** if associated with words that make it sound more dramatic, as in the texts of certain European anti-GMO movements, including:

"transmission"	**"infection"**	**"pollution"**

In our Country, the phrase *"pollution by genetically modified organisms"* often recurred in the dispute over a GM maize crop in the province of Pordenone.

As already mentioned, unlike the previous phrases originating outside the scientific domain, the genetic contamination issue is investigated very seriously by **science**. But it is interesting to note how a concept originating in an extremely rigorous field can be applied much more **creatively**, using a language purged of all concrete references.

For example, in September 2006 green-party leader José Bové, in the process of destroying a GM maize crop in France together with 85 "mowing volunteers", said: *"GMOs spread… when a conventional crop is contaminated, the process is irreversible."* And his mates said they acted out of fear of *"genetic pollution"* and of a *"planetary food robbery"* (L'Express, 11 October, 2010).

D) Recombinant DNA

This phrase is also perfectly legitimate in scientific discussions on the matter. At the basis of genetic engineering techniques, in fact, recombinant DNA is what allows to create genetically modified organisms.

However, from the framing viewpoint, the term "recombinant" is, as such, very likely to make this phrase **poorly appealing to the public**, particularly if combined with a perceived specific "artificial" character of GMOs.

In truth, the term is quite technical and only seldom used. For example, it is not included in the set of media under study. However it recurs now and then in the journalist jargon (including on TV) whenever GMOs are discussed and, though being scientifically justified, does not help reassure the readers.

E) Fish-strawberry

The GM strawberry obtained by insertion of a gene taken from an arctic fish, in view of improving its resistance to frost, **does not exist**, though its renown was promoted by a scientific paper[2]. In the vision of Dario Bressanini it is, in fact, an urban legend, an imaginary GMO *"that became, in time, a true icon of the anti-GMO movement"* (Bressanini, 2010a, 2010b).

While the foreign papers included in the set under study never mention it, the Italian ones do. Reporting on a meeting organized in last July in Rome, La Repubblica explained that the convention was intended to set GMOs aside and focus on other possible biotechnologies, and wrote:

"GMOs? Old stuff, a research strain that got stuck into implementation troubles and risks. The new frontier of advanced agriculture is a technology reading the future of seeds… Everything changes because the perspective is reversed: efforts are no longer aimed at an amazing event, a strawberry that grows under the snow thanks to a gene from an arctic fish." (La Repubblica, 20 July, 2010).

The fish-strawberry, then, has not disappeared from the media and continues to play a role in the framing of the theme, with the following general effects:

- GMOs are seen as **unnatural** (and somewhat disgusting) **creations**
- the public is invited to **react emotionally,** rather than strive to understand the objective and scientific traits of the theme.

F) NO GMO (or GMO FREE)

The acronym NO GMO or GMO FREE is another **important framing factor**. It is adopted as a banner by movements and associations opposing GMOs, but is also used as a marketing tool by lots of companies or supermarket chains, afraid of driving away part of their consumer base.

Significantly, this acronym has become renowned and widely used on the market. Indeed we are accustomed to use such phrases for substances deemed **harmful in some respects** (sugar free, no caffeine, etc.). The implied meaning is always that the thing denied by the NO is as such harmful and to be avoided.

The NO GMO or GMO FREE acronym is reflected by the media with a variety of stances. Within the set under study, it is not found in the American and British papers – something that points out to its limited framing power in the Anglo-Saxon world.

The French media report on the current discussion about the acronym in a **rather matter-of-fact** way stating, for example that, while the Ministry of Agriculture is preparing rules regulating GMOs in all respects:

"… the most complicated issue is the phrasing 'sans OGM' (GMO free). This text, still under discussion, was not submitted to the Haut Conseil. After lively debates, the French law now provides for GMOs to be only used respectfully of 'production and commercial chains with or without GMOs'." (Les Echos, 28 September, 2010).

The acronym circulates through the Italian media in a different and more controversial way.

