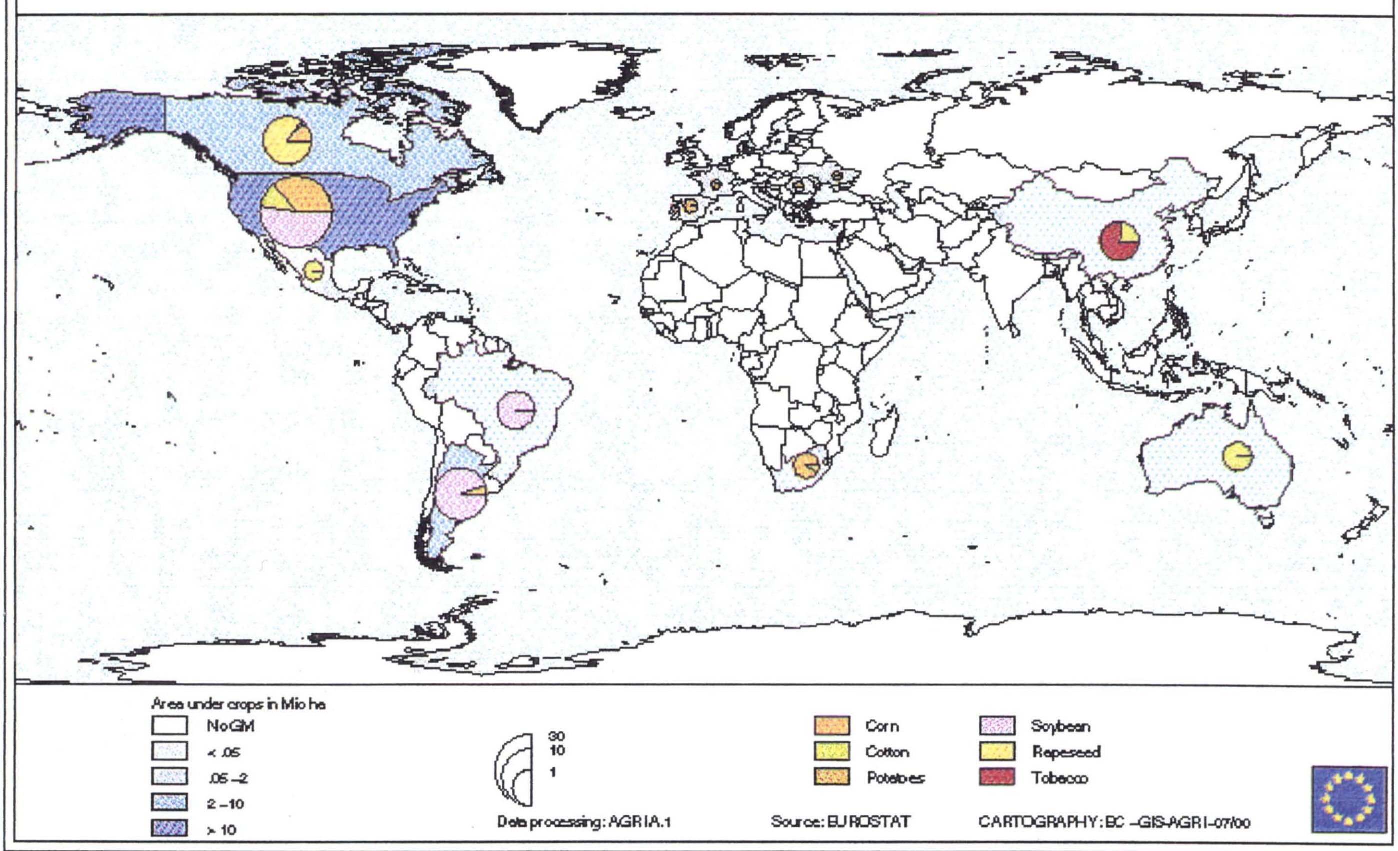
WORKING DOCUMENT

Directorate-General
for Agriculture

Economic Impacts of Genetically Modified Crops on the Agri-Food Sector

A SYNTHESIS

World GM Areas 1999/2000



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for their contribution to this working document

EXECUTIVE SUMMARY

The first Genetically Modified (GM) crops were introduced onto the market in the mid-nineties. Since then, quick but uneven developments have occurred from one continent or group of countries to another. This report analysis the extent of and the main reasons for these fast and uneven developments, with special emphasis on underlying economic issues which are of direct interest for the agri-food sector. A review of the available literature helped to answer three main questions:

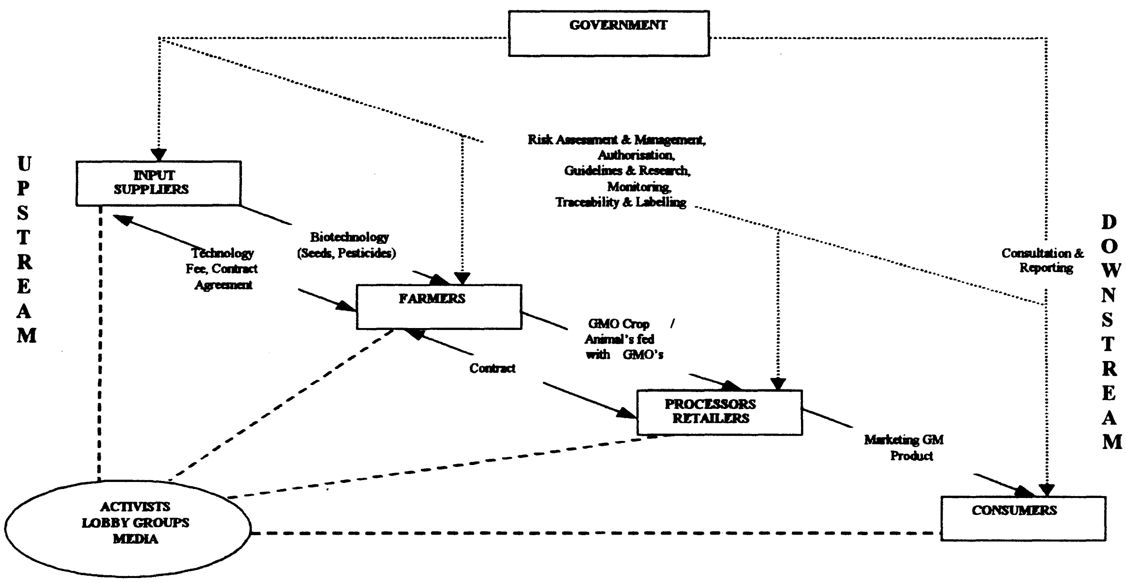
(1) How fast and to what extent have sowings of GM crops developed? Which crops are concerned?

(2) Which economic reasons explain the rapid adoption of GM crops by farmers?

(3) Which are the consequences of citizen/consumer reactions and food suppliers' initiatives?

The analysis follows the path of the food chain, from the supply side up to final demand (see figure). This approach takes into account the chronology of developments regarding agri-biotechnology, but it also allows for analysing driving forces and interactions between the main stakeholders all along the food chain.

Figure GMOs in the food chain, stakeholders and issues



The supply-oriented approach of both biotech companies and farmers has been quickly confronted with reactions stemming from the downstream side of the food chain. Citizen and consumer concerns on biotechnology have been echoed and amplified by NGOs and retailers, in particular in Europe. Their reactions provoked a cascading effect back to the upstream side of the food chain. Several initiatives to segregate GM and non-GM crops and to introduce Identity Preservation all along the food chain developed.

and retailers has cascading effects back to the upstream side of the food chain, both on domestic and on foreign markets.

In the EU, a prominent strategy of food processors is currently to avoid or to restrict GM food. In the US and in Canada, some grain traders and processors have started segregating GM and non-GM crops in order to meet the differentiated export -or even domestic- demand. Identity Preservation (IP) and traceability are concepts, which go beyond segregation and allow for keeping track of the origin and the nature of crops. The economic implications of Identity Preservation and of GM labelling are analysed in Chapter 5. In general, losses in economic welfare have to be expected because the potential for trade and specialisation will remain partially unused. Following EU legislation three different approaches to IP have been identified in the GMO context: voluntary IP of specific GM traits, voluntary IP of GMO-free products and compulsory IP for GM products (traceability).

Identity Preservation is a move away from commodity trade and it implies additional cost at all stages of the food chain. According to the literature available they range between 5 and 25 €/t, depending on the product and the IP system, which represents 6 – 17% of the farmgate price of the different crops. A critical factor to determine the cost – among others - will be the tolerance level for contamination. The distribution of these additional costs along the food chain depends on a number of factors, in particular the price responsiveness, the availability of substitutes and the market structure. The short-term development of prices on differentiated markets for GM and non-GM products will depend on the size of supply and demand, opportunities for substitution are more limited for non-GM products than for GM-products. Currently farmers may receive a premium for non-GMO soybeans and corn.

Soybeans and corn are widely traded commodities. Countries where GM varieties are grown are leading exporters. Conversely, main importers of soybeans, corn and associated products have adopted a restrictive stance on GM food. If a restrictive stance is also adopted for feed uses of GM soybeans and corn, the market implications can be significant.

While being limited to economic issues which are of direct interest for the agri-food sector, this report does not address other important issues. The reasons explaining the uneven developments of plant biotechnology throughout the world are not only of an economic nature and the implications of this new technology go well beyond the agri-food sector.

About documents and sources

The present synthesis is based on a review of literature on the economic effects of biotechnology on the agri-food sector. The full results of the review are outlined in a working document (available on request at DG AGRI.A.1).

To allow for selecting and channelling the widely available information on biotechnology, web sites and articles addressing economic issues which are of direct interest for the agri-food sector (fast developments in sowings, profitability of GM crops, consumers surveys, segregation GM-non GM) have been classified in databases (accessible on the DG AGRI Intranet - Dimitra).

Selected references to the articles reviewed can be found in the Appendices of the working document. These articles have been released or published by various sources: governments, international institutions, research centres and universities, associative, or private sources.

In addition, many press releases have been reviewed on a regular basis. The "Agri-Biotech Newsletter" provides a selection and a summary for this source of information.

Meetings with biotechnology experts and researchers have also been a useful source of information and have provided opportunities for exchanging views.

The closing date for documentation was the 31st March 2000.

A glossary can be found at the end of the present report.

1. GM CROP AREA IN THE WORLD: FAST BUT UNEVEN DEVELOPMENTS

The most comprehensive source for areas under GM crops in the world is ISAAA[1]. Their data are based on sales of GM seeds. In order to diversify sources, ISAAA data have been confronted and, where relevant, complemented with other figures. Despite all efforts to create a coherent, reliable and up to date picture of GM crop areas, all figures should be interpreted with care, in particular for China and Brazil.

Figures on areas reported in this chapter refer to GM crops which are commercialised and grown on a farm-scale basis. It does not include areas sown for experimental purposes.

1.1. Development of GM crops: a global picture

1.1.1. World area under GM crops: fast expansion up to 42 Mio ha

Research on GM crops for uses in agriculture started in the eighties but sales of first commodity seeds began only in the mid-nineties. The first significant sowings of GM crops (2.6 Mio ha) took place in 1996 and almost exclusively in the US. Since 1996, the areas have increased dramatically to reach 41.5 Mio hectares in 1999. Adoption of transgenic crops is progressing at a much faster pace than has been the case for other innovations in plant varieties, e.g. hybrids.

