ENVIRONMENTAL AND ECONOMIC ISSUES IN GM CROP AND FOOD PRODUCTION

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Abstract

Nowadays quality control is essential in the food industry, and efficient quality assurance has become increasingly important. Instrumentation and food safety practices are of central importance, with particular emphasis on very high sanitary and hygienic operating standards. In this context, labelling can help consumers take up their political responsibility. As citizens, consumers have certain sensible cares that can reasonable influence the market.

The current EU legislation for genetically modified organisms (GMOs) regulates issues concerning environmental aspects and food as well as feed safety, procedures for commercialisation and labelling provisions. At present, only a limited number of certified reference materials are commercially available and there is no reference material accessible for GMOs that are not authorised in the EU.

For the biotech detractors, safety, and environmental concerns far outweigh the importance in improved food quality, increased food production, and enhanced agriculture brought about by GM techniques. On the other hand, on the basis of a comprehensive literature research it is assumed that a relationship exists between production quality and control sistem allowing a deveolpment scenario including also plant biotechologies.

Nevertheless the cultivation of crop plants sometimes guides to such side effects as soil erosion, contamination by pesticide residues, gene transfer through

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crossbreeding or loss of natural species due to the higher competitiveness of invasive cultivated crops. Whether or not such effects can occur depends largely on certain traits inherent to the plants: reproduction behaviour, various resistance factors and different requirements concerning soil and climate.

The EU considers separate regulation to be necessary because, through genetic engineering, fundamentally new traits can be introduced, although an open behaviour in showed towards this new scientific field.

Riassunto

Oggigiorno il controllo qualitativo nell'industria alimentare ed un efficiente garanzia dei prodotti da essa risultanti costituiscono un fattore commercialmente centrale. In particolare, viene posta un'attenzione specifica agli standard sanitari ed igienici. In questo ambito l'etichettatura può aiutare i consumatori ad accrescere la propria responsabilità di scelta e porta la stessa domanda ad essere direttamente influente rispetto all'offerta.

La legislazione europea corrente, relativa agli Organismi Geneticamente Modificati (OGM) ed alla loro identificazione in etichetta, regola temi quali l'ambiente, gli alimenti e la sicurezza delle sementi. Ad oggi solo un numero limitato di referenze commerciali relative sono disponibili sul mercato e queste sono controllate in entrata dall'UE.

Per i contrari alle biotecnologie, gli aspetti relativi alla sicurezza alimentare ed ambientale sono da ritenersi più importanti di temi economico-quantitativi a sostegno degli alimenti biotecnologici.

D'altra parte, le moderne tecniche di gestione della qualità, come sostenuto da una parte della letteratura, permettono di avvalorare sistemi di controllo in grado di offrire un panorama di sviluppo comprensivo i frutti delle stesse biotecnologie. Ciò nonostante la coltivazione di piante OGM potrebbe determinare effetti collaterali quali erosioni del suolo, contaminazioni, trasferimenti genetici attraverso impollinazione incrociata o perdita di biodiversità dovuta all'alta competitività ed invasività delle coltivazioni GM. Se questi effetti possono presentarsi o no, dipende parte dalle caratteristiche intrinseche delle piante: comportamento riproduttivo, fattori di resistenza e diverse necessità riguardo il clima.

L'UE attualmente ritiene necessaria una regolamentazione separata tra prodotti e pratiche OGM e "OGM free", non nascondendo un atteggiamento aperto rispetto alle innovazioni in tale vasto ambito di studio.

Keywords: GMOs, Environment, Coexistence, Food production, Economic issues

Introduction

Coexistence as a topic is related to "the economic consequences of adventitious presence of material from one crop in another and the principle that farmers should be able to cultivate freely the agricultural crops they choose, be it GM crops, conventional or organic crops" (1). As well coexistence means believing in future advances of genomic sciences. These technologies pledge the discovery of new genes conferring advantageous characteristics to crops, promising additional nutritional improvement and benefits for the environment.

In this scenario, adventitious presence of GM crops in non GM crops turn out to be an issue where consumers claim for products that do not contain, or are not derived from GM crops.

The original driving force for differentiating currently available crops into GM and non GM came from consumers and interested subjects who expressed the aspiration of avoiding any support to GM crops and their derivatives, based on perceived doubts about GM crop impact on human health and environment.

Nowadays, in fact, many consumed foods are GM whole foods or contain ingredients derived from gene modification technology (GM crops). It comes that billions of dollars in U.S. food exports are come from sales of GM seeds and crops.

So, the question is: where is the core of all suspicions? And more: can the consumers believe in biotechnology as a safe science?

Basically a biotechnology is any technique that uses living organisms or parts of them to obtain goods or services. This includes both "classic" biotechnologies (based mainly on the use of certain fermenting micro-organisms) and "advanced" ones, which use the findings of genetic engineering and molecular biology for the selection of new organisms and the creation of new products (2). However, while public opinion is quick to accept the innovations and hope that biotechnology brings to the field of health, it is highly resistant when these same innovations are used in farming and food. This attitude stems from doubts and fears furled by a lack of well-balanced information and in this field it's too important being well informed.