2 *Firsov, A.P. and Dolgov, S.V. 1998, Agrobacterial transformation and transfer of the antifreeze protein gene of winter flounder to the strawberry. Acta Hort. (ISHS) 484:581-586 http://www.actahort.org/books/484/484_99.htm.*

In short, the framing analysis – that could be expanded to include additional phrases (only the most significant ones are reported here) – reliably confirms that the debate in the main mass media all over the world, but much more strongly in our Country, still seems to develop at quite a superficial level, not too focused on complexity, and immune to an unbiased analysis of actual data supporting the discussion.

Synthetic phrases are preferably used, capable to summarize a whole thinking universe in few words. This is something the front opposing the introduction of genetically modified organisms seems to have taken advantage of. With great creativity, it found terms capable to appeal to the common mindset and direct the debate as desired.

It is interesting to note that, in the course of the study, no positive equivalent, by power of expression, could be found for the mentioned words.

On the other hand, the nature of the theme – articulated, complex, difficult to fully understand – discourages a more qualified approach. The GMO issue opens up one of the most controversial pages of the modern era: while scientific progress discloses brand new perspectives for our society, hardly imaginable in the past, the average scientific culture of people is still very limited, and the assessment criteria are not always appropriately expressed and shared.

A1.3 Conflicting language structures

The language choices described on the previous pages – i.e. whether to use certain terms having a framing power – are not made at random, but reflect on one side different ways to provide information and, on the other, different points of view.

At the same time, such choices strongly influence the discussion on GMOs, i.e. their storytelling by the media, or by those whose voice is then reported by the media.

The shift from the language to storytelling can be very quick. By saying that GMOs "pollute" other crops, a storytelling dimension and a clearly directed narrative development are offered.

The reason for this is that some words are scripts as such. For example the phrase "Frankenstein food" has clear references to cinema, and easily leads to imagine a story where food takes unpredictable and abnormal connotations.

It should be noted that there is hardly a trace of words capable to determine framing forms in the British and American press included in the reviewed set. Information on GMOs in the Anglo-Saxon world tends to be offered in a more **sober** and **pragmatic** way. French, German, and Spanish publications too, despite the cautionary attitude of the Authorities and of the public in the respective countries, usually inform about GMOs using a moderate journalist style, focused on the legal and scientific traits of the issue.

Indeed Italy is where information on GMOs is most emphatic and inaccurate.

This stated, it should anyway be noted that the GMO issue – now the object of lively **discussions in several countries – tends to solicit conflicting language structures.** These different storytelling forms can be highlighted with reference to certain basic principles of semiotics.

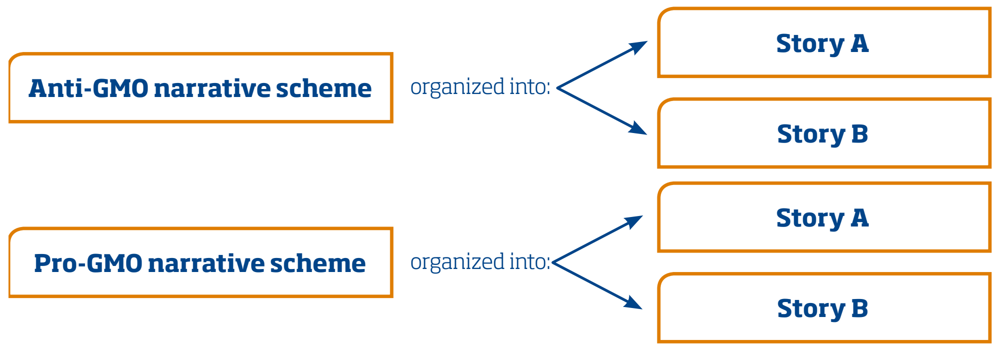
On the next pages, the stories on GMOs in the media are reported through an analysis of their narrative style, with reference to the following conceptual categories of the French school of semiotics (*École de Paris*):

Sender	**Object**
Subject	**Anti-subject**
Helper	**Opponent**

The role of these categories within a story can be defined as follows:

- the *Sender* is the party entrusting the Subject with performing an action;
- the *Object* is what the Subject intends to achieve;
- the *Subject* (or Hero) is the party that plays the main role in the story;
- the *Anti-Subject* is the party that hampers the Subject in playing its role;
- the *Helper* is the party that supports the Subject.
- the *Opponent* is the party that helps the Anti-Subject.