First indications on 2000 sowings of GM crops could be found in various sources, but they point to divergent directions. DG AGRI expects the GM area for 2000 to plateau just above 42 Mio ha.

1.1.2. GM crop area by country: American continent the most advanced

As shown in table 1.1, most of the GM crops are grown on the American continent. In 1999, the US had by far the most important area (29 Mio ha) of GM crops, around 70% of the total GM area worldwide, followed by Argentina (5.8 Mio ha or 14%) and Canada (4 Mio ha or >9%). In China, the GM area (mainly tobacco and limited sowings of GM cotton which started in 1998) ranks between 1 and 1.3 Mio ha, depending on the sources. This would represent about 3% of the 1999 world GM area.

On the European continent in 1999, Spain ranked first with around 10000 ha followed by Romania with 2000 ha and France, Portugal and Ukraine at just 1000 ha.

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[1] ISAAA = International Service for the Acquisition of Agri-Biotech Applications. ISAAA produces each year a global review of commercial transgenic crops.

Table 1.1 Development of GM area by country

Mio ha	1996	1997	1998	1999	1999 in %
USA	1,45	7,16	20,83	28,64	69,1%
ARGENTINA	0,05	1,47	3,53	5,81	14,0%
CANADA	0,11	1,68	2,75	4,01	9,7%
CHINA	1,00	1,00	1,10	1,30	3,1%
BRAZIL	0,00	0,00	0,00	1,18	2,8%
AUSTRALIA	0,00	0,20	0,30	0,30	0,7%
SOUTH AFR	0,000	0,000	0,06	0,18	0,4%
MEXICO	0,000	0,000	0,05	0,05	0,12%
EUROPE	0,000	0,000	0,002	0,01	0,03%
SPAIN	0,000	0,000	0,000	0,01	0,02%
FRANCE	0,000	0,000	0,002	0,000	0,0%
PORTUGAL	0,000	0,000	0,000	0,001	0,0%
ROMANIA	0,000	0,000	0,000	0,002	0,0%
UKRAINE	0,000	0,000	0,000	0,001	0,0%
TOTAL	**2,601**	**11,510**	**28,623**	**41,480**	100,0%

About Argentina and Brazil

Following a Court ruling, sowings of GM crops are not allowed in Brazil and public authorities are committed to control them. However, certain sources mentioned that at least 10% of the Brazilian soybean area in 1999 is GM. The GM area would be located south and the seeds would be fraudulently imported from Argentina. The estimated GM soybean area reported in table 1.1 is based on figures from the Argentinean "Direccion de Economia Agraria" and from the Argentinean seed association.

1.1.3. GM crop area by trait: pesticide-like crops dominate

Of the 41.5 Mio hectares sown with transgenic crops in 1999, the distribution of traits in order of importance is as follows.

- herbicide tolerant (HT) GM crop with 69% of total,
- insect resistant (IR) GM with 21%,
- GM crops containing both genes (HT+IR) represented 7%
- and virus resistant (VR) GM crop (almost exclusively Chinese tobacco) nearly 3%.

Although this is the same order as in 1998, the area of crops containing both genes, the herbicide tolerant and insect resistant, has increased.

TRAITS of Present GM crops
The curent "wave" of GM crops' primary objective is to improve pest resistance. In turn, this should reduce/change the use of crop protection products and/or increase yields.
1. Herbicide tolerance The insertion of a herbicide tolerant gene (glyphosphate or glufosinate tolerance) into a plant enables farmers to spray wide spectrum herbicides (such as Monsanto's Roundup Ready or AgrEvo's Liberty Link) on their fields killing all plants but GM's. For that reason, the new GM seeds opened new markets for both products.
2. Insect resistance By inserting genetic material from the *Bacillus thuringiensis* (Bt) into seeds, scientists have modified crops to allow them to produce their own insecticides. The Bt gene responsible for producing the toxin is directly inserted into the plant to produce pest resistant varieties. For example, Bt cotton combats bollworms and budworms, whereas Bt corn/maize protects against the "European" corn/maize borer.
3. Virus resistance Today a virus resistant gene has been introduced in tobacco and potatoes (also tomato, but this product is not analysed in this report). The insertion of a potato leaf roll virus resistance gene protects the potatoes from the corresponding virus which is usually transmitted through aphids. For that reason, it is expected that there will be a significant decrease in the amount of insecticide used. The introduction of a virus resistance gene in tobacco may offer similar benefits.
4. Quality traits Today quality traits-crops are only sown marginally and represent less than 50 000 hectares in Canada and the USA. It concerns high oleic soybeans, high oleic canola/rapeseed and laurate canola.

1.2. GM area by crop: soybeans and corn still the frontrunner

Of the 41.5 Mio hectares sown on a commercial basis in 1999, 53% were soybeans, 27% corn, 9% cotton, 8% rapeseed, 2% tobacco and 0.1% potatoes. Figures 1.1 and 1.2 show respectively the development of the GM crops between 1996 and 1999 and their share in the 1999 GM area.

Figure 1.1
Development of GM Area

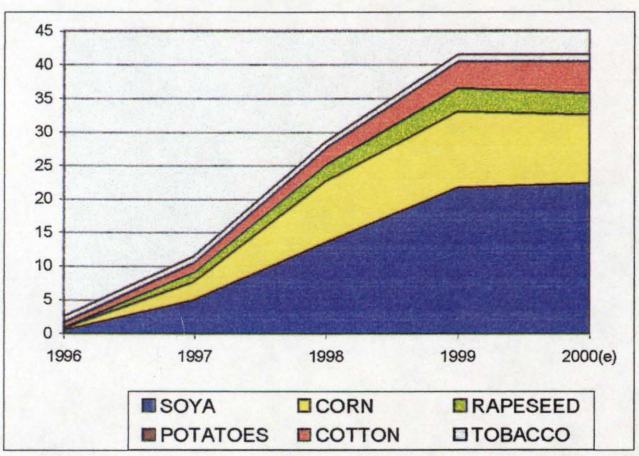
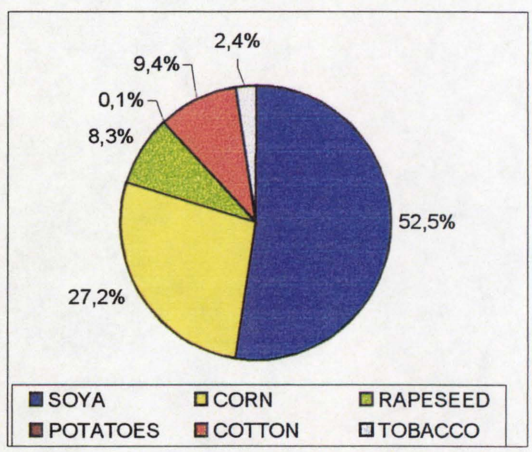


Figure 1.2
1999 Share of GM Crops in %



Soybeans and corn account for 80% of GM areas world-wide. The area development of these most frequent GM crops is specified below.

1.2.1. GM soybeans: mainly herbicide-tolerant

Commercialised GM soybeans were first sown in 1996 in 2 countries, the USA and Argentina and represented respectively 1.6 and 0.8% of their total soybean area.

Table 1.2 Development of GM soybean area

Mio ha	1996	1997	1998	1999	2000 (e)	GM %('99)
USA	0,40	3,64	10,12	15,00		51%
ARGENTINA	0,05	1,40	3,43	5,50		75%
CANADA		0,001	0,04	0,10		10%
BRAZIL				1,18		10%
ROMANIA				0,001		NR
TOTAL	**0,45**	**5,04**	**13,59**	**21,78**	**22,5**	**47%**

In 1999, GM soybean area represented nearly one third of world total soybean area and nearly 47% of area of countries producing GM soybeans. Of the 22 Mio ha, 15 or two-third of total are in USA (51% of US soybeans), 5.5 in Argentina (75% of Argentinean soybean), 1.2 in Brazil (10% of Brazilian soybean) and less than 0.1 Mio ha in Canada and Romania.

Almost all GM soybeans are herbicide tolerant (HT).

1.2.2. GM corn: mainly insect-resistant

First sowings of GM corn took place in 1996 exclusively in North America, 0.3 Mio ha in USA and 0.001 Mio ha in Canada and represented respectively 1% and 0.1% of their corn area.

Table 1.3 Development of GM corn area

Mio ha	1996	1997	1998	1999	2000 (e)	GM %('99)
USA	0,30	2,27	8,66	10,30		36%
ARGENTINA		0,07	0,09	0,31		11%
CANADA	0,001	0,27	0,30	0,50		44%
SOUTH AFR			0,05	0,16		5%
FRANCE			0,002	0,000		0,0%
SPAIN				0,01		0,2%
PORTUGAL				0,001		0,4%
TOTAL	**0,30**	**2,61**	**9,11**	**11,28**	**10,5**	**28,0%**

In 1999, GM corn sowings accounted for more than 11 Mio ha and 27% of total GM sowings. With this area, GM corn represents about 8% of world total corn area and 28% of area of countries producing GM corn. Most of the areas are located in USA (10.3 Mio ha or 36% of US corn), 0.3 Mio hectares in Argentina (11% of Argentinean corn), 0.5 in Canada (44% of Canadian corn) and a few thousands hectares in Spain, France and Portugal.

Two thirds of corn area or nearly 8 Mio hectares are insect resistant (Bt-corn), about 2 Mio ha is herbicide tolerant corn and around another 2 Mio ha of corn contain both genes. Experts (USDA) do not expect that the development of HT corn will be as fast as for HT soybeans.

Soybeans and corn are well adapted to growing conditions in Northern and Southern America. Thus, they are widely grown in this part of the world, while culture in Europe is limited. The fact that corn and soybeans were the first species for which GM varieties were put onto the market is one basic factor explaining their development on the American continent.

However, many other factors explain the rapid and uneven development of GM sowings throughout the world. The next two chapters provide an analysis of economic reasons explaining the rapid development of GM sowings in Northern America. The analysis focuses on the supply side of the food chain, considering first the strategy of biotech companies (chapter 2) and second (chapter 3) the adoption of GM crops by farmers.

2. BIOTECH COMPANIES: A SUPPLY-ORIENTED STRATEGY

2.1. Life sciences industry: concentration on the upstream side of agriculture

Biotechnology has been developed by the "life sciences industries", which are active in human, animal and plant health. Their experience in pharmaceutical biotechnology and their crop protection activities allowed them to implement and to amplify biotechnology for agricultural purposes.

Generally, the share of biotechnology in the agri-business part of life sciences industries is not indicated in financial reports or in publications. A ranking based on sales of crop protection products provides an overview, as shown in Table 2.1. The first six companies, Novartis, Monsanto, Du Pont, Zeneca, AgrEvo and Rhône-Poulenc, as well as Dow are also main players for agri-biotechnology.

Table 2.1 Top Ten agro-chemical companies, based on sales of crop protection products (US $Mio)

Rank	Company	1998	1997	1996
1	Novartis	4,124	4,199	4,068
2	Monsanto	4,032	3,126	2,555
3	DuPont	3,156	2,518	2,472
4	Zeneca	2,895	2,673	2,638
5	AgrEvo	2,384	2,366	2,475
6	Rhone-Poulenc	2,286	2,218	2,203
7	Bayer	2,248	2,283	2,350
8	American Cyanamid	2,194	2,119	1,989
9	Dow Agrosciences	2,132	2,134	2,010
10	BASF	1,932	1,913	1,536

Source: Inverzon International Inc. (St Louis, US), in Papanikolaw, 1999

Notes : AgrEvo and Rhone-Poulenc are merging into Aventis. AgrEvo figures include seed activities. Rank depends on average exchange rates used.