It's good peruse recent history which relates that the name "biotechnology" first appeared in Yorkshire early in the 20th century. Genetically engineered foods first appeared in the food market in the 1960s. In 1967, a new variety of potato called "Lenape potato" was bred for making potato chips. After two years of production, this new potato variety developed a toxin called solanine. Consequently it was withdrawn from the market by the USDA. Between 1986 and 1997 biotechnology was used more and more by new private sector actors in the agri-food sector to genetically modify 60 crops for ten different features. Thus, in large part the history of food processing is a history of bioengineering with the gradual replacement of human efforts and energy first supplied by animals, later by machines.

The biotech industry is becoming more competitive and is rapidly expanding beyond its borders. The industry is still dominated by the U.S. sector, and the relatively younger companies in Europe and Asia has some significant chellenges ahead as they try to catch up with the United States. But these companies also have a benefit that the U.S sector did not possess when it was at the same stage in its history- the ability to tap into resources and stregths from around the world, in what is rapidly becoming a truly global industry (Figure 1).

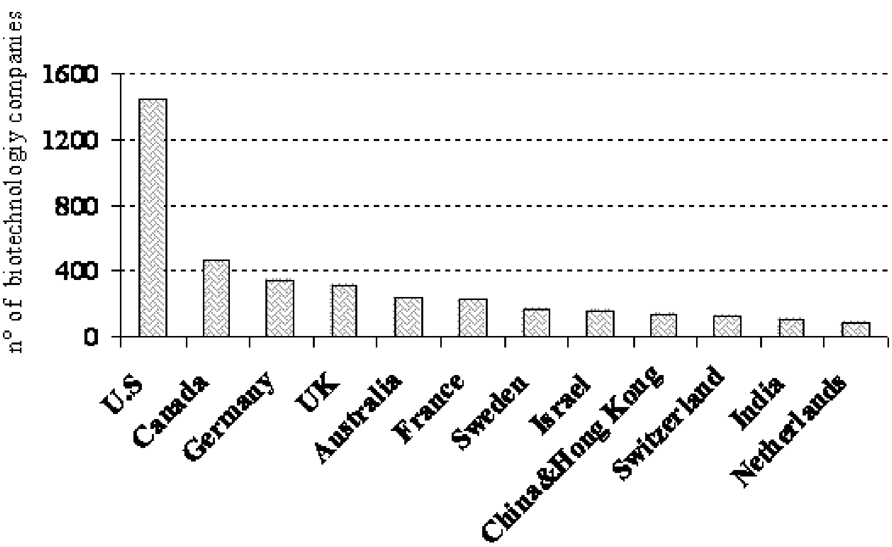

Fig. 1 - Top 12 biotechnology countries
Source: Ernst and Young 2005

The European industry is already facing a significant challenge on the fourth hurdle issue. In 2004, for example, Germany joined the bandwagon of contries introducing another evalution process on top of the regulatory approval to assess whether newly approved drugs qualify for reimbursement. The indurty is left with a paradoxical situation. While regulators wants more data about mechanism of action, pharmacogenetics, and safety issue, the grugs approval process itself becomes less, rather than more, predictable-creating new sources of risk for biotech companies. 2004 has been a years that many someday be recognized as a watershed for the industry. While huge challenges remain, there is also sufficient reasons to maintain a positive outlook. Having survived a particularly torturous period, the European biotech industry is now better placed to gain momentum (Figure 2).

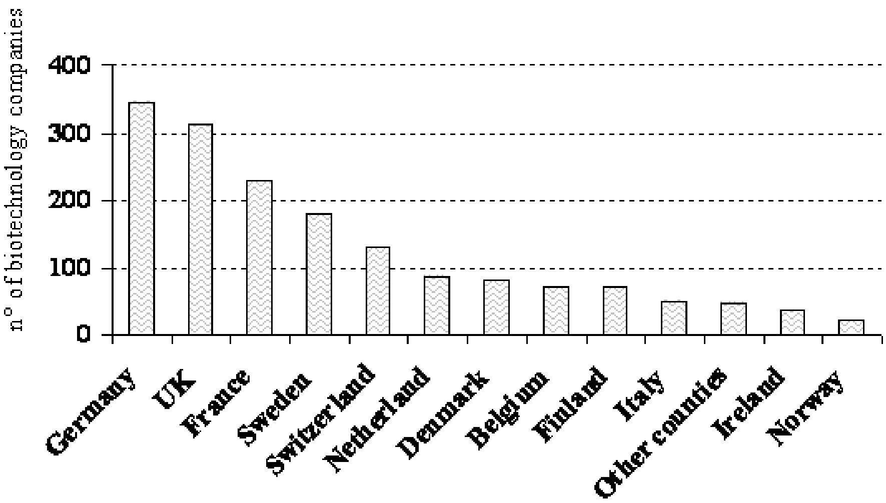

Fig. 2 - European companies per country (private and public companies)
Source: Ernst and Young 2005

Nowadays biotechnology is a new industry that is knowledge-based and mostly composed of a new small firms that have close links with University-based scientists. These industry innovations have several functional applications in agriculture and are helpful for developing countries. Furthermore a fundamental question arises considering that some firms are going global with their strategies while other firms with similar size and product mix are not.