On this basis, the following narrative schemes with respect to GMOs can be found in the media:

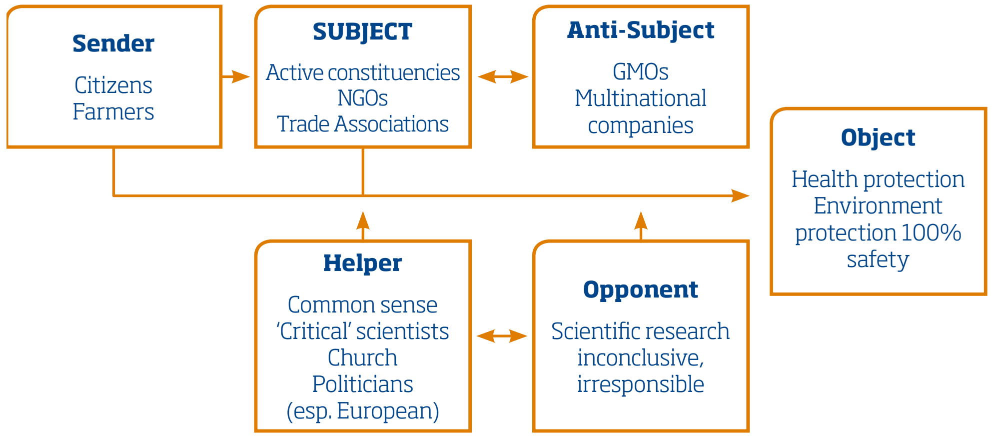


Such schemes can be analyzed as follows:

A) Anti-GMO narrative scheme - story A ("Save the planet")

In this first scheme, the Subject (active constituencies, etc.) states it operates on behalf and in the interest of the Sender (citizens, farmers).

Both the Sender and the Subject aim at achieving the Object, represented by **utmost protection for man and for the environment.**



In pursuing the Object, GMOs - and the multinational companies promoting them - are intended simply as enemies. The Subject is supported by the Helper (scientists "criticizing" GMOs, etc.), whereas the Opponent (allegedly unreliable scientific research) supports the Anti-Subject. The Helper and the Opponent are in contrast with one another.

It is often a radical reasoning approach, the result of extreme simplification, which avoids getting deep into specific arguments to offer a very clear basic direction.

Possible examples of this first approach include:
"We acted as a native community rising up to a virus at the service of multinational companies" (Luca Tornatore, spokesman of the group Ya Basta!, author of the extermination of the GM maize crop near Pordenone, La Repubblica, 10 August, 2010)

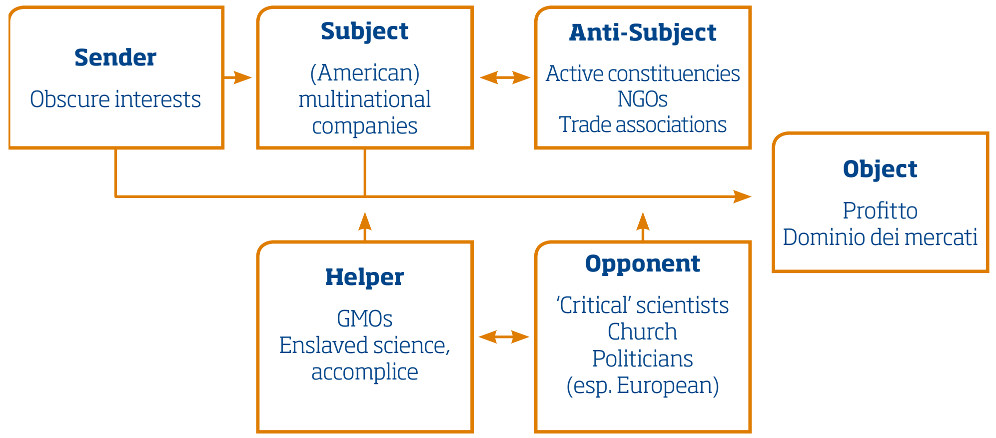
"We absolutely reject genetically modified crops… we want Bavaria to be free of genetic crops… and now we are all on the side of people" (Markus Söder, Minister for the Environment of Bavaria, Süddeutsche Zeitung, 9 July, 2010)
"There is no need for public research to demonstrate what we already know - that GMOs are useless and harmful and cause desolation wherever they are distributed." (Jean-Pierre Frick, pioneer of organic crops in Alsace, Le Monde, 24 August, 2010).

