WORKING DOCUMENT Rev. 2

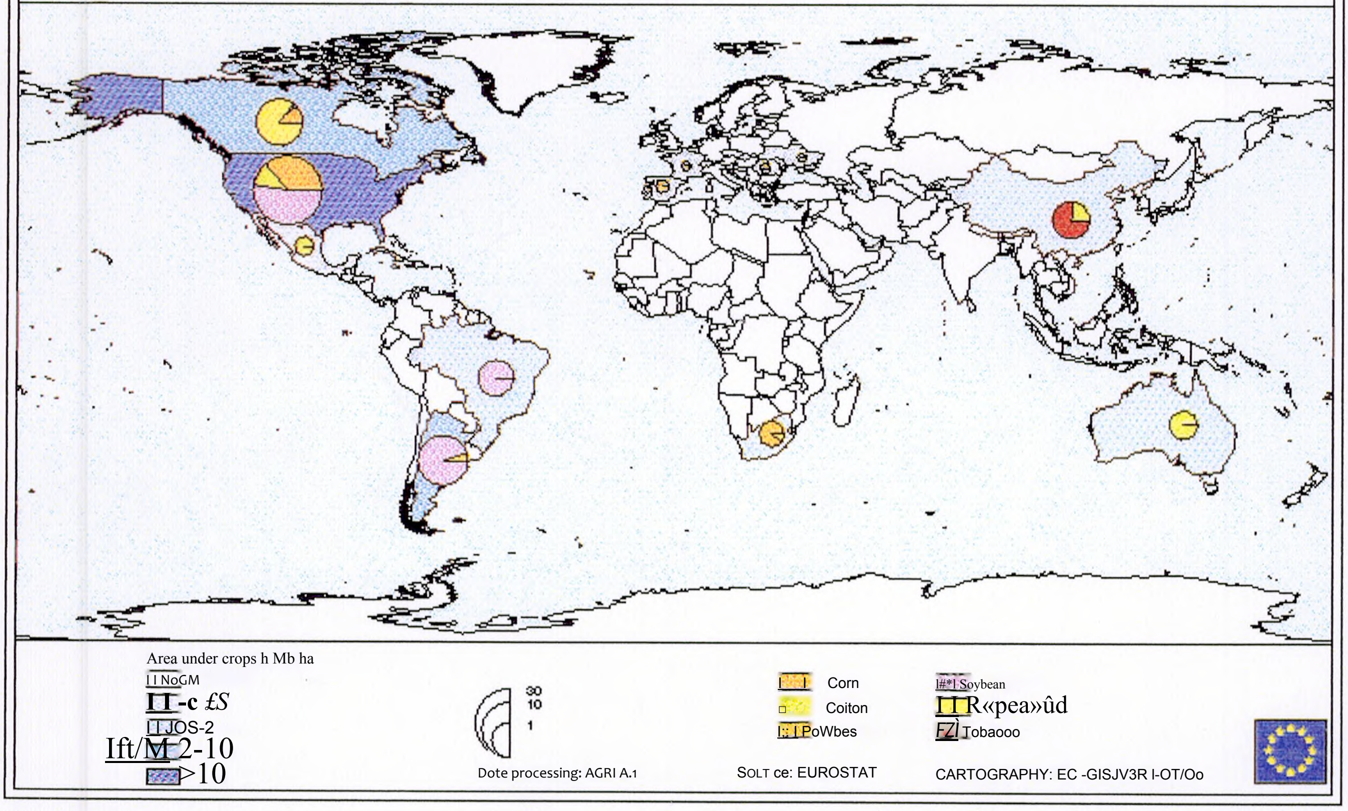
Directorate-General
for Agriculture

Commission of the European Communities

ECONOMIC IMPACTS OF GENETICALLY MODIFIED CROPS ON THE AGRI-FOOD SECTOR

A FIRST REVIEW

World GM Areas 1999/2000



INTRODUCTION

The rationale and scope of this review

The first Genetically Modified (GM) Crops have been put on the market in the mid-nineties. Since then, uneven developments have occurred from one continent or group of countries to another. This working document analyses the extent and the main reasons for these uneven developments, with special emphasis on underlying economic issues which are of direct interest for the agri-food sector.