On the other hand, these new technologies are protected by IPRs (Intellectual Property Rights). So the implications are different and through this fault too biotechnology applications in the agro-food sector are discussed controversially in many countries (3).

Detractors oppose the fact that seeds which have been largely known as commodity products are now regarded as proprietary products because of genetic modification. Many critics view the "terminator gene" technology as a monopoly and anti-competition.

Nevertheless biotechnology is an enabling knowledge, which uses the properties of living things to transform crops and produce foods, to obtain substances with salutary activity and search for solutions for solving environmental problems. In this way biotechnology is the one science correlated to food production that has caused most public debate. In fact, while the use of a number of GMOs promises to reduce the unfavourable effects of modern agriculture, apprehension for some hypothetical risks have also been raised in contrast to the expected economic advantages. Regarding hypothetical increased productivity from the use of recombinant DNA technology, some critics worry about corporate control over agriculture.

Moreover GM knowledge is also one of the issues where the perception gap between consumers on the one side and producers and scientists on the other has been most evident. For the most part scientists are enthusiastic about the ways in which GM can change development and food producers are persuaded about the potential of GM applications for increased process efficiencies and new products. Consequently farmers have embraced the technology so quickly for several simple reasons: biotech crops improve yields, cut costs and reduce spraying. Not only do these benefits improve farmers' bottom lines, but they also save time, improving their quality of life by giving farmers more time to pursue other activities. But consumers have been sceptical.

The principal reason of the delay in diffusion is connected to ambiguity and risk and to lack of information about new important technology. In fact, this generates a negative impact on the regulatory institutions involved, an increase in the economic vulnerability of the industrial sector associated with this particular technology and potential for the escalation of critical media interest (4). At the moment, yet, research and development of GMOs for food have been concentrating on a few "core crops", defined mainly by the actual or potential value of the market for seed (5).

Even so biotechnology continues to be the most rapidly adopted technology in agricultural history due to the social and economic benefits that crops offer to farmers and society.

Futher, 2 milion more farmers planted biotech crops last years to total 12 milion farmers globaly enjoing the advantage from thew improved technology. Notably, 9 out of 10, or 11 milion of the benefiting farmers, were resource-poor farmers, exceeding the ten milion mileston for the for time. In fact, the number of developing twelve countries planting biotech crops surpassed the number of industrialized eleven countries, and the growth rate in developping world was three time that of industrialized nations (21% comparate to 6%). Although the first commercial GM crops were planted in 1994 (tomates), 1996 was the first year in which a significant area (1.66 milion hectares) of crops were planted containing GM traits. As a result of consistent and substantial benefits during the first dozen years of commercialization from 1996 to 2007, farmers have continued to plant more biotech crops every single year.

In 2007, for the twelfth consecutive year, the global area of biotech crops to soar. Remarkably, growth continued at a sustained double digit growth rate of 12%, or 12.3 milion hectares (30 milion acres)- the second highest increase in global biotech crop area in the last five years- reaching 114.3 milion hectares (282.4 milion acres) (Figure 3).

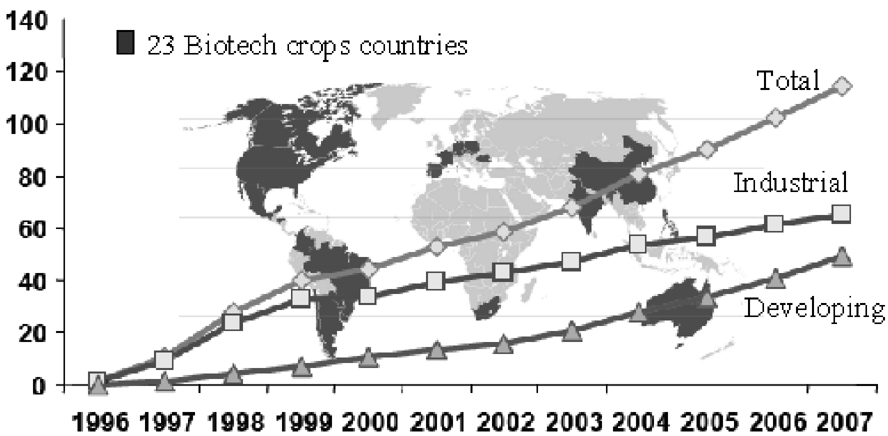

Fig. 3 - Global area of biotech crops (milion hectares 1996 to 2007)
Source: Clive James, 2007

In 2007 the number of countries planting biotech crops increased to 23, and comprised 12 developing countries and 11 industrial counties; they were, in order of hectarage, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania e Poland (Figure 4).