"Genetically modified versions of rapeseed thrive as weeds along the roads in North Dakota, say some scientists, in one of the first cases of genetically modified crops settling into the wild. The extent to which this may cause a problem is the object of a debate. But critics of biotech crops have warned some time ago that genes - in this case providing resistance to common herbicides - can hardly be stopped from spreading with undesired consequences." (New York Times, 9 August, 2010)

B) Anti-GMO narrative scheme - story B ("Dominating strategies")

Anti-GMO storytelling sometimes attributes the Subject's role to multinational companies themselves, described as operating on behalf of a fearful Sender (obscure economic and geopolitical interests).

The Subject's Object is pursuing profit and market control at world level.



The Helper of such Subject is on one hand GMOs, on the other a scientific community that is not just enslaved to dominating interests, but also an **accomplice** thereof.

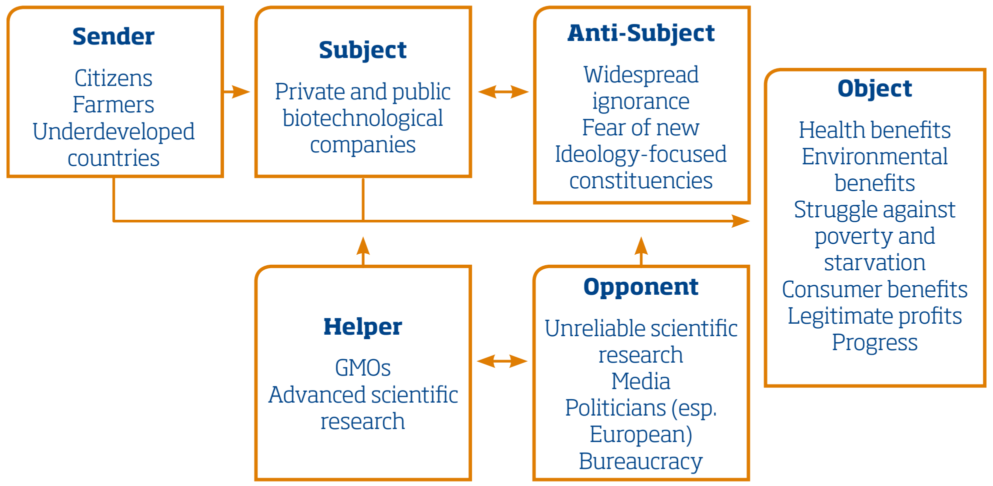
The party that counters this project for world control is an Anti-Subject, including active anti-GMO constituencies and the relevant associations, supported by an Opponent represented by scientists and socio-political forces, sharing a critical vision.

The examined set includes the following phrases referred to this issue: *"… there is a well-founded fear that current research on genetically modified plants is biased by the attempt to concentrate seed production and sale into the hands of multinational companies interested in producing and selling such plants", "…the true business belongs to the multinational companies that patent seeds and bind the farmers, who are forced to buy them every year because GM plants are made sterile for the purpose", "…. the European Food Security Agency (EFSA) has formed a closed loop with the industries. It takes the analyses submitted by the latter as gospel and does not produce true expertises. Its 'specialists' are not even interested in the blood tests of the animals fed GMOs… They authorized the first GMOs on the basis of these unreliable tests. The European Parliament should start an inquiry on the friends of the experts in charge of making their assessments".*

C) Pro-GMO narrative scheme - story A ("The walk of progress")

GMO supporters attribute the Subject's role to small and large biotechnological companies and institutions.