A review of the economic literature helped to find answers to three main questions concerning the agri-food sector.

1. **How fast and to what extent have GM sowings developed?**

   Various tables and graphs on areas sown with GM seeds since 1996, broken down by countries and by type of crops, allow for judging on the rate of progression and the magnitude of GM sowings.

2. **Which reasons explain the rapid adoption of GM crops by farmers?**

   As for other innovations, the rapid uptake of GM crops is driven by profitability expectations. Have these expectations been met? Is profitability the only driving force behind the rapid adoption of GM crops? The review focuses on studies analysing the profitability of the mainly grown GM crops. Such studies are mainly available for Northern America.

   Farmers have been the first target-group in the strategies of biotech and seed industries, as the first generation of GM crops incorporates agronomic traits, like herbicide tolerance or insect resistance. The approach of both farmers and biotech firms has mainly been input-oriented. At the outset, reactions down the food chain have been underestimated.

3. **Which are the consequences of citizens'/consumers' reactions and food suppliers' initiatives?**

   Recent developments on the demand side have a cascading effect on the upstream sector. Based on consumer resistance to GM foods, many food suppliers have taken a restrictive stance to GM food. In the EU, food processors and retailers are trying to avoid or to restrict GM food. In the US and in Canada, some grain traders and processors are considering segregating GM and non-GM crops for meeting the differentiated export, or even domestic, demand. Segregating implies setting up, organising and monitoring separate market channels for GM and non-GM products, throughout the food-chain. One step further is identity preservation, a production and marketing process which preserves the source and the nature of a specified crop. In the case of GM crops with quality traits (second generation), identity preservation is necessary for preserving their value. Identity preservation of GM products would be a move away from the mainstream of commodity-based trading. However, identity preservation is already implemented for some speciality products. Could it be extended to separate GM and non-GM crops, at what costs and for which benefits? How are the additional costs and benefits distributed along the food chain? What are the consequences for cropping and trading practices?

While being limited to these three 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 beyond the agri-food sector.

Other issues have an economic impact on the agri-food sector, in particular developments in technology, science and legislation. Risk assessment with regard to food safety and environment and related regulatory approaches are not covered in this report. Some regulatory elements dealing with risk management and consumer choice are however taken into account, where they have a direct impact on the agri-food sector. For example, traceability and compulsory labelling of GM products will imply adjustments in farming **and trading practices.**

This review of existing economic literature on GM crops intends to provide a basis for further analysing the impact of plant biotechnology on the European agri-food sector.

EXECUTIVE SUMMARY

A review of the available literature helped to answer three main questions:

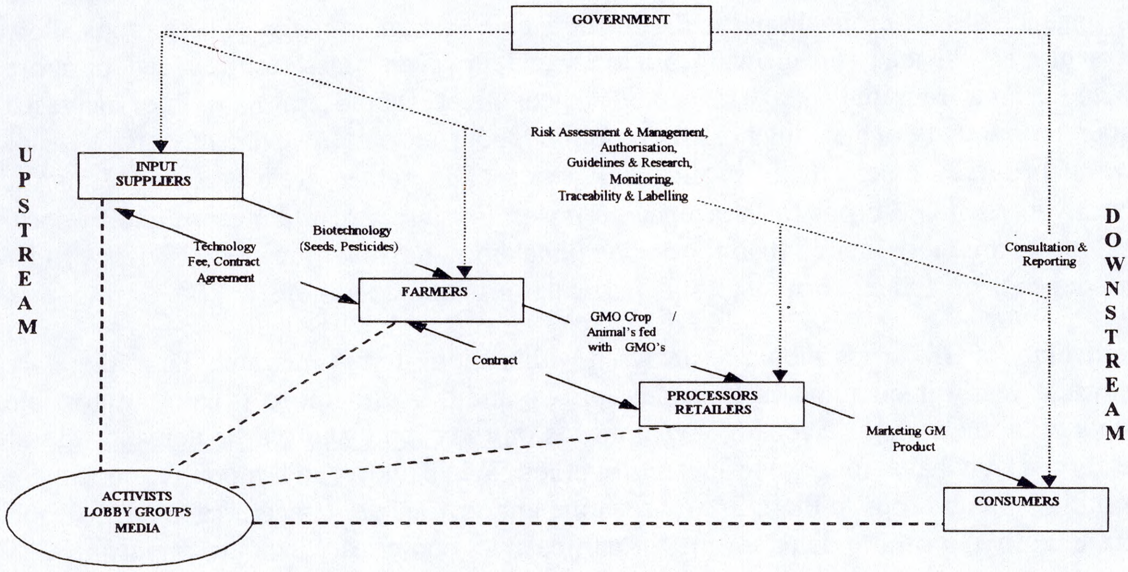
(1) How fast and to what extent have sowings of GM crops developed? Which crops are concerned?

(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.

The first chapter provides a global picture of areas sown to GM crops throughout the world. The first significant commercial sowings of GM crops (2.6 Mio ha) took place in 1996, almost exclusively in the US. Since 1996, the areas have rapidly expanded to reach 41.5 Mio ha in 1999. GM crops are mainly grown on the American continent: the USA accounts for 70% of worldwide sowings of GM crops, Argentina for 14% and Canada for 9%. Of the 41.5 Mio ha sown in 1999, 53% were soybeans, 27% com, 9% cotton, 8% rapeseed and 0.1% potatoes. These crops have been genetically modified to be more resistant to pests or/and tolerant to herbicides.

Starting from the upstream side of agriculture, chapter 2 considers 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. The life science sector is undergoing a rapid consolidation process. In this context, the development of biotechnology has increased concentration on the upstream side of agriculture. Biotech companies are not only leaders in crop protection, but most of them also hold key positions on the seed market. Farmers adopting biotechnology are confronted with a certain number of constraints: GM seeds are often sold and grown under contract, they are more expensive than conventional ones, in some cases seed-saving is forbidden. As a result of increased concentration and constraints, farmers depend more and more on a limited number of input suppliers for crop production.

Farmers in Northern America and in Argentina have quickly and massively adopted GM crops. Does this mean that farm-level benefits of biotechnology outweigh the above-mentioned constraints? Chapter 3 analyses the economic reasons for the rapid and vast uptake of GM crops by US farmers. They had strong profitability expectations. However, the studies reviewed do not provide conclusive evidence on the farm-level profitability of GM crops. Other factors have played a significant role. In practice, the most immediate and tangible ground for satisfaction appears to be the combined effect of performance 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 properly assessed in profitability studies. It rather translates in terms of attractiveness of GM crops for efficiency purposes. For insect resistant crops like Bt com, yield losses are more limited than for conventional com, however the cost-efficiency of Bt com depends on a number of factors, in particular growing conditions.

Profitability of GM crops should be analysed within a long-term timeframe. First, there are important yearly fluctuations in yields and prices, and it is difficult to isolate the possible effects of biotechnology. Second, developments on the supply and on the demand side of the food chain have to be considered together. While more and more farmers were adopting biotech crops in the US, in Argentina and in Canada, concerns about GM food were intensifying on the demand side, in particular in countries which are importing GM crops.

Chapter 4 provides an overview of differences in citizen concerns and consumer preferences between the EU and Northern America. These differences had direct consequences on the strategy of retailers. European retailers have moved first 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. The restrictive stance of EU consumers 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-GM soybeans and corn.

Soybeans and com are widely traded commodities. Countries where GM varieties are grown are leading exporters. Conversely, main importers of soybeans, com 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 com, 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 sources

The present review is mainly based on economic articles which have been published or posted on the world wide web.