Any ranking of life sciences companies has to be considered with caution, as this sector is undergoing a rapid globalisation and consolidation process. Beginning in the last quarter of 1995 up to the first half of 1999 the sector has been characterised by a large number of mergers, acquisitions and joint ventures. For instance, AgrEvo and Rhône-Poulenc merged to form Aventis.

Four of the most important factors that are currently driving the consolidation of the life sciences sector are:

- The development of new genetic traits that are able to (1) increase the efficiency of farm production; (2) offer new product specifications for industrial or end users.
- Synergies, whereby research capabilities and technology are shared across multiple product lines.
- Closely linked to the above point are economies of scale in research and development in the area of agrigenomics[2], marketing and a whole host of other functions. Such economies of scale are of strategic importance, considering the need to invest vast sums of money in regard to biotechnology to develop new GM traits.
- Intellectual property rights create barriers to entry. Transformation events introduced in plants via biotechnology are protected by patents.

Extending and securing access to the seed market has been a driving force for a second wave of acquisitions and agreements, resulting in a further consolidation within the agri-biotech sector. As a result, concentration has diffused from the agro-chemical sector to the seed sector. As indicated in table 2.2, the same key players in crop protection can be found in the seed sector.

Table 2.2 Top Ten Seed companies, based on 1997 seed sales (US $ Mio)

Rank	Company	Headquarters	Sales 1997
1	Du Pont/Pioneer	US	1,800
2	Monsanto	US	1,800 (e)
3	Novartis	Switzerland	928
4	Limagrain	France	686
5	Advanta	UK & NL	437
6	AgriBiotech, Inc	US	425
7	Pulsar/Seminis/ELM	Mexico	375
8	Sakata	Japan	349
9	KWS AG	Germany	329
10	Takii	Japan	300 (e)

Source: RAFI

2 Agrigenomics specifically refers to the research of crop genomes and encompasses such areas as gene sequencing, gene mapping, molecular probes and bio-informatics amongst other things.

Significant changes in the biotech sector have occurred in 1999. Growing consumer concerns, extended public debate and food suppliers' initiatives have had a feed-back effect on the biotech industry. There has been a slowdown in mergers. Some leading biotech firms are separating their pharma and agri-biotech activities, hence departing from a "global life sciences" strategy.

The agreement between AstraZeneca PLC and Novartis AG to spin off and merge "Zeneca Agrochemicals" and "Novartis' Agribusiness" to create Syngenta might represent the start of a new phase in the restructuring of the agri-biotechnology sector. It will effectively mean a departure from the life sciences strategy and a move in the direction of "pure play" agri-business. In December 1999, Monsanto and Pharmacia & Upjohn announced a merger of their pharmaceutical activities, for creating a common company. The agri-business part of Monsanto remains out of the merger, and the name Monsanto will only apply to this autonomous entity. This case provides another significant example of the separation between pharma- and agri-biotech business. This echoes the gap in public acceptance between these two areas of biotechnology. It can also mean that synergies between various life sciences activities are not as optimal as expected.

While carrying out further research on second-generation GM plants, which will include quality traits of interest to industrial or end users, biotech firms are preparing the introduction of these new generation crops. On their upstream side, they have entered new agreements with genomics companies, to increase their research/technology portfolio. On the downstream side, biotech firms seek to invest further down in the food chain. They have concluded or are considering agreements with food processors.

2.2. Consequences for farmers: increased dependency

The marketing strategy developed by biotech firms has been focused on farmers, the first customers interested in agronomic traits of GM crops. They have shaped farmers profitability expectations. In the case of herbicide tolerant crops, the marketing strategy was based on the concept of "technological package". Many biotech firms are selling both the GM technology/seed and the associated crop protection product. This allows for "combined marketing", including adjusting prices of seeds and chemicals and using the same distribution channels.

When selling their technology, biotech companies are charging a "technological fee". It results from the private origin of the new technology and has to be considered together with property and patenting rights. Generally, the technological fee is first paid by seed firms (which are sometimes subsidiaries of biotech companies), and is later transferred to farmers. GM seeds are sold in the framework of contracts which generally preclude seed-saving by farmers. The technological fee and the restriction on seed-saving imply increased seed costs- as such costs are to be paid each year- and a loss of autonomy for farmers.

Some authors (Alexander and Goodhue 1999) have analysed the breakdown of profitability of GM corn between biotech/seed firms and farmers. For Bt corn, "although [their] analysis provides suggestive rather than conclusive evidence" they consider that "seed companies capture a significant, but by no means all of the net revenue advantage of Bt corn" and that "the likelihood of monopolistic pricing of the technology appears limited". For HT corn, they showed the sensitivity of profitability results to both the price of seeds and of herbicides, hence the sensitivity to the "combined pricing" strategy of the firms.

As far as HT soybeans are concerned, the American Soybean Association (ASA) has recently complained about significant differences in prices of Round Up Ready soybean seeds between the US and Argentinean markets. According to ASA, a bag of such seeds costs 12 US $ more in the US, and part of this difference is attributable to the 6 US $ technological fee, which is apparently not charged in Argentina.

The combined pricing strategy and the observed variations in GM seed prices point to the existence of margin of manoeuvre of biotech firms for the price of technology. The market power of seed and agro-chemical suppliers deserves further assessment.

As shown in the previous subsection, biotechnology has generated increased concentration on the input side of the crop sector. This raises the question of increased dependency of farmers on a limited number of suppliers for crop production. Moreover, some biotech firms have already concluded agreements with grain processors, as is the case with the Monsanto/Cargill cluster. As a result, biotech appears as a driving force for vertical integration and for further consolidation throughout the agri-food sector. The downstream side of the food chain is also quite concentrated, either at the level of food processors (US) or at the retailing industry (European Union). The position of farmers in a rapidly changing agri-food sector is an issue of concern. The risk for them is to be "squeezed" between two (more or less) oligopolistic industries.

Heffernan (1999) analysed the "emerging clusters of firms that control the food system from gene to supermarket shelf". In this context, he drew conclusions on the future role of farmers: "the farmer becomes a grower, providing the labour and often some capital but never owning the product as it moves through the food system and never making the major management decision".

At a first glance, this sentence may seem excessive. Nevertheless, more and more contracts are governing the supply of crops by farmers, from the seed to the wholesale or processing stages. Biotech is very likely to be a driving force in such a process, for two reasons.

- GM seeds are sold and sown under contract. GM crops require adjustments in growing and management practices.
- If segregation or identity-preservation develop, crops, be they GM or not, will increasingly be grown and sold in the context of contracts.

For this reason, some farmers are considering GM crops as "another liability". To strike a balanced view between constraints and benefits of GM crops, studies assessing their farm-level profitability are summarised in the next chapter.

3. FARMERS : STRONG PROFITABILITY EXPECTATIONS, MIXED OUTCOME

The adoption of GM crops by farmers in the US, Canada and in Argentina has proceeded at an unprecedented rate compared to the uptake of conventional hybrids. The economic reasons for this rapid and massive adoption are analysed in section 3.1. The role of agricultural policy in this process is considered in section 3.2. The analysis is based on the available economic literature, which mainly concerns Northern America. It is limited to the two main GM crops under cultivation Herbicide-Tolerant (HT) soybeans and Insect-Resistant (Bt) corn. Two Canadian studies on HT Canola[3] have also been taken into account.

3.1. Economic driving forces: profitability and/or convenience

3.1.1. Factors of profitability: costs and yield

Profitability is defined as the margin left over to farmers when costs have been deduced from receipts. The profitability of GM crops is judged against corresponding conventional crops.

Table 3.1 Cost and yield comparison of GM vs conventional crops

Profitability criteria	Unit	GM crop	Difference GM vs conventional		Source
			Min	Max	
Costs					
Seeds	€/ha	HT Soybeans	13.5	15	*Various, convergent*
		Bt Corn	3	35	*Alexander, Goodhue*
		HT Canola	11	25	*Various*
Weed control	€/ha	HT Soybeans	-33	-35	*Furman, Selz*
		Bt Corn	6		*Duffy*
		HT Canola	-8	-54	*Fulton, Keyowski*
Yields	%	HT Soybeans	-12%	4%	*Benbrook*
		Bt Corn	3%	9%	*Gianessi, Carpenter*
		HT Canola	-11%	79%	

On the one hand, GM crops are expected to allow for saving in costs through different/reduced pest control and/or to achieve higher yields. On the other hand, GM seeds are more expensive than conventional ones. Under the assumption that the price of non-GM and GM crops is the same[4], the latter

[3] Canola = a type of rapeseed which has been developed in Canada. It is a registered trademark, corresponding to specified characteristics (low erucic acid and glucosinolate), equivalent to double 0 in Europe.

[4] This assumption needs to be reconsidered: see chapters 4 and 5.

will become more profitable for farmers if the increased seed costs are offset by savings in pest control costs and/or by higher yields.

Therefore, yields, seed and pest control costs are key factors for the profitability of GM crops. Figures relating to those factors are summarised in table 3.1, based on various sources.

3.1.1.1. On the cost-side: the input-effect

GM seeds are sold at a higher price than conventional ones, as indicated in table 3.1. While convergent figures could be found for HT soybeans (around 15 €/ha additional costs, i.e. a 35% premium compared to conventional seeds), various figures are reported for HT Canola and Bt corn, depending on trade-mark varieties. The most frequently cited figure for Bt corn is a 22 €/ha premium. The price wedge is mainly attributable to the "technological fee" (see subsection 2.2), but it also reflects the fact that markets for both types of seeds are separate.

As far as weed and insect control is concerned, the situation is different for HT and insect-resistant (Bt Corn) crops.

HT crops appear to allow for savings in herbicide costs. However cost differences between biotech-based and conventional weed control programmes are not clear-cut and there are wide margins of fluctuations. While the total use of herbicides associated with HT crops (in particular those including glyphosate like Round Up) has increased, the use and price of other herbicides have decreased. According to USDA, the net effect is a decrease in herbicide use. The herbicide effect of HT crops deserves further assessment, both on farm-level and globally, based on the experience of several years of cultivation.

According to an USDA case-study, insecticide applications are significantly lower for Bt Corn than for conventional varieties. Based on a survey in Iowa (1999), Duffy confirms that applications are reduced but notices increased insecticide costs, hence the net effect is not clear-cut. In addition, Duffy observed slightly higher (+ 17 €/ha) weed control and fertiliser costs for Bt fields. To prevent the emergence of resistance to Bt, US Environmental Protection Agency requires setting up refuges, i.e. non-Bt corn zones next to Bt-fields. This requirement has an impact on the management of Bt crops.