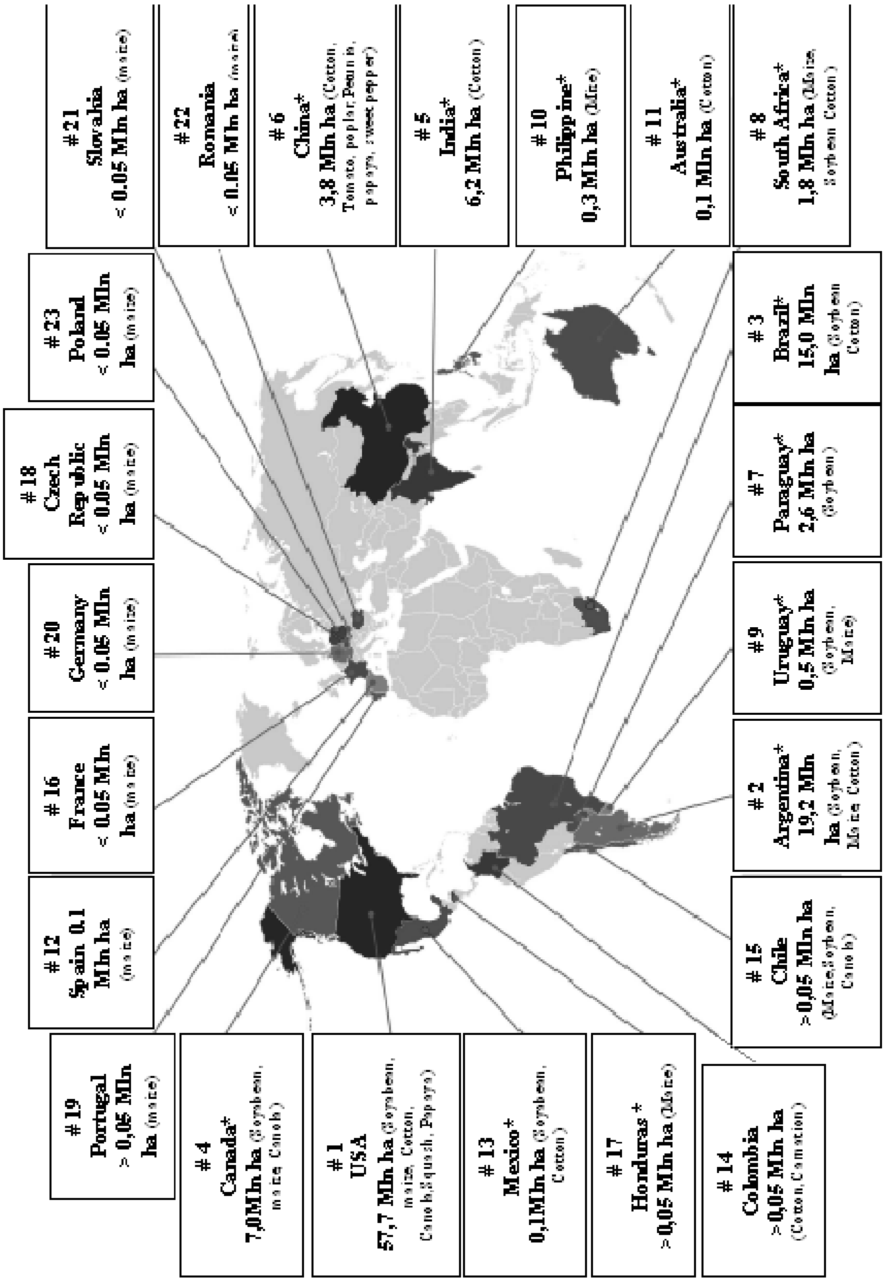

Fig. 4 - Biotech crops countries and mega-countries, 2007
*13 biotech mega cauntries growing 50,000 hectares, or more, of biotech crops
Source:Clive James, 2007

In Table 1 is reported the share of the global crops market for the main GM crops (soybeans, maize, cotton and canola).

- Soybeans: in 2005, 30% of global production was exported and 98% of these trade came from countries which grow GM soybeans. Assuming that the same proportion of production in these GM exporting countries that was GM in 2005 was also exported;
- Maize: about 11% of global production was trade in 2005. Whiting the leading exporting nations, the GM maize growers of the US, Argentina, South Africa and Canada are important players (80% of global trade);
- Cotton: in 2005/06, about 26% of global production was trade. Of the leading exporting nations, the GM cotton growing countries of the US and Australia are prominent exporters accounting for 54% of global trade;
- Canola: 12% of global canola production in 2005 was exported, with canada being the main global trading country. The share of global canola export accounted for by to GM canola Porducing countries (Canada anc US) was 73% in 2005 (98% of this came from Canada).

In this context, there are two diametrically opposite probable future scenarios. Supporters of biotechnology and many agri-food policy makers around the world forecast a positive situation in which technology could solve food deficiencies, get better the environment, heals or eliminates illness and leads to a prosperous and healthy society.