To allow for selecting and channelling the widely available information on biotechnology, web sites which are of interest with regard to the economic issues addressed in this report (fast developments in sowings, profitability of GM crops, consumers surveys, segregation GM-non GM) have been classified in an intemet-database.

References to the articles reviewed can be found in the bibliography, which is included in the Appendixes. These articles have been released or published by various sources: governments (e.g. USDA), international institutions (e.g. OECD), research centers (e.g. INRA) and Universities (in particular in the USA), organisations (mainly NGOs), or industry (firms or their associations).

In addition, many press releases have been reviewed on a regular basis.

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

Additional specifications about sources and data can be found in different chapters of the report.

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

ABBREVIATIONS

ha	ha
Mio ha	million ha
t	tonnes

GLOSSARY

TERM	DEFINITION
Asri-senomics	Study of the make-up of and interaction between genes in crops and combinatorial chemistry
Biotechnology	According to the draft Protocol on Biosafety, modem 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 (ML	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 boll worms.
Bt corn/maize	Bt com/maize is genetically modified to provide protection against the European Com Borer. The words Com 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 modem 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.
Germylasm	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, com, 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 an	System of crop or raw material management which preserves the identity of the source or nature of the materials.
Living Modified Organism(IJMO)- according to Biosafety Protocol	Any living organism that possesses a novel combination of genetic material obtained through modem 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

1. Areas sown to GM crops in the world : fast but uneven developments

About the data

The data used in this chapter are derived from a GMO dataset established by DG AGRI in co-operation with external experts. They originate from various sources: agricultural and economic administrations and related research institutes (of which USD A, ERS), biotech companies, seed associations or seed companies, scientific reviews, news agencies and private consultants (of which ISAAA[1] and SPARKS) .

The main objective was to obtain a dataset which was as coherent as possible, offering a good comparability of data. ISAAA seemed to be recognised by most of the GMO specialists as a consistent and comprehensive source of data. However, ISAAA data have been confronted and complemented with other sources.

Despite all efforts to create a coherent, reliable and up to date dataset, all figures presented in this report should be interpreted with care, certainly for Chinese figures and for the 2000 projections. Indeed, most of the data are based on sales of seeds and not on area surveys which can lead to a bias.

1.1. Development of GM crops: a global picture

Analysis was restricted to studying the sowings of five transgenic crops which are covered by a EU Common Market Organisation (CMO), soybeans, corn, rapeseed, cotton and tobacco respectively. Figures concerning areas planted with GM potatoes are also provided. Research on genetically modified crops[2] started in the eighties but sales of first commodity seeds began only in the midnineties. The first significant sowings of GM crops (2.6 Mio ha) took place in 1996 and almost exclusively in the US[3]. Since 1996, the areas have increased dramatically to reach 41.5 Million hectares - Mio ha - in 1999. Adoption rates for transgenic crops are in some countries the highest for new technologies by agricultural industry standards, much faster than has been the case for hybrids. Of the 41.5 Mio ha sown in 1999, 53% were soybeans, 27% com, 9% cotton, 8% rapeseed, 2% tobacco and 0.1% potatoes. Figures 1 and 2 show respectively the development of the GM crops between 1996 and 1999 and their share in the 1999 GM area.

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1 ISAAA international Service for the Acquisition of Agri-Biotech Applications is a not-for-profit international organisation co-sponsored by public and private institutions that facilitate the transfer of agri-biotech applications from industrial to developing countries for their benefit. ISAAA produces each year a global review of commercialised transgenic crops, which contains reliable data on GM area.

2 We do not consider here GM "products" for medical purpose.

3 Since end of the eighties, China has a considerable area of GM tobacco of about 1 Mio ha. This technology is "home made" and is not linked with Western biotech companies.