The Object is very complicated and includes multiple benefits for man and the environment, as well as for the same biotechnological companies, considered as utterly lawful economic players operating in view of progress.



The Helper is GMOs, which support the pursuit of the Object, and research that created them and controls their development.

The Anti-Subject is identified, in particular, with ignorance and the fear of new, which ideology-focused constituencies exploit for their purposes supported by unreliable scientific research and other social forces, including the media.

Possible examples of this approach include:

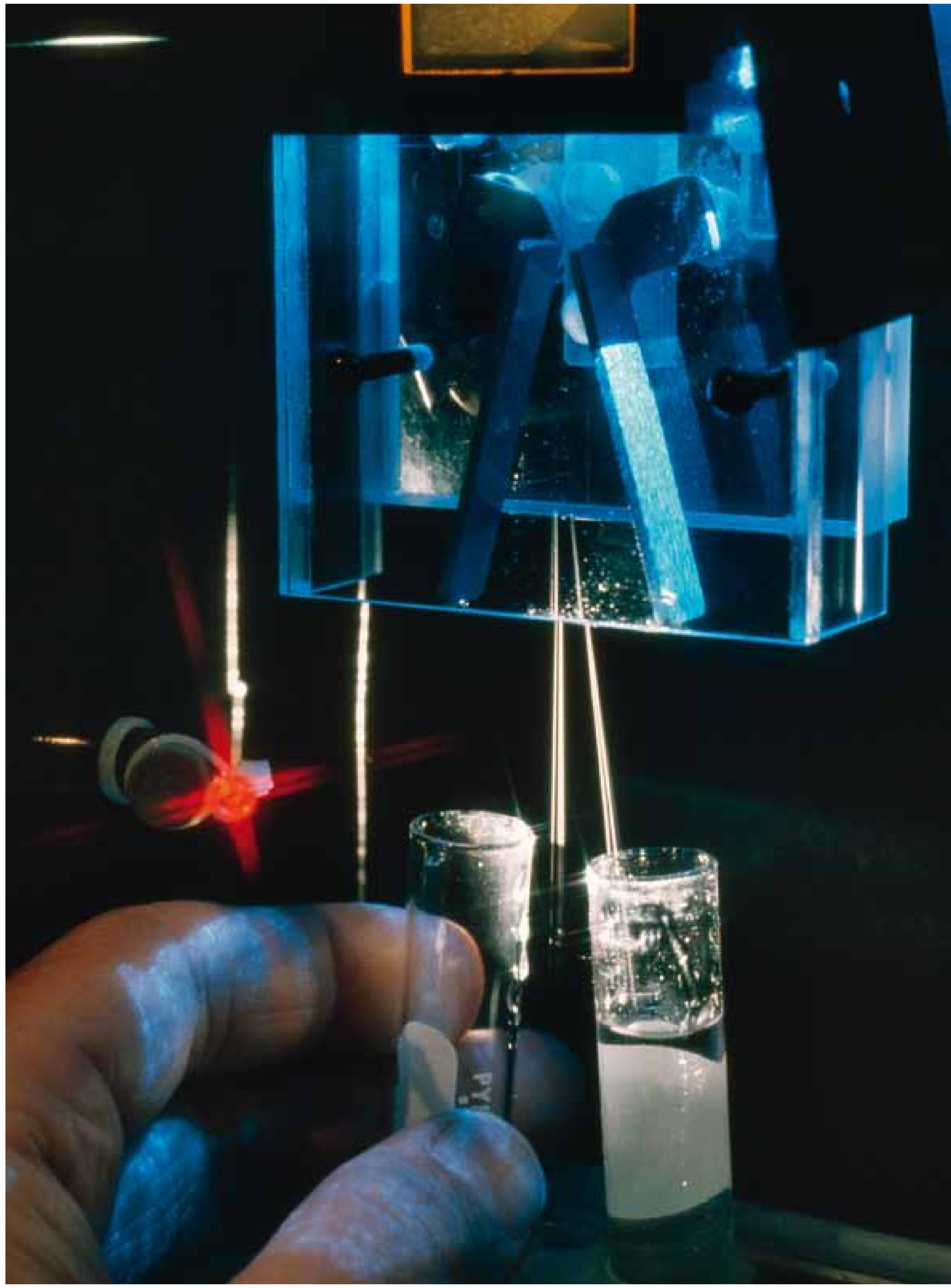
"For laymen, for citizens in general, rejecting the opportunity offered by GMOs a priori is a result of fear of the unknown" (Il Sole 24 Ore, 31 August, 2010)