3.1.1.2. On the receipt side: the yield effect

Several studies provide evidence about yield gains for Bt corn. Based on 1996-1998 data of the Agricultural Resources Management Data, the USDA has observed that adopters of Bt corn had obtained higher yields than non-adopters. However, this might partly be explained by performance differences between these two groups of farmers. Gianessi and Carpenter (1999) report about average gains of 0.73 tonnes/ha in 1997 and 0.26 tonnes/ha in 1998, respectively, + 9% and +3% compared to 97/98 average yield for corn. The gap between 1997 and 1998 results can be explained by the difference in weather conditions and in insect pressure. Infestation was low in 1998. Other studies (like Alexander and Goodhue, Hyde *et al.*, 1999) show the sensitivity of Bt performance to these two factors.

By contrast, the yield of HT soybeans appears to be lower than for conventional varieties. A factor of explanation might be that HT genes have not been incorporated in top-yielding varieties.

Comparing yields of GM and non-GM crops is not a straightforward exercise. Yields depend on a large number of factors, and the inserted trait of GM crops is only one factor amongst others. It is worth recalling (OECD 1999) that first generation genetic modifications address production conditions (pests, weeds), they do not increase the intrinsic yield capacity of the plant. Not surprisingly yield performance of GM crops against their non-GM counterparts depends on growing conditions, in particular on the degree of infestation in insects or in weeds, hence on region of production. Data about yields of GM crops are widely available, however, often specifications on factors which influence yields are missing, such as temperature, weed control applied etc.

3.1.2. Effective profitability: mixed and unclear results

The available studies do not provide conclusive evidence on the effective profitability of GM crops:

- HT soybeans: when comparing returns per ha or per labour unit, no significant difference appears between HT and conventional crops.

- The cost-effectiveness of Bt corn depends on growing conditions, in particular on the degree of infestation by corn borers. Results regarding profitability are contrasted, none can be considered as significant.

- There are no clear-cut results allowing for comparing the profitability of HT Canola with non-GM crops.

These rather contrasted and unclear results indicate that short term profitability is not the only driving force for adoption of GM crops by farmers.

Other factors must have played a significant role in the rapid extension of GM sowings.

In practice, the most immediate and tangible ground for satisfaction appears to be the combined effect of performance (not necessarily measured by yields) and convenience of GM crops, in particular for herbicide tolerant varieties. These crops allow for a greater flexibility in growing practices and in given cases, for reduced or more flexible labour requirements. This convenience effect should translate into increased labour productivity and savings in crop-specific labour costs. However, this effect is not always assessed in profitability studies. One author (Duffy 1999) concludes that HT soybeans provide the same returns on ha or on labour as conventional crops. But if they allow for reduced labour costs, the same return on less labour means increased profitability. This convenience effect has to be further assessed in particular, the valuation of the labour effect. For the time being, it does not translate into increased profitability, but rather in terms of attractiveness of GM crops for efficiency purposes.

The USDA (1999) has examined different factors affecting the adoption of HT soybeans and concluded that "larger operations and more educated operators are more likely to use the technology". It is very likely that the same applies to Bt Corn. The decision to plant Bt corn is a complex one, it implies assumptions as to the expected degree of infestation, adjustments in planting planning to foresee refuges. Such differences between adopters and non-adopters of biotechnology have to be taken into account when comparing yields and returns obtained on both types of farms. The higher degree of education might echo the skills required for changes in growing and management (e.g. contracting) practices. The farm size of adopters might be a factor explaining, amongst others, the dramatic increase in areas sown to GM crops. The adoption of biotechnology is not size-neutral.

The reviewed studies only compare farm-level and short-term profitability. Profitability of GM crops should be analysed over a longer timeframe. First, there are important yearly fluctuations in yields and prices, and it is difficult to isolate the possible effect of biotechnology. Results are very sensitive to the price of seeds and agro-chemical products on the one hand and to commodity prices on the other hand. In most profitability studies, prices for GM and conventional crops are assumed to be equivalent.

Developments on the supply and on the demand side of the food chain have to be considered together, and this is another reason for assessing profitability over several years.

In the case of HT crops, gains in efficiency should translate into improved labour productivity. In the case of Bt corn, yield gains mean enhanced productivity of land. Both types of effects imply a shift in farmers supply functions. Under given prices, enhanced farm productivity leads to an increase in supply. If the demand function remains unchanged, prices drop. In the long run, enhanced productivity will have an impact on farm restructuring, alongside with many other factors playing a role in this process. While more and more producers are adopting biotech crops, thus contributing to the increase in supply, on the demand side, concerns about GM food are emerging. As a result, segregation between GM and non-GM crops is developing, which implies differentiation in costs and prices.

The economic implications of segregation and identity preservation are analysed in chapter 5. They are likely to change the outset as regards profitability of GM versus non-GM crops.

According to Bullock and Nitsi (1999), only quality enhancing innovations would induce a structural change of the demand function, and possible increases in prices. However, there are not many GM crops entailing quality traits on the market, and prospects are still limited for the medium term.

When considering the profitability of GM crops and the reasons for their rapid adoption, the effect of agricultural policy measures should also be taken into account.

3.2. The effect of agricultural policy: not neutral

In the US as well as in the EU, GM and non-GM crops are not treated differently under the various support schemes, both are eligible. In the US, crops for which GM varieties have rapidly developed are all eligible for support under the flexibility payments, the marketing loan system, as well as for crop insurance.

Soybeans became eligible for flexibility payments and under the marketing loan system in 1996, which is the year of first commercial sowings of GM varieties. Several analysts (FEDIOL, 1999) consider that existing support systems have favoured the development of soybeans sowings. In particular, the loan rate applied to soybeans makes this crop attractive compared to wheat and corn. The area under soybeans is expected to reach a record level in 2000, while prices are low. By mid-November 1999, the USDA estimated that 90% of the 1998 soybeans crop had received a marketing loan benefit, and that the average value of this benefit was worth around 0.44 US $/bushel (14.5 €/t). Oilseed producers are also eligible for the 1999/2000 emergency packages. A specific assistance programme was set up in early February for oilseeds producers, to offset record low market prices. Under this programme, payments for soybeans could average 0.141 US $/bushel (5.3 €/t), according to calculation by private consultants.

Favourable support conditions for soybeans could have played a role in the rapid uptake of GM technology for this crop. In addition, in a low market price context, the expectation on cost savings is a further driving force for the adoption of the technology.

Eligibility of GM crops under various support schemes limits the price risk of the productivity-enhancing technology. It accounts as another reason for the farmers to focus their planting decision on expected farm-level performance, on cost-efficiency of inputs. In other words, farmers also had an input-oriented approach.

The supply-oriented approach of both biotech companies and farmers has been quickly confronted with reactions stemming from the downstream side of the food chain. Consumer concerns have been echoed and amplified by NGOs and retailers, and they had a cascading effect on the upstream side. These reactions are analysed in the next chapters.

4. CONSUMERS, RETAILERS: CASCADING EFFECTS

In the EU, where public awareness and debate about GMOs first emerged, retailers have taken a restrictive stance on GMOs. This is giving birth to differentiated markets leading food processors to adapt their products to regional conditions, and US grain elevators to segregate commodities (chapter 5). The present chapter first reviews consumer preferences in different regions of the world through an overview of available public opinion studies (section 4.1). The second section explores the strategy of the retailing industry (section 4.2).

4.1. Citizens/consumers: differences in concerns and preferences

Public opinion polls and surveys show differences in consumer perceptions in Europe and in Northern America.

In Europe, data can be found in the Eurobarometer studies on biotechnology, which provide comparative data across countries; and in a series of surveys conducted by private polling institutes for the retailing and food industry, NGOs, or the media. This corpus of studies evidences some differences among European countries, with Italians, Spaniards, and Portuguese displaying more positive perceptions of biotechnology in general than their fellow Europeans (Eurobarometer 1997 and 2000; Menrad 1999).

Beyond these variations, clear regularities emerge:

- Knowledge and perception: According to the 2000 Eurobarometer, the use of biotechnology in food production is the most commonly known application. Only 11% of the respondents feel adequately informed on biotechnology. Factual knowledge has hardly improved since 1997. Asked about the source of information they mainly trust, respondents cite consumer organisation first (26%), just ahead of medical profession (24%) and environmental protection organisations (14%). International organisations and national public authorities record poor results (respectively 4 and 3%).
- High level of concern: A large majority of Europeans are worried about transgenic food. More than 60% of the 1997 Eurobarometer respondents are concerned about the risks associated with GM food, compared with 40% in the case of the medical applications of biotechnology. This result is consistent with those of private polling institutes. The 2000 Eurobarometer has helped assessing the reasons for consumer concerns on GM food. Items gaining the highest support are: "even if GM food has advantages, it is against nature"; "if something went wrong, it would be a global disaster"; "GM food is simply not necessary". The share of respondents thinking that food production is a useful application of biotechnology decreased from 54% (1997) to 43% (2000).
- Demand for labelling and non-GM: Only 18% of the respondents judge GM labelling useless; 8% do not have an opinion; and 74% favour a clear labelling of GM food (Eurobarometer 1997). 53% of the respondents say that they would pay more for non-GM food, 36% would not (Eurobarometer 2000).

For North America, the main surveys reviewed stem from the USDA, Novartis (1997), Time magazine (1999), the International Food Information Council (1999) and some Canadian organisations. Two broad tendencies emerge:

- Eroding trust in GM food: In 1997, Novartis found that only 25% of Americans "would be likely to avoid labelled GE foods". However, two years later, the poll commissioned by Time magazine indicated that 58% of American consumers "would avoid purchasing [labelled GE foods]" (Center for Food Safety 1999). These results point to a certain erosion in the consumers' trust in GM food.
- Demand for labelling: In the last four years, the demand for mandatory labelling of GE foods has been high, and fairly stable: 84% of the respondents favoured it in a 1995 USDA survey in New Jersey; 93% in the 1997 Novartis survey; and 81% in the Time magazine poll. In Canada, a 1994 survey showed that "83% to 94% of Canadians polled… want labelling on foods that are produced using biotechnology" (Center for Food Safety 1999).

This cursory review shows the contrast between European and North American perceptions of agricultural biotechnology. While Americans and Canadians would hold benevolent views or simply be indifferent, European consumers would display more scepticism for reasons which are said to be: cultural (relation to food, degree of faith in science…), historical (recent food scares in Europe), and political (degree of trust in public/private actors). European consumers see more risks than benefits in GM crops.

However, this dichotomy needs qualifying for at least three reasons.

- First, some issues of concern are "global", even emerging from globalisation, as reflected by the transboundary, multi-faceted mobilisation campaigns against GMOs. Mobilisation started on concerns about the safety of GM food, but other issues were raised: environmental risks, sustainability, benefit-sharing…
- Second, some differences that once appeared readily between European and North American public opinions have eroded with time.
- Finally, the two blocks overlap only loosely with geographic boundaries. Not all European countries share the same concerns over GMOs; conversely, some countries outside Europe—Australia, New Zealand—have joined in the mobilisation against transgenic food.

While NGOs are expressing citizen concerns, retailers are relaying consumer preferences.

4.2. Retailing industry: following and shaping the demand

The contrasts in regional mobilisation and consumer perceptions have had direct consequences on the strategy of retailers. European retailers have moved to meet and further shape the demand for non-GM food, in contrast with the "wait-and-see" approach adopted by the bulk of North American retailers.

Faced with growing popular pressure to phase out GMOs and legal uncertainties on GM food labelling, many retailers have adopted a restrictive stance on GM food. Supermarket chains first moved in the UK, and the movement spread to continental Europe in 1999, with a consortium of European supermarket chains being formed in March 1999.