Table 1.1 Development of GM area by crop

Mio ha	1996	1997	1998	1999	2000(e)	1999 in %
SOYA	0.45	5.04	13.59	21.78	22.49	52.5%
CORN	0.30	2.61	9.11	11.28	10.53	27.2%
RAPESEED	0.11	1.42	2.43	3.46	3.12	8.4%
POTATOES	0.01	0.01	0.03	0.04	0.04	0.1%
COTTON	0.73	1.43	2.46	3.92	4.90	9.4%
TOBACCO	1.00	1.00	1.00	1.00	1.00	2.4%
TOTAL	**2.60**	**11.51**	**28.62**	**41.48**	**42.08**	100.0%

Figure 1.1
Development of GM Area

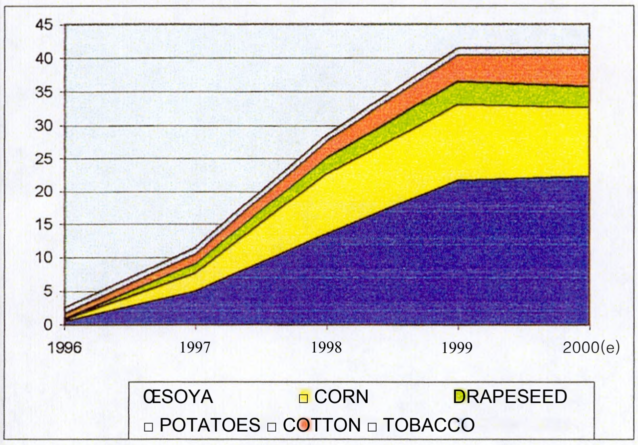
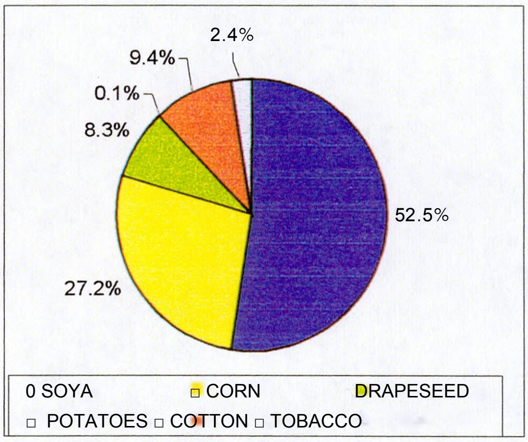


Figure 1.2
1999 Share of GM Crops in%



As shown in table 1.2 and in figures 1.3 and 1.4, most of the GM crops are sown on the American continent, 96% of the total in 1999. Australasia follows with 3.8% whereas Europe and Africa represent together around 0.1%.

Table 1.2 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%

The US have by far the most important area (29 Mio ha) of GM crops, around 70% of the total, followed by Argentina (5.8 Mio ha or 14%) and Canada (4 Mio ha or >9%). In China (3%), the GM tobacco area ranks between 1 and 1.3 Mio ha, depending on the sources, whereas they started limited sowings of GM cotton in 1998. In Europe, Spain ranks first with around 10000 ha followed by Romania with 2000 ha and France, Portugal and Ukraine at just 1000 ha.

About Argentina and Brazil

Following a Court ruling, sowings of GM crops are not allowed in Brazil and public authorities are committed to control it. However, certain sources mentioned that at least 10% of their soybean area in 1999 was GM. The GM area would be located south and the seeds would be fraudulently imported from Argentina. ISAAA does not give figures for Brazil and that is the reason why their total GM area in Argentina is higher than the one reported here, which is based on figures from the Argentinean "Dirección de Economia Agraria" and from the Argentinean seed association.

For that reason, '1999 seeds were reallocated to Brazil to cover 1.2 Mio ha. The total of Argentinean and Brazilian soybean area of this report (7 Mio ha) is close to ISAAA figure for Argentina (6.4 Mio ha).