In short, they believe that the potential good of the technology is considerable. On the other hand a significant number of policy makers, citizens and consumers fear that the biotechnology will aggravate food insecurity, threaten the environment, endanger human health and ultimately impoverish some parts of society.

TABLE 1

SHARE OF GLOBAL CROP TRADE ACCOUNTED FOR GM PRODUCTION 2005 (MILLION TONNES)

	Soybeams	Maize	Cotton	Conola
Global production	210	695	24.2	46.4
Global trade (export)	62.9	76.2	6.3	5.45
Share of global trade from GM producers	61.9 (98%)	61.24 (80%)	0.6 (57%)	3.98 (73%)
Share of global trade from Gm producer if GM share of production used as proxy for share of export	48.7	32.55	0.5	3.3
Estimated size of market requiring certified non GM (in countries that have imported requirements)	5.0	< 1.0	Negligible	Negligible
Estimated share of global trade that may contain GM (ie. Not required to be segregated)	56.88	61	0.61	3.98
Share of global trade that may be GM	90%	80%	57%	73%

Source: PG economics Ltd 2006

Environmental aspects

As everybody knows, a position against the use of genetic modification in food and agriculture in industrialised countries might be perfectly compatible with its promotion in developing countries (6). Many European positions agree with this statement. But the state of art is surely no easy. In fact, each society may have different principles assigned to the positive and negative impacts of GMO crop on sustainable development.

The EU crisis in terms of food chain quality and consumer assurance, as experienced in the past, has resulted in the agro-industry coming under rigorous supervision from soil to consumer.

On the other hand, in the industrialized world farmers, who are progressively confronted with strong competition because of trade liberalization, good methodology in terms of agricultural costs and praxis may play an important role in the economic dimension of sustainability.

In this direction characteristics of herbicide tolerance and insect resistance of the GM feed crops achieved by multinational corporations evidently reflect the need for cost-efficiency by the industrialized agricultural sector (7).

It can be argued that one reason for the debate about GMOs in the developed world is the discrepancy of interests between overseas consumers of final products and the exporting agricultural sector, which is upstream in the global food chain. In this context, traceability systems document the history of a product and may provide the aim of both marketing and health protection.

The need for traceability systems in the area of GMO derived products originated from the indications in Regulation 258/97 (8), where labelling requirements have been set for GMO-derived products to enable consumers to make a choice, even though in this regulation no clear reference to traceability is made (9).

The current EU legislation for GM crops regulates problems concerning environmental aspects and food and feed safety, procedures for commercialisation and labelling provisions, including in the environmental aspects the contained use and the deliberate release of GMOs into the environment.

Official positions of especially the European Union and the United States diverge on which objectives justify mandatory traceability provisions. In contrast to the EU, the US has serious concerns regarding mandatory product tracing systems for reasons other than food safety. The US strongly opposes mandatory measures to support product labelling, consumer information, or identity preservation of a product. According to the US, products tracing should only be considered where it is necessary to protect the health of consumers, to meet a food safety objective, or to manage an identified risk. Tracing requirements should be scientifically based on risk assessment. In practice, the US government establishes food safety performance standards that food production and processing plants must meet, that then are continually verified through inspections. Negligence in carrying out HACCP (Hazard Analysis and Critical Control Points) plans results in regulatory action (9).

Thus environmental aspects in GM crops are simply crucial. Nevertheless environmental effects frequently are still associated with sub-optimal variation to local environmental conditions.

Some critic voices deal with Gm crops danger for the environment and for the health of consumers. In fact, often it is said that there is a contraposition between natural food and GMOs.

So nowadays it's correct to speak about risk analysis and risk management. The general main beliefs for risk analysis were first established for the evaluation of health effects from potentially toxic substances. Risk is defined as the possibility that, under particular conditions of contact, an intrinsic hazard will represent a menace to human health. Risk is consequently a function of hazard and exposure. Hazard is defined as "the intrinsic potential of a material to cause adverse health effects; implicit in the definition is the concept of severity and adversity of the effect" (10-11). Risk management is defined as "the process of weighing policy alternatives to mitigate risks in the light of risk assessment and, if required, selecting and implementing appropriate control options, including regulatory measures" (10).

Agricultural practice emerged to be of greater empirical importance with regard to ecologically significant properties than either invasiveness or gene transfer. Plant-cultivation measures are determined by the needs of the individual culture interacting with the environment, especially by resistance factors and tolerances. Breeding changes have led to modify cultivation conditions and thus had ecological impacts.

Several significant crops are already being grown from seeds engineered with built-in immunity to herbicides, viruses, pests, and disease. From GM plants are derived ingredients (oils, flours, meals, flavours, colorants), whole foods, food products, and feed used in various industries. In the same way other possible benefits are: the use of GM livestock to develop organs for transplantation into humans, increased crop yield, progress in agriculture through breeding insect, weather resistant crops, utilize of GM plants as bio-factories to yield raw materials for industrial uses, employ of GM organisms in drug manufacture, in recycling and/or elimination of toxic industrial wastes.