"One paradox in this situation is that, while the European countries have protected themselves from transgenic products as they would from the devil, China and other emerging countries have created their own think-tanks and developed their own genetically modified seeds. The scientific community agrees that biotechnology is a must to produce more food without taking more lands from forests or wasting more water." (El Pais, 4 July, 2010)

"The increase of wheat prices… shows how dangerously precarious food is on our planet, and particularly stresses the illusion of abundance that often justified the abandonment of agricultural policies, especially in the third world. These soaring prices will at least remind the 'mowing volunteers' of how dangerous it is, in most parts of the world, to exclude GMOs from the possible farming options." (Le Monde, 7 September, 2010)

"Biotech crops seem to have brought great benefits to the environment so far, at least in terms of reducing pesticide use (an important source of water contamination) by 10%...In China and India, 13 million farmers grow biotech cotton, and in few years India has become one of the world's main cotton exporters." (Time, 21 June, 2010)

"Scientists from no-profit institutions have been working for over two decades on genetically modified seeds that can provide benefits to farmers coping with more and more pervasive droughts, as well as old and new pests. Drought-resistant manioc, insect-resistant cowpeas, fungus-resistant bananas, virus-resistant sweet-potatoes, and high-yield pearl millet are just a few examples of genetically modified foods that could improve the life of poor populations around the world." (New York Times, 14 May, 2010)

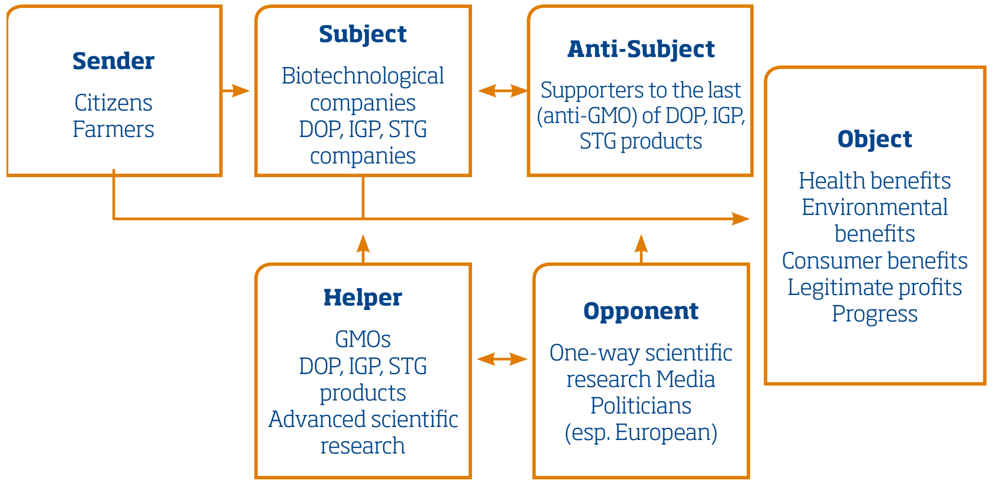


Jim Richardson/National Geographic Image Collection

D) Pro-GMO narrative scheme – story B ("Coexistence between GMOs and typical products")

In this last case the Subject is represented by biotechnological companies, together with those operating in the field of typical DOP (or IGP or STG)[3*] products, not necessarily in contrast with each other.

The Sender and the Object are the same as in the previous scheme, but in this case the focus is on Europe.