Figure 1.3
Development of GM area by country

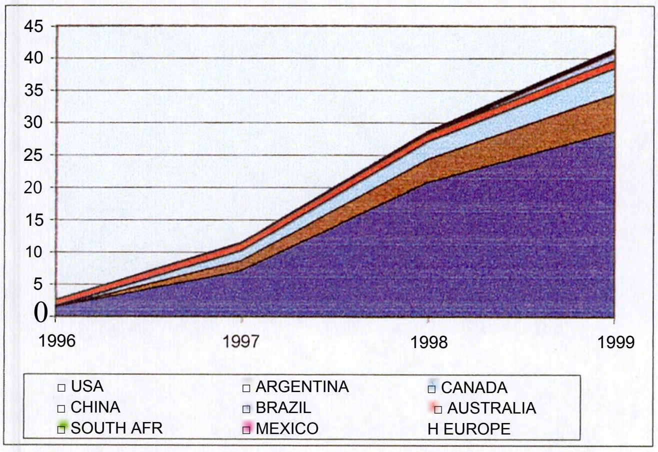
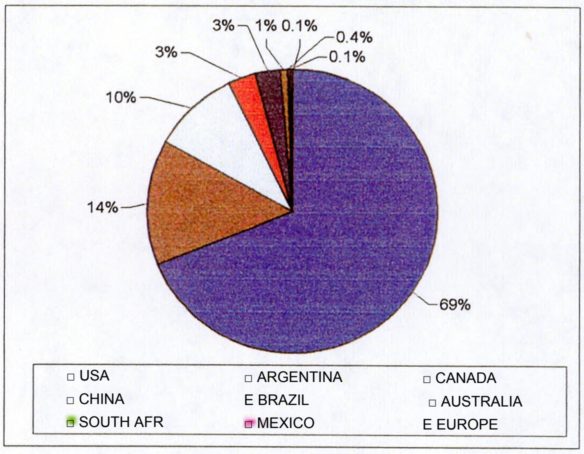


Figure 1.4
1999 Share of GM by country in%

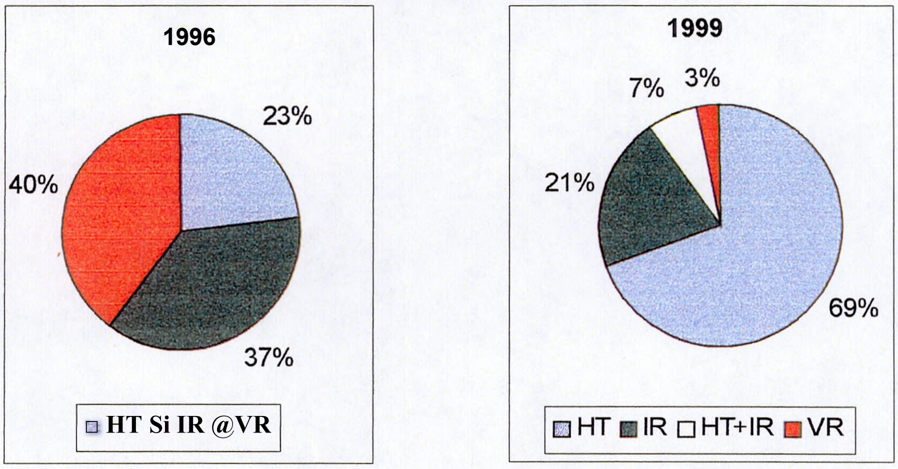


Of the 41.5 Mio ha sown with transgenic crops in 1999, the distribution of traits is as follows.

- Ranked first is the herbicide tolerant (HT) GM crop with 69% of total,
- followed by 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%.

This is quite the same order as in 1998 but with an increase of crops containing both genes, the herbicide tolerant and insect resistant. However, this is an important shift compared with 1996 where virus resistant GM represented 40% of total, insect resistant 37% and herbicide tolerant only 23%. This is mainly due to the dramatic increase in HT soybeans.