Hence genetic modification has a positive impact on farming and food production. Through innovations in chemistry, biotechnology and crop science, agricultural productivity is increased. GM also improves fertilizer efficiency and make stronger the world's food supply by creating environmentally friendlier crops. Among the first transgenic crops approved for release were Bt maize and Bt cotton, which contain genes encoding insecticidal proteins from the bacterium Bacillus thuringiensis. These crops have been readily adopted by farmers, have resulted in increased yields and reductions in pesticide applications, and have been sustainable when used with resistance management programmes. In Table 2 are summarized the environmental impact over the last ten years and shows that there have been important environmental gains associated with adoption of GM technology.

In term of the division of the environmental benefit associated with less insecticide and herbicide use for farmers in developing countires relative to farmers in developed countries. Table 3 shows that in 2005, the majority of the environmental benefits associated with lower insecticide and herbicide use have been for developing countires farmers. The vast majority of these environmental gains have been from the use og Gm IR (insecticide resistent) cotton and Gm HT (herbicide resistent) soybeans.
However, continuous controversies surrounding the risks and benefits of this novel technology have prevented its benefits from reaching consumers in many parts of the world. Another transgenic food is rice, it is the target crop for many improvement programmes because it is the staple diet for nearly two billion people worldwide and the major food for over half of those living in Asia (12). Although Bt is non-toxic to humans, and decomposes in the stomach acid, it's toxic to insects such as the European corn borer, cotton bollworms, and potato beetles. This toxic Bt protein eliminates the need for chemical pesticides against insects that transmit viruses and other dangerous microbes.

Besides in both the U.S. and the European approach, the initial step in evaluating GMOs has an environmental matrix. Generally speaking, a new protein should be estimated carefully for toxicity and for characteristic considered desirable (pest resistance, tolerance to herbicides, increased vitamin content, and so forth). If the tests are negative, then the transgenic

TABLE 2

IMPACT OF CHANGE IN THE USE OF HERBICIDES AND INSECTICIDES FROM GROWING GM CROPS GLOBALLY 1996-2005

Traits	Change in volume of active ingredient used (mln Kg)	Change in field EIQ* impact (in terms of mln field EIQ/ha units)	% change in ai** use in GM growing countries	% change in environmental impact in GM growing countries
GM erbicide tolerant soybeans	-51.4	-4,865	-4.1	-20.0
GM erbicide tolerant maize	-36.5	-845	-3.4	-4.0
GM erbicide tolerant cotton	-28.6	-1,166	-15.1	-22.7
GM erbicide tolerant canola	-6.3	-310	-11.1	-22.6
GM insect resistant maize	-7.0	-403	-4.1	-4.6
GM insect resistant cotton	-94.5	-4,670	-19.4	-24.3
Totals	-224.3	-12,259	-6.9	-15.3

**EIQ: environmental impact quantity*
***ai: active ingredient*
Source: PG economics Ltd 2006

plant can be evaluated to see whether it is "substantially equivalent" to its non GM counterpart.

At the present time the limits for the presence of GMOs in human foods are rigorous and unambiguous. Even if the current legally enforceable limit for GMO presence labelling is 0.9%, some organic certification bodies apply a more severe de minimis threshold on their members (0.1%, limit of detection).

TABLE 3

GM CROPS ENVIRONMENTAL BENEFITS FROM LOWER INSECTICIDE AND HERBICIDE USE 2005: DEVELOPING VERSUS DEVELOPED COUNTRIES

	% of total reduction in environmental impact: developed countries	***% of total reduction in environmental impact: developing countries****
GM HT[1] soybeans	53	47
GM IR[2] maize	92	8
GM HT maize	99	1
GM IR cotton	15	85
GM HT cotton	99	1
GM HT canola	100	0
Total	46	54

**developing countries include all countries in South America*
1 HT: Herbicide Tollerance
2 IR: Insect Resistent
Source: PG economics Ltd 2006

Detractors of the theory of substantial equivalence declare that current testing approaches do not sufficiently address putative unintended and unforeseen effects and can not rule out the amount of potential long-term effects that result from sustained human exposure to such crops that might have subtle compositional changes that may be difficult to detect (13).

In addition, some critics sustain that there is a lack of detailed international standards guiding the choice of parameters to be measured in the comparative analysis and in the application of rigorous statistical analysis, reducing the quality of individual assessments (14).

It can be argued that randomised controlled human trials could be used to examine possible medium/long term effects, but the ample variation in diets and dietary components from day to day and year to year should be accepted. Whereas clinical studies in humans may supply wider guarantee of safety of whole foods, they cannot fully reproduce the variety of the populations who will consume the marketed product.

A methodical knowledge of the composition of the parent crop should be established both from the literature and from analytical data resulting from field examinations. Models should be taken from a range of different varieties of the same specie. This could be used as reference point for subsequent evaluation with samples from the specific GM crop line that is tested.

Thus, in answer to current doubts about biodiversity preservation, biologists, ecologists and economists have advanced a range of techniques to identify priority sites for "biodiversity conservation".