The Helper is both GMOs and the typical DOP (or IGP or STG) products, all capable to support the pursuit of the Object in different modes and circumstances, including – if appropriate – with focused alliances.

The Anti-Subject is represented by the extreme supporters of either perspective, in a limited vision that implies the exclusion of the other.

Possible examples of this approach include:

"Virtually all agro-biotech multinational companies own a seed company that develops and sells non-transgenic seeds as well. It is no longer the time for farmers to create new varieties, selecting and crossing the best specimens found in crops, perhaps changing by chance. Today the production of a new variety requires years-long development, investments, and advanced biotech scientific research, as well as a strategic vision. Modern biotechnologies are not against typical products, whose plants are constantly improved while remaining 'typical'." (Dario Bressanini, Corriere della Sera, 6 September, 2010)

"Francesco Sala, a guru of botanic science in Milan and the author of 'Gli Ogm sono davvero pericolosi?' (Are GMOs truly hazardous?), notes that typical products themselves are the result of cross-breeds and mutagenesis on seeds – from Nero d'Avola grapes to red onions of Tropea. And in genetic mutations they can find a safe harbour, rather than a threat. Twenty-five percent of Carnaroli rice crops are destroyed by a fungus, but could be saved by inserting a gene promoting resistance… and the same process could help manage the virus that devastated San Marzano tomato crops. Good reasons to hope that Italy will follow Spain, Portugal, the Czech Republic, Romania, and Slovakia along the way towards GM crops. And that, by ensuring appropriate rules on crop coexistence and on consumer information, the populism of horror campaigns on Frankenstein food may cease." (Il Sole 24 Ore, 3 March, 2010)

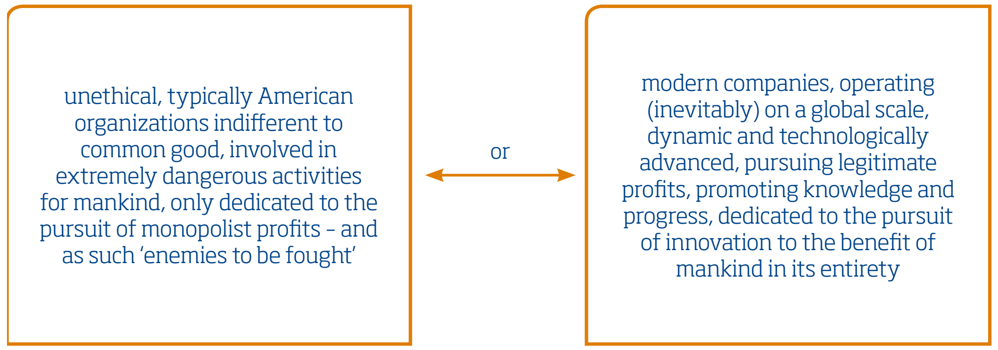
In the studied press set such narrative development is only found in the Italian media. It should be noted, however, that the same point of view is also offered in the United States by outstanding experts, who expand this perspective to include organic products.

3 * *DOP (Denominazione di Origine Protetta) – Protected Designation of Origin; IGP (Indicazione Geografica Protetta) – Protected Geographical Identification; STG (Specialità Tradizionale Garantita) – Guaranteed Traditional Specialty (Translator's note)*

A1.4 Interests at stak

As described in the above schemes, the interests at stake in GMO storytelling by the media can be represented in radically different ways.

For example, how is the role of multinational GMO companies described? Based on the previous pages, multinational companies can be described as the Subject or the Anti-Subject of the story, and play a role in very different scripts as::



With respect to such dualism, the media provide several qualifications, modulations, and different tones – but there is no doubt that anti-GMO opinions tend to approach the first end, and pro-GMO ones are inclined towards the second.

Opponents to the power of multinational companies, then, describe GMOs as part of a logical principle contrary to the interests of small-scale producers and farmers.

This principle is deemed adverse to local productions (on a small scale, in harmony with the territory, aware of biodiversity) and rather inclined towards the homologation of few large-scale crops, which multinational companies try to impose through their financial power, their market control, and their quasi-monopoly in research on biotechnologies.