Figure 1.5 Share of GM traits in 1996 and 1999



TRAITS of Present GM crops	
The present "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[4] into a plant enables farmers to spray wide spectrum herbicides on their fields killing all plants but GM's. For that reason, the new GM seeds opened new markets for both products. In fact, these crops contain a slightly modified growth-regulating enzyme that is immune to the effects of the active ingredient and allow it to be applied directly on the crops and kill all the plants not possessing this gene.
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. 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 com/maize protects against the "European" com/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 ha in Canada and the USA. It concerns high oleic soybeans, high oleic canola/rapeseed and laurate canola. More explanations are given in chapter 1.3 "In the pipeline: quality/outputs traits crops"

[4] The gene introduced is either glyphosphate or glufosinate herbicide-tolerant

Providing early estimates for the 2000 sowings of GM seeds proves difficult. 1999 was a turning point as far as demand is concerned, as explained in chapter 4. In Europe, as well as in some Asian countries, many food suppliers took a restrictive stance on GM food. In the US, some export- oriented food processors are considering segregating GM and non-GM crops. Whether, and to what extent, these recent developments on the demand side will have a feed back effect on 2000 GM sowings remains a controversial issue. In early 2000, first indications could be found in various sources, but they point to divergent directions.

Given the contradictory signals by the time of closure of the report (end of March 2000), an own approach has been adopted for estimating the 2000 GM sowings indicated in tables 1.1. First, the latest USD A previsions for 2000 sowings of soybeans, com and rapeseed in the main producing countries have been recorded. For the US, the USDA prospective plantings are based on farmers' surveys carried out in early March. This first step allows for taking into account various factors which are influencing farmers' planting decisions, in particular expected commodity prices. Second, an estimated percentage for areas under GM crops is applied to these USDA forecasts. This percentage is based on "expert judgement". It takes into account the results and developments outlined in the present report. First, results concerning the profitability of GM crops are mixed, depending on varieties, growing conditions, prices etc. Second, developments on the demand side are expected to have a cascading effect backward in the food chain, up to farmers. However, this effect still is of limited and variable magnitude. The lack of non-GM seeds might be a factor limiting a potential move back to conventional crops.

As a result, the GM area for 2000 is forecast to plateau just above 42 Mio ha. Further specifications by type of crops are given below in chapter 1.2.

1.2. GM crops grown on a commercial basis: input-oriented

A detailed picture is provided for the main GM crops which are grown on a commercial basis. These crops are ranked according to the importance of areas under cultivation. Soya and corn account for 80% of GM areas world-wide.

1.2.1. Soybeans

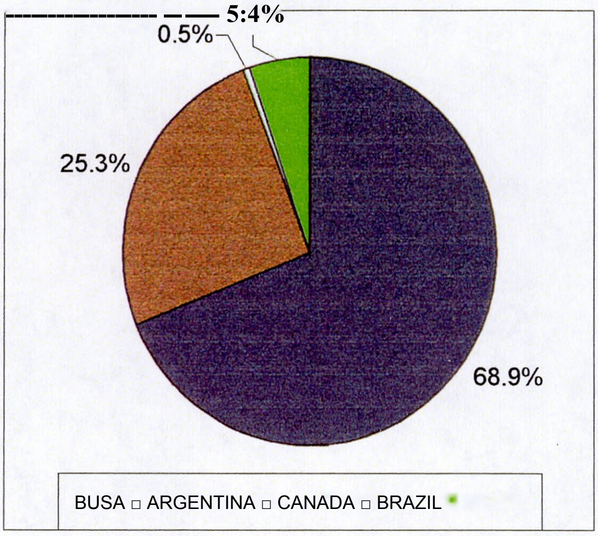
Commercialised GM soybeans were first sown in 1996 in 2 countries, the USA and Argentina and represented respectively 1.6 and 0.8% of their total soybean area.

Table 1.3 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 sowings accounted for nearly 22 Mio ha or more than 52% of total GM sowings. With this area, GM soybean represents 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 soybean[5]), 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. Figure 1.6 shows the geographic breakdown of GM soybean area in 1999.