Of course, purchasing lands as a means for enhancing biodiversity conservation objectives is only one of many possible habitat conservation policy optionsn (15). Further approaches include encouraging preservation on privately administered land through land lease activities, creating easements and obtaining concessions. Other strategies consider efforts to promote ecologically friendly uses of the territory, either by paying for sustainable services or by providing financial supports and income sharing arrangements that promote specified activities (i.e., ecotourism).

Economic consideration on GM foods diffusion

Human nutrition has been changed during past forty years and food quality is getting better and better. For example, a number of studies on humans reported significant reductions in total cholesterol with an intake of 25g soya protein per day. Five of these studies have shown a cholesterol reduction of 0.22 mmol/L (16).

However the consumption of many "traditional" foods is deeply fixed in traditions which may entail special preparation processes such as selection or cooking. In this wide context it is difficult to calculate the width of the GMOs potential market. On the other hand, national evaluations are mainly based on consumer surveys (17). Without any doubt data obtained from national surveys generally only focus on actual consumption.

The GM crop market can basically be related to the use of soybean and maize (and their derivatives). Many researches (18-19) suggests that current EU requests for non GM ingredients of maize and soybeans accounts for about 27% of total soybean/derivative use and 36% of total maize use.

Thus the EU share of organic crops for which GM counterparts are currently available or probable to become soon commercially available is extremely low (about 0.40%).

In the same way, even if there could be a substantial increase in the EU organic area dedicated to combinable crops, the sector would remain very small in comparison to total arable crop production.

Surely, for the most part in EU still prevail a sentiment of scepticism: i.e., the Eurobarometer reveals a range from 59 (20) to 50% of Americans agree that GM foods are convenient, even if it is declined slightly over time (21) while in EU it's only 46%. In fact, for a large part of European consumers the opposition to GM foods come from the lack of benefits, representing a sufficient condition for rejection, as would be expected for any model about the diffusion of innovations.

These indications mean different parameters concerning U.S. and European GMOs food markets.

Often EU newspapers or environmental newsletters inform that the government or a local organization has spent millions of euro to acquire a property in order to promote "biodiversity conservation objectives". The challenge comes with the need to give good reason for priority choices across a range of alternative areas. This can only be done by showing that fundamental objectives of the biodiversity attempt are satisfied as best as possible.

It sounds as if a large part of EU is still uncertain about the present and the past crops cohabitation. Nevertheless once again technology is compelled to find the right way for development. Thus in EU many firms already play a significant role in biotechnology research.

As everybody knows, diffusion of technology is characterized by involving the substitution of an old technology with a new one. There is some evidence that, as already said, in the area of technology innovation, people will tolerate risk if they perceive some direct benefit to themselves, rather than to other demographic groups, producers, industry, etc. (22) One reason for the controversy about GMOs in the developed countries is the divergence of interests between overseas consumers of final products and the exporting agricultural sector, which is upstream in the global food chain.

In economic words, the technology used in food production is, for consumers, a credibility characteristic, for the reason that the product does not usually look, smell or taste different because of the new technology. It follows that the role of production technologies in consumer decision-making is to a large extent related to perceptions, conjectures and feelings. In order to analyse them, a new approach is needed going over the boundaries of traditional economics and assuming psychological approaches to the analysis of consumer behaviour.

The leading role played in the world by the United States in the development of biotechnology has led to the acceptance of those dynamics as the model for the development of this emerging knowledge. As it's well known, the North American model is characterised by the establishment of many new firms based around the knowledge embodied in the key figure of the "entrepreneur-scientist". There is ready availability of risk capital to support these firms and a generally positive public attitude to their activities. But such a model is unlikely to occur in all countries.

Nowadays in spite of the importance of the sensory properties of the product, studies examining consumer attitudes towards new technologies used in food production, have revealed that consumers are also becoming increasingly interested in non-sensory food qualities. As previously mentioned, aspects such as nutritional quality, microbiology safety, agrochemical residue and environmental pollution are all assumptions of consumer alarm. In this context, the use of technologies non-hazardous to the environment may contribute to perceptions of increased consumer benefits. On the other hand, the negative impact of new technology and food processing may be a source of consumer concern (23). The aim is surely the health of consumers. But if there are no roads to health, nobody can reach the health goal (24), meaning that, people with less food and nutrition competence are still subject to disorientation and erroneous behaviour, particularly in relation to GMOs.

Life Cycle Assessment (LCA)

LCA is an environmental management tool that enables quantification of environmental burdens and their potential impacts over the whole life cycle of a product, process or activity. Life Cycle Assessment, as defined by SETAC (Society of Environmental Toxicology and Chemistry), "is a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to effect environmental improvements" (25-26).

It follows the life cycle of a product, process or activity from extraction of raw materials to final disposal, including manufacturing, transport, use, re-use, maintenance and recycling.