Retailers did not align on a single non-GM model. Rather, they adopted various types of actions. Retailers having taken a restrictive stance on GM food mainly focused on own-brands, for which they commit themselves to phase out GE ingredients. Where such phasing out is not possible, compulsory labelling applies, in accordance with EU legislation.

Supermarket chains' actions can be differentiated on the basis of two criteria:

- group v. individual initiatives: Group initiatives, such as consortia or the GM-free working group, enable group members to share the burden of reorganisation of the supply chain and give them additional weight with respect to the food processing industry. On the other hand, individual initiatives are likely to diminish the negotiating power of the chain with regard to food processing.
- Choice v. no choice: some supermarkets allow GM-labelled foods; others will not sell products labelled as containing GMOs. Yet, others do not exclude GM labelled foods.

The retailing industry is the linchpin in the food market due to its proximity with consumers. In addition, over the last years, a global concentration process has increased the market power of retailers. They are in a key market position which allows them to amplify consumer preferences and relay them to the food industry. Moreover, given the transnational character of supply chains, the restrictive stance of European supermarkets has triggered a reorganisation that transcends Europe. Their restrictive approach on GM food has cascading effects back on the upstream side of the food chain, on domestic as well as on foreign markets. Food processors and grain companies have been hard pressed to segregate GM from non-GM products and regionalize their production.

5. MARKETS: SEGREGATION, IDENTITY PRESERVATION AND LABELLING

The introduction of GM crops has until now mainly addressed the supply side of agricultural crops and food markets. The development of efficiency enhancing GM crops dominates the agricultural applications in most countries where GM crops are grown. The EU debate on GMOs, on the other hand, is dominated by demand factors, such as food safety concerns.

Consumer reaction to GM food (see chapter 4) has given rise to uncertainty about market developments, both as regards to the short term prospects for GM products and to the future competitiveness of conventional non-GM production. Several economists have recommended labelling as a tool to enable consumer choice between products and to avoid further market and trade disruptions.

5.1. Key features of agricultural trade systems

Trade of agricultural products today is based on the commodity system, which works on the basis that crops from different farms are sufficiently alike to be traded at a common price and to a common grading specification. On its journey to a milling plant, the crop can be sampled and blended several times and there is no traceability back to the producer. Bulking up the produce of many producers means that transport and handling costs can be reduced. Furthermore, bulk transport enables a continuous flow for processing, since taking a processing plant down and firing it up again can be time consuming and costly.

Segregation refers to a system of crop or raw material management which allows one batch or crop to be separated from another (House of Commons 2000). It implies that specific crops and products are kept apart, but does not necessarily require traceability along the production chain.

Identity Preservation (IP) is a system of crop management and trade which allows the source and/or nature of materials to be identified (Buckwell et al. 1998). The objective of IP is to ensure that a particular crop is monitored throughout the food chain and thus to guarantee certain traits or qualities which might command a premium (House of Commons 2000). IP requires a set of actions to allow traceability and is usually communicated to the consumer by a label.

Currently IP is used to identify crop varieties which provide additional features concerning the content or composition of products (eg, protein content, starch level, oil content). In addition, IP is also applied for features which are not related to the contents but to the method of production (organic food or animal welfare standards) or the geographical origin of the product.

Compared to the main commodity markets, the quantities currently traded under IP systems are small. Organic food is for instance representing a market share of less than 5% in most EU Member States (Michelsen *et al.* 1999). Identity preservation systems in the US currently account for 8 – 10%

of US agricultural production, and in ten years' time would be accounting for 25-30% (Young, 1999). Although currently only 100 000 tonnes of US soybeans are identity preserved, compared to 75 Mio tonnes harvested under the commodity system (Rawling 1999), trade experts have estimated a 25% market share for IP corn and IP soybeans by 2005 (Clarkson 1999).

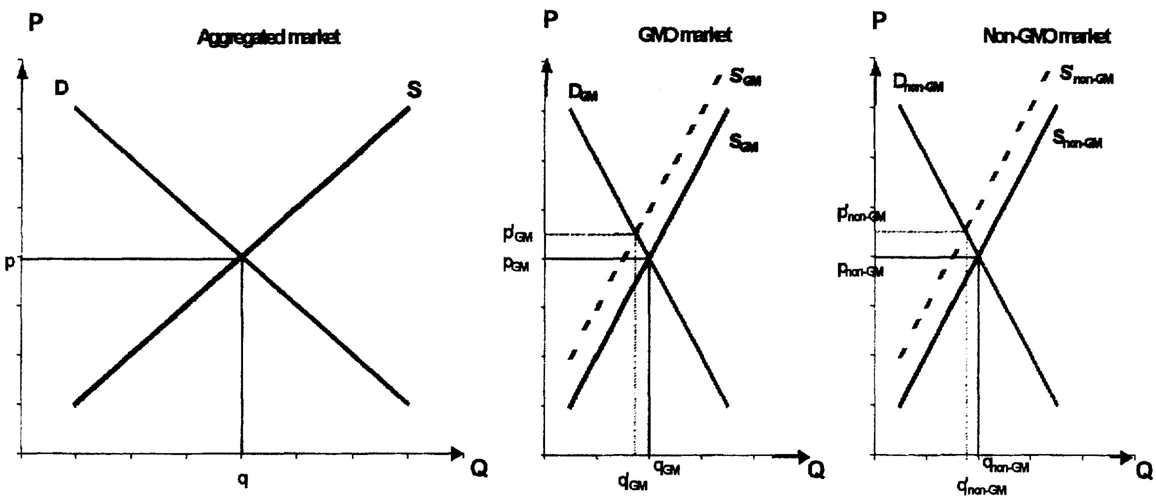
5.2. Identity Preservation and labelling in the context of GM crops

There are several reasons to consider IP systems in the GMO context:

- consumer request for traceability in order to control health and environmental effects,
- international agreements, in particular the Biosafety Protocol,
- mandatory GMO-labelling requirements in certain countries,
- differences in approval status of GMOs in different countries,
- consumer demand for certified non-GMO or GMO-free products, and
- the development of GMOs, with specific traits addressing the consumer and the processing industry.

Segregating and Identity Preservation are attempts to create and establish separate markets for differentiated products or to set up a "new" market for a "new" specific crop. The economic effects of segregated markets for GM and GMO-free crops correspond to a dis-aggregation of the supply and demand curve.

Figure 5.1: Segregation of GM and non-GM markets



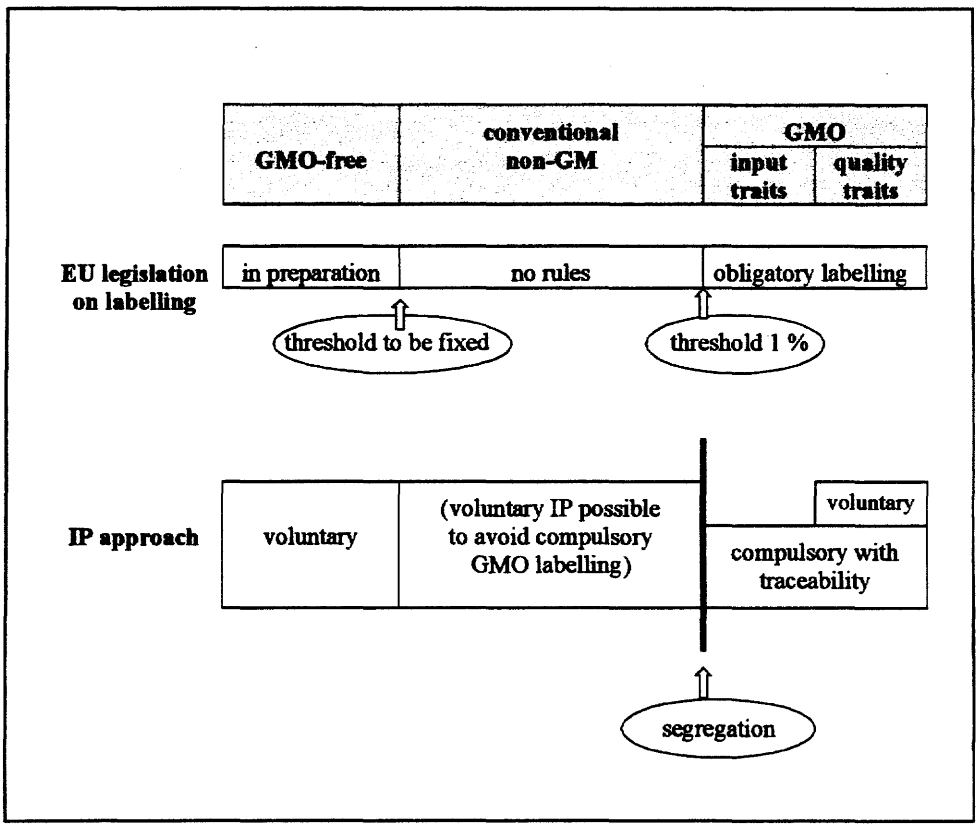
Assuming that the aggregated supply for a certain crop would be subdivided equally among GM and non-GM markets and demand would follow the same pattern for both sub-markets, the price should be the same on the GM and on the non-GM market. However, due to lower quantities produced and traded, potential economies of scale may not be used and production cost per unit might be higher than on the aggregated market. In figure 5.1 this effect is captured by shifting the supply curves from S_{GM} to S'_{GM} and from $S_{non\text{-}GM}$ to $S'_{non\text{-}GM}$ (indicated by dotted lines). The effect will be a reduction of quantity produced and an increase in prices on both markets. In general, losses in economic welfare can be expected because the potential for trade and specialisation gains will remain partially unused.

Following the current EU legislation on labelling and the general features of Identity Preservation systems, three different approaches to IP have been identified in the GMO context (figure 5.2).

1. Voluntary IP of specific GM traits: IP systems are common practice for crops that have a specific value to their consumer. With the development of new traits by GM, the economic incentive for IP would increase. In addition to the labelling requirements under the novel food regulation, there would be a clear incentive on the supply side (farmers, processors and retailers) to introduce IP and thus to preserve the additional value or quality of such a GM crop through the processing chain. IP would distinguish a product for which consumers are expected to pay more than for a conventional product.

2. Voluntary IP of GMO-free products: The second approach for IP is to preserve and label GM-free products in order to enhance consumer choice. Current EU legislation already requires compulsory labelling for food containing GMOs. Thus, the introduction of labelled GMO-free food would in theory enable the choice between three categories of foodstuffs: novel GM food, conventional non-GM food and GMO-free products.

Figure 5.2: Labelling and Identity Preservation



However, it can be expected that the share of conventional food will diminish over time, since the pay off for GMO-free products can be expected to be higher than for conventional non-GM products. If producers decide to make an effort to segregate, the additional costs to comply with GMO-free standards might be low compared to the additional premia achieved on the market. On the other hand, if at least part of the consumers accept labelled GMO food, some conventional raw material would enter into GM-labelled final products if voluntary IP of non-GM products is not rewarded by a sufficiently high premium.

3. Compulsory IP for GM products (GM traceability): Trading GM crops through commodity systems prevents material being traced within the transportation and processing chain. Thus any commodity sample originating from a region or country where GM and conventional crops are grown in parallel might contain GM crops. Traceability, i.e. a compulsory IP system, has been introduced as a strategy to re-establish consumer confidence in the EU beef sector following the BSE crisis. Traceability could also be a strategy to monitor the environmental and health effects of GMOs and to enable choice to those consumers who want to avoid GMO consumption.