But some GMO supporters stress that the market leadership of multinational companies in genetically modified products is largely due to the short-sightedness of their opponents.

While multinational companies, like all large companies, may have a monopolist inclination, anti-GMO movements – deprived of reliable scientific foundations – are acting against the interests of those they claim to represent:

"The opponents of genetically modified crops spent the best part of the past decade stimulating consumer distrust towards this accurate and safe technology although… these crops never caused damage to man's health or to the environment. By doing so, they pushed regulation costs upwards, so that now technology is not affordable for small companies or foundations that could otherwise develop a broader range of healthier crops for farmers in need. The European restrictions, for example, make it virtually impossible for scientists in small labs to perform tests on genetically modified seeds. Thus, opposition to genetic engineering has confined technology even more to the few seed companies that can afford it." (Pamela Roland & James McWilliams, New York Times, 14 May, 2010).

With reference to interests, it should be noted that Pamela Roland, just quoted, in articles and particularly in her recent book *Tomorrow's Table: Organic Farming, Genetics and the Future of Food*, claims that while genetic manipulation and organic products are often unduly opposed, they are two different entities that could very well integrate one other to provide food to future mankind in an ecologically balanced way.

In particular, Roland observes that:

- organic agriculture started as an answer to environmental and health issues associated with an overuse of chemical agents in conventional agriculture
- it can be described as 'farming through biology', being based on the concept of using living organisms instead of chemicals
- at local level, organic agriculture is surely environment friendly, but may not be globally sustainable, because it requires more water and land than conventional agriculture
- genetic engineering is a valuable tool that farmers can use to manage actual problems, like pests, plant diseases, weeds, or droughts
- genetic engineering has an extraordinary potential, not least because it allows to improve knowledge of biological phenomena
- genetically modified products will inevitably grow, what is important is not so much whether to use them, as how we will use them
- a very valuable development is the opportunity to obtain genetically modified products with the desired traits, and then grow these crops according to organic agriculture criteria.

The same subject is only included in one short French article of the set under study, basically confirming the same assumptions: "*Organic products, not necessarily more environment friendly, could find an ally in GMOs. By making organic products more effective, GMOs would make this green supply chain more competitive. And by redistributing productivity gains to the customers in the form of price reductions, an organic-GMO supply chain would also be well prepared to compete with traditional agriculture. This would allow to reduce the consumption of chemical pesticides or fertilizers, with a positive impact on the environment… Instead of fearing GMOs, their benefits and drawbacks should be objectively studied.* (Les Echos, 18 August, 2010).

A1.5 Closing remarks

This review leads to conclude that the debate on GMOs is carried out in the media starting from largely misleading framing effects, which contributed to frame and influence it from the outset and are still used by the press.

These terms and phrases, which tend to make emotions prevail over reason, are more often used by the European than by the US media and, in Europe, particularly by the Italian ones.

Starting from framing choices, the GMO issue is developed by the media according to different and contrasting storytelling styles.

Anti-GMO and pro-GMO stories diverge in some basic aspects. While the Object partly overlaps (although it changes completely in anti-GMO scripts), a true reversal of other crucial narrative figures is observed.

For example, multinational companies are seen in radically different ways in the individual schemes – as a Subject operating in view of progress or as an "enemy to be fought".

The scientific community is also controversial – being seen either as the Helper of a project to the benefit of mankind or as an irresponsible Opponent.

Sometimes GMO storytelling is more complicated – and confused – by the fact that each stance (in favour or against) can actually adopt two different scripts (story A and story B), which can in practice mix with one another.

One conclusion of the analysis is, however, that in GMO storytelling the Italian media differ from the foreign ones for their special propensity towards being over-polemic and using inappropriate metaphors, strong emotional stimuli, and a poor approach to actual facts.

This judgement obviously does not concern all the Italian media and commentators considered. But there is no doubt that significant improvements are required in terms of information on the issue in Italy. In particular, the debate should make a leap in quality, avoiding catchwords and sticking to concrete and objective references – without losing the ability to talk to the widest possible audience.

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