The first step in any analysis must be definition of the system under study. In LCA, this is done in the Goal Definition and Scoping Phase (25); the environment is then interpreted in the thermodynamic sense as "that which surrounds the system", i.e. the whole universe except the system under study. LCA is generally accepted as an application of system analysis whose prime objective is to provide a picture of the interactions of an activity with the environment, thus serving as a tool for environmental management. As such, LCA has two main objectives. The first is to quantify and evaluate the environmental performance of a product or a process and so help decision makers choose among alternatives. Another objective of LCA is to provide a basis for assessing potential improvements in the environmental performance of the system. LCA has been used for both corporate and public decision making.

In the EU scenario the instrument of LCA could demonstrate to be a useful instrument in guaranteeing careful evaluation of environmental effects of GM plant products, taking into account the whole production process, agricultural custom and other environmentally important factors. Thus, the decisions on a case-by-case and regional basis as well as the choice among different alternatives will have a more appropriate scientific background. The main challenge will be the promotion of a method in order to permit a fusion between the classical L.C.A. of quantifiable parameters (like fertilizers, pesticides, etc.) and the qualitative or semi-quantitative part of the specific risks of organisms (GM or not) - like gene transfer and invasiveness.

Socio-economic risks

The industry as a whole has become an instrument of social change, probably equalled only by the media. Besides food has been always used to satisfy hunger and to meet nutritional needs.

Food is used to support family unity when members eat together. It can indicate ethnic, regional and national identity. Food can be used to show status or prestige, express feelings and emotions, and to mitigate stress or dullness. Food can affect people behaviour when used as recompense, punishment or as a political tool in protests and hunger strikes. Nowadays, in fact, food can be considered as a instrument to convince people, especially in poor countries. In this context GM crops and food can play a crucial role.

In contrast to the expected economic advantages some critics fret about corporate control over agriculture. Even if the productivity increase and labour saving may improve the living standards of rural communities, the emerging market economy in GM seeds might worsen disparities between and inside communities.

Bio-scientists and bio-technologists should acquire more sensitive awareness of civil societies concerns and the ability to communicate with private citizens, politicians and media.

Public perceptions and attitudes about emerging biosciences and other new technologies are some of the most important factors determining the likelihood of the successful development and implementation of technology.

There is substantial debate about how GM products can be positioned in the market. First, there is extensive debate about citizens agreement and about what consumers really want from their food system (27).

In fact, the lack of transparency makes consumers worried about the use of biotechnology in food production. For retailers and brands it becomes more and more important that they are "trusted". Retailers need to know the concerns of their consumers in order to have an adequate response to these concerns. For novel food, consumer doubts have already given rise to action. In answer to consumer apprehensions regarding biotechnology, some big European retailers have decided that, as long as consumers distrust "GM-food", they want to keep their shops "GM-free". Other retailers and brands do not want to ban these products. They have chosen in favour of a labelling system which can solve a part of the dilemma. Without any doubt labelling creates more transparency for consumers. Increased transparency in regulation means that any lack of consensus about risk management processes and associated doubts is open to public check. Nevertheless, increased transparency in itself does not mean that regulation will be influenced by broader social apprehensions.

The need of public involvement would seem particularly clear in the food field, as food is of fundamental, unavoidable and everyday interest to all members of society (28).

In the same way food safety systems (comprising modern agriculture, institutions, policies, laws, and guidelines) incessantly advance. The evolution of crop and food safety systems in individual fields is influenced both by science and society. Scientific evolutions improve consumers awareness of health implications of crops and foods and lead to the adoption of new agro-food production technologies. The change of society values can guide the modification of consumer protection policies as well as regulatory and institutional changes. Regulation in turn can influence both innovation and risk perception. On this subject the OECD (29) listed and described the national food safety systems of its twenty-nine Member States. These descriptions also specifically direct national approaches to the regulation and assessment of foods derived from GM crops.

Conclusion

The food insecurity of former generations, originated by occurring unbalances in food production and food needs related to season and region, seem to be decreased.

Today there is surplus on save and cheap food. Besides the opponents of genetic engineering are still concerned and are asking many questions. Should scientists be allowed to cross nature's confines by cloning micro organisms, plants, animals, livestock, and possibly humans? (30).
Inside the co-existence quarrel in Europe, anti GM groups frequently assert that there is no demand for GM crops in Europe and that GM and organic crops cannot successfully co-exist without causing important economic damage/losses to organic growers.

Progress in sampling, detection and traceability strategies, strongly influences the potential for adequate implementation and maintenance of legislation and labelling requirements.

Biotechnology offers opportunities for greater availability and variety of food, increasing overall agricultural productivity while reducing seasonal variations in food supplies. Through the introduction of pest resistant and stress tolerant crops, biotechnology could lower the risk of crop failure under difficult biological and climatic conditions.

Information from the only current example of where GM crops are grown commercially in the EU (Bt maize in Spain) shows that GM, conventional (non GM) and organic maize production have coexisted without environmental, economic and commercial problems.

For the future, the probability of economic and commercial problems of coexistence will remain very limited, even if a significant development of commercial GM crops and increased plantings of organic crops were to happen because the organic area of these crops is likely to continue to be a very small part of the total arable crop areas, with a very limited economic contribution relative to the rest of the EU's arable crops.

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