According to the EU Council Common Position with a view to amending Directive 90/220/EEC on the deliberate release of GMOs[5] traceability will be required.

5.3. Costs of Identity Preservation in the GMO context

Additional costs of IP arise with the additional work involved in growing, handling, storage, transport, processing, cleaning, and administration (Buckwell *et al.* 1998). They would apply to all three IP approaches identified above, independently of their voluntary or compulsory character.

Seed production: Already under conventional systems basic and certified seed is normally distributed separately bagged and labelled. The crucial variable to determine additional costs in seed production will be the tolerance level for contamination with other (GM) varieties. Representatives of the seed industry have confirmed that they could provide seeds at any desired tolerance level. However, costs would rise following rather an exponential than a linear function with a tolerance level approaching zero percent.

Farm production and on-farm handling: The farmer will be able to control the likelihood of volunteer plants, mechanical commingling and the distance to avoid cross pollination. Physical distance between the pollen donors and the crop is the most important factor to avoid cross pollination among specific varieties.

[5] Common Position (EC) No 12/2000 adopted on 09/12/2000

Cross-pollination raises a number of legal and economic issues concerning the coexistence of different production systems, i.e. GM, conventional and organic farming. For instance, the standards for organic farming provided by the UK Soil Association require minimum distances from GM crop plantings (Soil Association 1999). In the UK, seed producers have set up guidelines for good agricultural practice for growing herbicide tolerant crops which provide minimum distances (SCIMAC 1999). These guidelines also propose that "the onus lies with the GM grower to notify neighbouring farms in writing of his planting intentions." Policy will have to address the question of how and at what level to solve conflicts related to cross pollination.

The crucial factors to determine IP costs at the farm level will be the tolerance level to be achieved, the physical ability of cross pollination and rules and legislation concerning neighbouring farms. However, most of the additional costs at the farm (and the processing) level would be avoided, if the full production could be switched to a single type of IP.

Testing: For GM crops providing quality traits testing will refer to these specific modifications. GMO traceability would extend the need for testing to all genetic modifications, including agronomic traits. For GMO-free products, the testing would not be limited to determine the presence or absence of GMOs, but would also have to confirm that the tolerance levels have been respected.

GMO testing methods

A Genetically Modified Organism can be distinguished from a non-GMO by the fact that it contains either unique novel deoxyribonucleic acid (DNA) sequences and/or unique novel proteins not present in its conventional counterpart. Two methods are actually applied:

PCR: The polymerase chain reaction is based on the detection of DNA fragments that are inserted in the plant genome. This method allows amplification in a few hours of specific DNA fragments to a degree that they can be analysed qualitatively and quantitatively by common laboratory techniques (e.g. electrophoresis). However, it requires specialised equipment and training. PCR testing is applicable and extremely sensitive in the case of unprocessed food where the DNA is still intact. This is not the case for processed food where it is more difficult to isolate high quality DNA and where GM material from more than one GM species can be present. PCR requires little reagent development time, but it can still take 1 to 3 days to receive results from a testing laboratory. The test is estimated to be about 99.9% accurate.

ELISA: This method is able to detect and to quantify the amount of a certain protein which is of interest in a sample that may contain numerous other dissimilar proteins. ELISA uses antibodies to bind specific proteins, for instance those newly synthesised following a genetic alteration. A colorimetric or fluorometric reaction can visualise and measure when the antigen and specific antibody bind together. One restriction for using the ELISA test is the denaturation of proteins in some food processes. This method also requires high investments to develop the assay and to generate antibodies and protein standards. However, once reagents are developed, the cost per sample is low. The test is reported to be 95% reliable.

In order to compare the different cost elements, testing costs have been calculated per tonne, although testing is not only applied to raw products but also to processed foodstuffs. The additional cost per tonne of soya or corn for testing the presence of a specific biotech trait by the ELISA technique has been estimated at 0.4 € (Lin 2000). However, since current ELISA testing methods require a separate test for detection of each unique trait, several tests may be necessary. At subterminals and export elevators, PCR testing is more common than ELISA because it is more sensitive and can be used to detect presence of several genetic modifications by one set of tests. Furthermore, it becomes more efficient with larger volumes of grain to be tested (Lin 2000).

Overall cost for an IP testing system have been estimated to range from 1 €/t for a simple checking to as much as 20 €/t for the most disciplined systems of overlapping documentation, field inspections, product sampling and laboratory testing by third parties (Clarkson 1999).

An alternative to expensive tests could be the introduction of additional genes that provide visual markers to facilitate identification. However, IP documentation is likely to reduce the need for testing compared with on the spot testing of commodities for GMO contamination or specific traits.

Transportation and storage: In general, increased IP trade would reduce the value of the traditional commodity infrastructure. Additional costs will occur with the need to find separate storage at local elevators with cleaning and with possible restrictions in the delivery schedule. If transportation and storage facilities in silos, trains, trucks or ships cannot be fully used by IP crops, further costs might occur per unit.

According to the literature available, the additional transport cost range from 1 to 9 €/t for the different products and IP approaches. These costs represent about 0.5 – 5% of the farmgate price. The key factors will be the amount of crop traded under the different IP systems and the tolerance level for contamination.

Processing industry: Normally, processing plants for soybeans and corn are run continuously except for annual cleaning or repair breaks. Stopping production and cleaning the facilities would cause additional cost. The specific cost of IP processing further depend on the number of secondary products produced from the raw material. If only one of the output products is required to be IP, e.g. the soya oil, it will bear the whole cost of IP. If there is a market for all the products of IP however, then the costs of IP will be spread across all end products.

If there is sufficient IP supplies of a crop, it may be possible to dedicate a plant to processing such supplies, in which case there would be no additional costs involved from separate processing and storage.

The examples for the processing level indicate additional costs of 1.5 – 9 €/t, which is about 0.5 – 3% of the farmgate price of the product concerned.

Total cost of IP systems: Summarising the different costs along the production chain allows estimating the total costs of IP. According to the literature available, they range from 5 to 25 €/t depending on the different grains and the IP systems (table 5.1). Thus, IP would increase the grain price by 6 – 17% compared to the farmgate price. Since such a range corresponds to the experience with well established IP systems for value added market segments, it can be taken as a reliable estimation of IP costs.

Table 5.1: Examples for total costs of IP for GM/non-GM crops

Crop	GM / non-GM	Country	Tole-rance	Year	IP cost	% of price	
Soybean	GM quality traits: low linolenic, high oleic, low saturate, high protein, high sucrose	USA		(1997)	15 – 22 €/t	6 – 9%*)	(1)
Soybean	Non-GM: herbicide resistant	USA	(0%)	1998	Soyameal protein: 119 €/t	50% **)	(1)
Soybean	Non-GM	Italy		1999	Soyameal > 23 €/t		(9)
Soybean	Non-GM	UK		(1999)	17.2 €/t		(8)
Soybean / corn	Any type of identiy preservation	USA		1999	4.7 – 21.4 €/t		(4)
Corn	Post harvest chemical free	USA		(1997)	14 €/t	16% *)	(1)
Corn	High oil content	Europe		1997/ 1998	17.6 €/t	17% *)	(1)
Oilseed rape	GM: herbicide resistant	Canada		1996	10.4 – 13.3 €/t	6 - 8% *)	(1)
Oilseed rape	GM herbicide resistant (limited acreage:5% of total acreage in CAN)	Canada		1996	19.7 – 21.4 €/t	9.5% *) 8.5-9% **)	(3)
Sun-flower	High oleic	USA		1997/ 1998	16.0 – 23.0 €/t	7 – 10% *)	(1)

*) farmgate price **) commodity price

Sources: (1) Buckwell et al. 1998; (3) Van Wert (AgrEvo) 1996; (4) Clarkson 1999; (8) House of Commons 2000; (9) Brookins 2000

Summarising the analysis, the following main factors have been identified to determine IP costs:

– Tolerance level: The more stringent the purity requirements, the more expensive will be the IP system. The tolerance level appears to be the most important cost determinant for all three IP approaches discussed in this report. Fixing a threshold will particularly concern the cost of seed production, the costs for testing, storage and transportation and the decision to switch a whole farm and a whole processing plant to specific (IP) production. Choosing a severe level of tolerance may increase the cost to such a high level that they would override the possible benefits of IP production. An extremely low tolerance level for GMO-free products could thus be a strong disincentive to establish GMO-free production and would reduce the GMO-free market to niche production for high income households.

- Agronomic traits: The genetic disposition for cross pollination and for volunteers will determine in particular the costs on the farm.
- Market volume: Economies of scale can be expected for any IP system. The more crops are traded under such a system, the higher will be the potential to reduce costs. Furthermore, if an entire stream can be devoted to an IP system, additional costs should be quite low.
- Seasonality: A strong seasonality of market supply could increase the storage costs of an IP system, in particular if the IP crop is grown only in a particular region or country.
- Derived products: IP costs per unit depend on the share of all processing products which can be marketed as IP. If only one of a whole range of the output products is to be identity preserved, it will bear the whole costs of IP.

Nevertheless, the magnitude of the additional costs is not fixed. It depends on the particular circumstances. Buckwell *et al.* (1998) concluded that first, IP costs are likely to be overstated by those who might not be convinced of the need of an IP system and second, they are "likely to change as the industry learns how best to organise IP and as the volume of material involved increases."

5.4. Distribution of costs along the production chain - who pays for IP?

Additional costs for segregation and IP systems have been shown to occur in the different stages of the production process. However, these costs can be shifted between the different stages along the chain. Analysing their allocation is important to understand the economic effects of IP. Four factors, which determine the sharing out of costs have been described by Buckwell *et al.* (1998):

- Price responsiveness (own-price elasticity): Depending on the responsiveness of demand and supply to price at each of the stages additional costs can be shifted – at least partially - to the previous or to the following stage of the production chain. Generally the less price-responsive demand is at a certain stage, the more of the additional costs will be absorbed by the consumer at this stage. Equally, the less price-elastic is supply, the more of the additional costs have to be absorbed by the producer (Buckwell et al. 1998).
- Availability of substitutes: The more substitutes are available, the more responsive would be the price. Thus for products, which can easily be substituted, additional costs will hardly be shifted to the processor or the final consumer. In this case, it will be the farmer who has to bear most of the additional costs of IP. On the other hand, if a product is difficult to substitute, it will be the consumer who has to bear the IP costs.
- Market structure: Price-responsiveness can be affected by the competitive structure of the industry. The more concentrated the structure, the more likely that any additional costs are passed over to the previous or the next stage of the chain. In the food sector, the market power is in general stronger at the food processing and retailing levels compared to the farmer

and consumer level. Thus IP costs are very likely either to be passed back to the farmer through lower prices for his products or to be passed forward to the consumer in the form of higher food prices.

- Agricultural price policy: Agricultural policy measures, in particular those established to control agricultural prices may have an adverse impact on the transmission of additional costs to the consumer. On the other hand, price policy may also reduce the transmission of benefits of cost reductions by new technologies and thus reduce the economic incentives to apply these innovations.

These factors apply to all three IP approaches which have been identified in the context of GMOs.

1. Voluntary IP of specific GM traits: If GM crops have a specific value to the consumer, these crops have to be handled separately, in order to preserve their value through the chain. Price elasticity of supply can be expected to be high. On the demand side, the new trait will create a situation in which the scope for substitution is limited and thus demand gets fairly price inelastic. The effect will be that most of the additional cost can be passed on to the consumer. The market will be a niche market – at least in the beginning - for each of the new traits introduced by genetic modifications.

Thus it is very likely that the consumer will be charged a premium which covers not only the intrinsic additional value of the new product, but also the costs to handle them separately through the food chain.

2. Voluntary IP of GMO-free products: If GMO-free products have a specific value to consumers, they are willing to pay a premium for these products, which are handled separately or identity-preserved.

With a voluntary IP system for GMO-free products, additional costs will be borne by the producers, processors and consumers of these GMO-free products. The scope for passing over the costs of IP for a GMO-free product will depend upon how strong the demand for GMO-free products will be. The stronger the demand, the less responsive will it be to price change. This would increase the scope for suppliers to pass over the costs of IP in the form of higher prices (Buckwell *et al.* 1999). Thus it will be more likely that the consumer bears the costs than the farmer of GMO-free crops.

For the short-term development, however, some impact on the market for GM crops cannot be excluded. In a short-term analysis supply of GM and GM-free products is assumed to be fixed. Consumers without specific preference for non-GMO products will not care whether they consume GMO or GMO-free products. However, GMO-free demand will not accept GMO supply. So there will be one-way situation for substitution and the magnitude of demand for IP products relative to the demand for commodities will be the crucial factor to determine the distribution of the additional costs as well as of the price of GM and GMO-free crops.

To analyse the short term market effects, two scenarios can be distinguished:

<u>Scenario 1:</u> The share of total demand for GMO-free crops is greater than the share of GMO-free market supply.

In this case, severe market disruptions may occur as processors strive to locate and purchase GMO-free crops. With a high demand for GMO-free crops, their prices would increase rapidly and a surplus of GM products is likely to be build up. Substitution of GMO-free by GM products would in general be rejected by consumers or processors which are looking to avoid GMOs. However, the increasing price gap might be an incentive for some of them to change their minds and accept purchasing GM products.

Furthermore, a surplus of GM crops could only be avoided by offering a discount which makes customers buy more GM crops. Processors will be forced to develop a price schedule that reflects the relatively low value of GMOs in the market. The discount would be applied to all GMOs and not just to the proportion of GMOs that are in surplus. (Miranowski et al. 1999)

<u>Scenario 2:</u> The demand for GMO-free products is relatively small compared to the available supply.

The marketing of the GM crop would not be affected by the relative surplus of GMO-free crops. Any GMO-free crop would be accepted by the conventional production chain. In this case, the purchasers will not pay a premium or discount for GMO-free products and producers of GM-products will not have to take a discount.

However, farmers have to invested in producing GMO-free crops and – at least for some of them - the additional costs will not be covered by the conventional marketing. It would be those farmers and the consumers of GMO-free products who are very likely to bear the costs under scenario 2.

Price information for <u>soybeans</u> indicate that US producers have received a premium of 5 - 9 €/t for non-GM soybeans in the last years. This amount corresponds to about 4% of the farmgate price. More recent sources signal a lower premium level of 3 – 7.5 €/t. In contrast, GM soybeans are being discounted by up to 10% of the farmgate price in many parts of the USA.

However, according to US grain handlers, the premium paid for food quality soya was much higher than the non-GM premium. The premium for organic soybeans was estimated at 245 €/t (commodity quality), a premium of almost 150% of the commodity price (Clarkson 1999). Thus, farmers who are thinking about entering into non-GM production might consider as well to switch to high quality varieties or to organic farming in order to realise the higher market price.

While quality trait premia (high oil contents) for <u>corn</u> range between 4 and 6 €/t, non-GM premia appear to be slightly lower. They range between 1.8 and 5.6 €/t. IP premia range between 2.5 and 9% of the farmgate price for corn. However, when these price differences per tonne are translated into price differences per hectare the farmer will have to take account of yield differences. Yields of quality trait varieties are often lower than average, while several studies have found evidence on yield gains for Bt corn compared to conventional varieties (see chapter 2).

Some examples for other crops, i.e. sunflower and oilseed rape, unveil that a premium of 3.5 to 5% of the farmgate price is paid to the farmer for cropping (conventional) quality trait varieties (Buckwell *et al.* 1998).

3. Compulsory IP for GM products: Since most of the quality traits introduced by genetic engineering can be expected to rely on voluntary IP to preserve the additional value, GMO traceability would mainly affect crops with modification of agronomic traits.

Agronomic traits address the producer and the crops are marketed similar to conventional crops. Thus any consumer without particular preference for GMO-free food should be indifferent when comparing GM and GMO-free products. A high degree of substitutability can be supposed, because the consumer could easily switch completely to the conventional product if additional cost for IP would increase the price of a product. This would mean that IP costs would be passed back to primary producers and processors of GM crops. The producers of conventional crops would not be affected and the additional IP costs at the farm level would reduce the profitability of GM crops.

The relative position of GM and conventional crops could be altered, if the agronomic trait is sufficiently advantageous at the farm level. As soon as the GM crop accounts for a significant proportion of all traded crops, it becomes the norm and will set the baseline for the commodity price of this crop (Buckwell *et al.* 1999). This would reduce the competitiveness of conventional crops and increase the incentive to adapt the production programme.

5.5. Market implications

5.5.1. EU markets for soybeans and corn

Soybeans: The EU is the world's leading importer of soybeans and soymeals. Domestic production of soybeans is covering only a small percentage of EU consumption (table 5.2). The degree of self-sufficiency varies between 6% (soymeal) and 18% (soya oil) in 1998/99.

Most soya-bean/meal production and imports are used for animal feed, but a small share (less than 1 Mio tonnes) is used for food. The EU main - and nearly exclusive - trading partners for soya beans and meal imports are Brazil, Argentina and the US.

The European market is of particular importance for Brazil and Argentina. 40 to 50% of their soya production is sold to the EU. The USA as the world's leading soybeans exporter, are sending 10 to 15% of their production towards the EU, which, is equal to around 30% of USA soya exports. Thus, for soya bean and meal trade, there is a mutual dependency between the three main exporters and the EU as the main importer.

Table 5.2: EU balance sheets for soya beans, meals and oil (1000 t)

Soybeans	**1995/96**	**1996/97**	**1997/98**	**1998/99**
EU Production	907	978	1 578	1 843
Imports	15 212	14 313	14 189	13 948
Exports	25	28	58	26
Availabilities	16 094	15 263	15 709	15 765
Self-sufficiency (%)	6	6	10	12
Cake and cake equivalent (meal)	**1995/96**	**1996/97**	**1997/98**	**1998/99**
EU Production - from Community seed - from imported seed	 688 11 865	 741 11 164	 1 185 11 067	 1 417 10 880
Imports	12 678	10 544	10 673	14 110
Exports	735	737	1 253	1 399
Availabilities	24 496	21 712	21 673	25 007
Self-sufficiency (%)	3	4	6	6
Oil and oil equivalent	**1995/96**	**1996/97**	**1997/98**	**1998/99**
EU Production - from Community seed - from imported seed	 159 2 738	 171 2 576	 274 2 554	 327 2 511
Imports	3	15	8	4
Exports	511	816	919	1 008
Availabilities	2 389	1 946	1 916	1 834
Self-sufficiency (%)	7	9	15	18
Source: European Commission 2000				

Given this mutual dependency, and taking into account that:

– more than 50% of the US soybean area and almost three quarter of the Argentinean soybean area are under GM crops,

– segregation of GM and non-GM crops is still limited in the US and there is no evidence on segregation in Argentina,

it is very likely that animal feedstuff in the EU consisting of or containing soya imported from these countries contain GMOs. Soymeals represent an important source of proteins for poultry and pigs. Therefore it must be assumed that currently most chicken and pigs fed in the EU have already eaten some GMOs.

Corn: In corn production, the EU has reached a degree of self-sufficiency which is around 100% (table 5.3). Imports contribute 4 – 8% to total availability on the internal market. Feed use absorbs about 75 – 80% of the EU market volume, industrial use accounts for 4.2 Mio tonnes each year (11-12%), and human consumption for 2.6 Mio tonnes (7%).

Table 5.3: EU balance sheets for corn (Mio t)

	1996/97	1997/98	1998/99	1999/2000 *)
EU Production	34.3	38.1	34.7	36.6
Imports	2.4	1.4	2.9	1.9
Exports **)	1.8	2.1	1.8	1.8
Availabilities	34.9	37.4	35.8	36.7
Self-sufficiency (%)	98	102	97	100

*) estimation **) includes 85-95% processed products and animal feed
Source: European Commission, Grains Outlook March 2000

However, imports of corn by-products, in particular corn gluten feed, surmount the imports of corn grains. In 1999, around 4.7 Mio tonnes of corn gluten feed was imported by the EU.

For corn the USA is the worlds leading producer and exporter, although only 20% of the US corn production is exported. The main part is sold on the domestic market for feed (60%) or non-food uses (ethanol) (USDA 2000). EU imports of US corn have decreased dramatically. The share of US in EU corn imports dropped from 86% in 1995 to 12% in 1999. Meanwhile Argentina has become the major supplier for EU imports.

5.5.2. Market supply to serve potential EU non-GMO demand

Soybeans: World production of soybeans is expected to be 153.5 Mio tonnes in 1999/2000 (USDA forecast). Neglecting any difference in average yield between GM and non-GM varieties, GM soybean production can be estimated to exceed 50 Mio tonnes in the marketing year 1999/2000. Cross-pollination is not a concern for soybeans, and refuge stripes have not been requested. Nevertheless, co-mingling is very likely to reduce the available non-GM quantity. In theory, non-GMO production should be sufficiently large to supply EU import demand.

The main producers, in particular the US have already reacted to the EU and the Japanese demand. The Iowa State University has estimated that the US market should handle the situation quite easily, if about of 7 to 10% of EU demand would switch to non-GMO soya products. However, if EU food retailers and consumers should decide to reject meat from animals fed with GM soymeal, a significant price difference between GM and conventional soya would emerge. Therefore, the consumer attitude on meat from animals fed with GMO feed-stuff will be a crucial factor for the price development.

However, other factors are influencing the import demand for non-GM soybeans:

- there is certain scope to substitute soya by other products,
- EU soymeal import demand has proven to be quite price elastic.

– Sourcing non-GM soybean suppliers often implies establishing new trade partnership, including contracts governing identity preservation, which has a cost (e.g. transaction) and requires time. When the number of significant exporters is limited as is the case for soybeans, it is even more difficult to find alternative suppliers.

Corn: The usable percentage of non-GMO corn crops is uncertain, although the percentage of GM plantings is quite well known. Many fields were planted with alternating stripes of Bt and non-Bt-corn to provide a refuge for corn borers. Thus some of the non-GM corn would be cross-pollinated and co-mingled with the GMO crop during harvest.

For the USA, some estimations of possible market share have been made: If the entire US food processing industry switched to non-GM corn, the market for non-GM corn would constitute 8% of the 1998 US corn market. If the sweetener and the ethanol (by-product of corn) industries joined, non-GM corn would constitute 20% of the US corn market. Finally, 17% of the US 1998 production was exported of which 80 to 90% is fed to livestock and only a small percentage is directly processed into food products. This implies that an upper limit of the market share for non-GM corn in the US is 37%.

US reaction to non-GM demand

In the US, segregation initiatives are mainly export driven, or they concern specific clusters like baby food.

According to a recent survey of nearly 1200 US elevators about a quarter of the respondents will segregate GM and non-GM corn and 20% will segregate soya in autumn 2000. One out of ten elevators has declared to offer a price premium for conventional corn and 14.3% are planning to offer a premium for conventional soya. The resistance to buy GM crops also differs among the two crops. Only 12% of the elevators are planing to refuse biotech soybeans in fall 2000 and 18.4% of the elevators will refuse to buy biotech corn (Pioneer Hi-Bred International, 2000).

According to a Reuters' survey of 400 US farmers, 15% of them have made or are planning to make investments to handle or segregate GM crops. (Reuters Business Brief 13 Jan 2000).

5.5.3. Different stance on food and feed uses

The EU balance sheets for soya and corn have shown that the main use of soya and corn is in the feed sector, which will have a significant effect on the breakdown of demand between the GM, conventional and GMO-free segments. The EU Commission has announced to table a proposal dealing with novel feed, including GM feed in the second half of 2000. The labelling rules and in particular the level of the tolerance threshold will be key elements influencing market behaviour.

Corn, in the form of grain, represents a quarter of cereals used for animal feed. Corn Gluten Feed and Corn Germ Cakes, which are mainly imported from the US, represent 20% of energy rich feedstuffs. Soymeals, which are mainly imported from Argentina and Brazil, represent nearly half of the protein rich elements in the EU. This points the EU dependency on imports of corn products and soybeans for energy and protein rich feedstuffs, and its exposure on GM products.

In short term, a segregation on the feed market would increase feed production costs within the EU, restricting trade in soybean meal, corn gluten products and other ingredients. There would be higher demand for locally produced feedstuffs, particularly rapeseed meal, barley and wheat. (Gill 1999)

Substitution: As long as there are significant origins with non-GM crops, no IP system would be set up by the origins with GM crops. Trade would just be adapted to this new demand. Secondly, if a product is easily substitutable, then IP is also unlikely to occur, because it will be far easier to switch to the substitute. Thirdly, if the commodity in question has many outlets around the world, then what other markets are doing is relevant to the EU market. If Japanese are paying a premium for non-GM soya then any IP system set up is going to supply them first.

Some EU operators are already organising non-GM soybean supply chains for animal feed. Depending on their needs, the source is domestic (French and Italian soybean production) or a foreign one, mainly Brazil. However, these initiatives concern a limited share of the feed market. Most initiatives are taken in the poultry sector, some also concern pigmeat. This echoes both the dependency on soybeans and corn for feeding purposes and the willingness to restore market confidence after the dioxin crisis. In addition the market for poultry is a segmented one, there are already price premia for identified quality (example red label chicken). In the EU 20% of the key marketable feedstuffs[6] are absorbed by the poultry sector and 42% by the pigmeat sector, which also relies on soybeans/meals imports. Soymeals also enter in the feed rations of cattle, accounting for 32% of the EU feedstuffs market. However, the use of soybeans in cattle rations is more price elastic than for pig and poultry, mainly because of the number of available substitutes.

Non-food/feed uses of GM crop are expected to provide market opportunities in the medium or long term. There are possibly good prospects for renewable resources used in energy production and in the chemical industry. In general, the societal and ethical acceptance of these applications is higher than that of GM food products (Menrad and Eurobarometer 2000).

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6 Marketable feedstuffs do not include green forages.

5.6. The trade issue/dimension

While accounting for the main producer of GM corn and soybeans, the US are the leading exporter for these commodities. Argentina is the second biggest producer of GM soybeans and the third exporter. The main importing countries for these commodities, the EU and some South-East Asia countries, have taken a restrictive stance on GM food. In particular, labelling of the GM nature of food ingredients is compulsory in the EU. Japan intends to implement mandatory labelling by the second half of 2000.

Not surprisingly, this situation has become a trade issue. However, it is difficult to isolate the possible effect of biotechnology on developments in trade, as many other factors play a role, like changes in competitiveness, transportation costs and the transaction costs of giving up of long-established trade links.

The issues at stake are of a different order of magnitude for soybeans and for corn. Between 1995 and 1997, EU imports from the US were worth, on average, 2 billion € for soybeans and soymeals and 0.03 billion € for corn. In addition, EU imports of Corn Gluten Feed are estimated to be worth around 500 Mio €.

US soybean exports declined from 26 to 20 Mio tonnes between 1997 and 1998, while world soybean trade held fairly steady. EU soya imports from the US have been partially replaced by imports from Argentina. The USDA has concluded that "traditional competitive forces (primarily prices) appear to be the main driving factors behind the changes in observed bilateral trade patterns". As the share of GM soybeans is much higher in Argentina than in the US, this shift in trading pattern cannot be attributed to reluctance to import GM soybeans.

The drop is even sharper for corn than for soybeans. US corn exports fell from 60 Mio tonnes in 1995 to 41 Mio in 1998. Most of the drop occurred on South-East Asia markets (with the exception of Japan) and is explained by the situation of China, which became again a net exporter of corn. On the EU market for corn, the share of US has steadily fallen while the share of other partners, in particular Argentina and Hungary, has significantly increased. The USDA considers that the loss of shares on the EU market results from issues related to biotechnology, in particular the differences in regulatory approaches.

Table 5.4 Approvals of GM crops in the EU and the US

	US		EU		
GM crops	approved	% sowings	approved	pending	
Corn	11	30%	4	5 among which	1 already approved for imports&process 2 are the same GM crop but with different uses
Soybeans	3	60%	1	none	
Rapeseed	3	15%	4	3	only one is same as in US

Source: Communication to International Grain Council, May 1999

While 11 types of GM corn have been approved in the US, only 4 have been cleared at EU level (table 5.4), and some Member States have decided to suspend authorisations for growing. Non-authorised GM crops cannot be placed on the EU market. In the absence of tolerance thresholds, if traces of such crops are found in a given consignment, it cannot be cleared for importing into the EU. According to the USDA, this situation has created uncertainties.

However, the type of GM soybeans which is mostly grown in the US (herbicide tolerant) is authorised in the EU for imports and processing (but not for growing purposes). According to the USDA, only a small part of US areas have been sown to non-EU approved corn varieties and the EU only accounts for 1% of US corn exports.

Trade issues have been addressed in the Biosafety Protocol, which aims at ensuring an adequate level of protection for transfer, handling and use of LMOs which might have an adverse effect on biodiversity. Reference is made to the precautionary principle in this respect. It is hoped that procedures foreseen under this Protocol, in particular information sharing and accompanying documentation, will help improving the predictability of transboundary movements of GMOs.

In addition, as already mentioned, the EU regulatory framework is under revision. Changes are also considered in the US and in many other countries. Biotechnology is discussed in the context of the transatlantic dialogue.

GLOSSARY

TERM	DEFINITION
Agri-genomics	Study of the make-up of and interaction between genes in crops and combinatorial chemistry
Biotechnology:	According to the draft Protocol on Biosafety, modern biotechnology means the application of: i) in vitro nucleic acid techniques ii) fusion of cells beyond the taxonomic family that overcomes natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection. Biotechnology is currently applied in the health sector (antibiotics, insulin, interferon...), in the agri-food system (micro-organisms, plants and animals), and in industrial processes such as waste recycling. Biotechnology and genetic engineering are often used interchangeably (see below).
Bacillus thuringiensis (Bt):	Bacillus thuringiensis (Bt) is a soil bacterium that produces toxins against insects (mainly in the genera Lepidoptera, Diptera and Coleoptera). Bt preparations are used in organic farming as an insecticide.
Bt crops:	Bt crops are genetically modified to carry genetic material from the soil bacterium Bacillus thuringiensis. Crops containing the Bt genes are able to produceBt-toxin, thereby providing protection against insects during the growth-stage of the plant..
Bt cotton:	Bt cotton is genetically modified to control budworms, and bollworms.
Bt corn/maize:	Bt corn/maize is genetically modified to provide protection against the European Corn Borer. The words Corn and Maize are used interchangeably in this report
Canola	Canola is a type of rapeseed which has been developed and grown in Canada. Canola is a registered trademark, corresponding to specified low contents in erucic acid in oil and in glucosinolates in meals equivalent to double 0 in the EU. It has initially been obtained by conventional breeding, but in recent years, GM herbicide tolerant varieties have been developed.

DNA

(Deoxyribo Nucleic Acid) The molecule that encodes genetic information in the cells. It is constructed of a double helix held together by weak bonds between base pairs of four nucleotides (adenine, guanine, cytosine, and thymine) that are repeated ad infinitum in various sequences. These sequences combine together into genes that allow for the production of proteins.

Genetic engineering:

The manipulation of an organism's genetic endowment by introducing or eliminating specific genes through modern molecular biology techniques. A broad definition of genetic engineering also includes selective breeding and other means of artificial selection.

Genetically Modified food

Foods and food ingredients consisting of or containing genetically modified organisms, or produced from such organisms.

Genetically Modified Organism (GMO)

An organism produced from genetic engineering techniques that allow the transfer of functional genes from one organism to another, including from one species to another. Bacteria, fungi, viruses, plants, insects, fish, and mammals are some examples of organisms the genetic material of which has been artificially modified in order to change some physical property or capability. Living modified organisms (LMOs), and transgenic organisms are other terms often used in place of GMOs.

Germplasm

Germplasm is living tissue from which new plants can be grown--seed or another plant part such as a leaf, a piece of stem, pollen or even just a few cells that can be cultured into a whole plant. Germplasm contains the genetic information for the plant's heredity makeup.

Herbicide-tolerant (HT) crops:

The insertion of a herbicide tolerant gene enables farmers to spray wide-spectrum herbicides on their fields killing all the plants but the HT crop. . The most common herbicide-tolerant crops (cotton, corn, soybeans, and canola) are tolerant to glyphosateand to glufosinate-ammonium, which are the active ingredients of common wide spectrum herbicides. There are also HT rapeseed and cotton which are tolerant to bromoxynil.

Identity Preservation (IP)

System of crop or raw material management which preserves the identity of the source or nature of the materials.

Living Modified Organism(LMO)- according to Biosafety Protocol

Any living organism that possesses a novel combination of genetic material obtained through modern biotechnology. A living organism is biological entity capable of transferring or replicating genetic material.

Novel Food	GM food and other foods and food ingredients consisting of or isolated from micro-organisms, fungi, algae, plants or animals, or which have been obtained through new processes.
Plant breeding:	Plant breeding is use of techniques involving crossing plants to produce varieties with particular characteristics (traits) which are carried in the genes of the plants and passed on to future generations. Conventional/traditional plant breeding refers to techniques others than modern biotechnology, in particular cross-breeding, back-crossing.
Segregation	Segregating implies setting up and monitoring of separate production and marketing channels for GM and non-GM products.
Traceability	Traceability measures covering feed, food and their ingredients "include the obligation for feed and food businesses to ensure that adequate procedures are in place to withdraw feed and food from the market where a risk to the health of the consumer is posed. Operators should keep adequate records of suppliers of raw materials and ingredients so that the source of the problem can be identified.
Transgenic plants	Transgenic plants result from the insertion of genetic material from another organism so that the plant will exhibit a desired trait.

Based on various sources