Figure 1.6 Geographic breakdown of GM soybean area in 1999



Almost all GM soybeans are herbicide tolerant (HT). HT crops allow for increased flexibility in growing practices. This "convenience effect" appears to be a driving force for the quick adoption of HT soybeans by farmers. On the demand side, the main soybeans producing countries are dependent on exports, in particular on the European and the Japanese markets. Reluctance against GM food on these markets might have an incidence on growers' and handlers' decisions. However, feed uses are the main outlets for exported soybeans/meals (see chapter 4) and no firm stance has been taken up to now on the feed issue.

Given these factors of uncertainty, a conservative assumption has been adopted for the estimated areas under GM soybeans in 2000. Depending on countries, this percentage is estimated to remain unchanged, or to decline slightly. However, as USD A forecasts a global increase in areas sown to soybeans, a merely unchanged share of GM applied on this basis means an increase in absolute terms. In particular, in the US, the total soybean area is expected to reach an unrecorded level of 30 Mio ha. Hence, the world area sown to GM soybeans in 2000 is forecast to increase by 3%, reaching 22.5 Mio ha.

5 In late 1999, the USDA revised upwards the total soybeans area for 1999. However, no indication was given as to changes for areas under GM varieties. In addition, the USDA initial estimation for the share of GM soybeans (57%) covered major producing States and included non-GM herbicide tolerant varieties. The forecasted share for 2000 (52%) only covers GM HT varieties. For these reasons, own estimates have been adopted for 1999 and 2000.

1.2.2. Corn

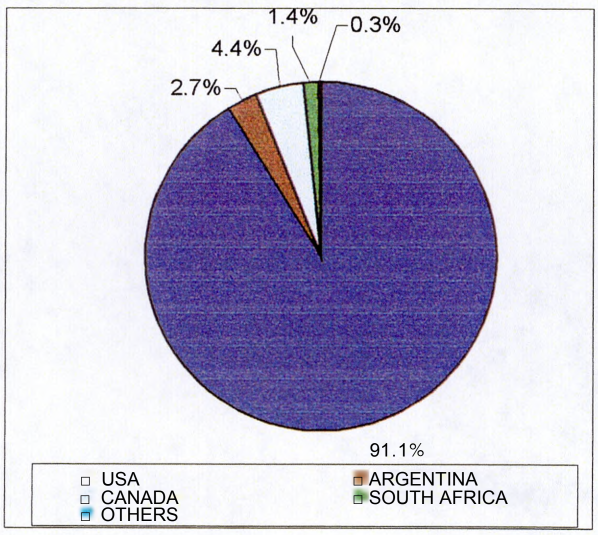
First sowings of GM corn took place in 1996 exclusively in North America, 0.3 Mio ha in USA and 0.001 Mio ha in Canada and represented respectively 1% and 0.1% of their corn area.

Table 1.4 Development of GM corn area

Mio ha	1996	1997	1998	1999	2000 (e)	GM %099)
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 com sowings accounted for more than 11 Mio ha and 27% of total GM sowings. With this area, GM com represents about 8% of world total corn area and 28% of area of countries producing GM com. Most of the areas are located in USA (10.3 Mio ha or 36% of US corn), 0.3 Mio ha in Argentina (11% of Argentinean corn), 0.5 in Canada (44% of Canadian com) and a few thousands of ha in Spain, France and Portugal. Figure 1.7 shows the geographic breakdown of GM corn area in 1999.

Figure 1.7 Geographic breakdown of GM corn area in 1999



Two thirds of corn area or nearly 8 Mio ha are insect resistant (Bt-corn), about 2 Mio ha is herbicide tolerant corn and around another 2 Mio ha of corn contain both genes.

Herbicide Tolerant corn was introduced onto the US market in 1998. However, experts (USDA) do not expect a development as fast as for HT soybeans.

There is evidence about yield gains for Bt corn, however, its profitability depends on different factors, in particular the degree of infestation and market prices. In addition, farmers are required to set up refuges (ie non-Bt areas to prevent resistance) for at least 20% of their Bt-area. For these reasons, the share of GM corn in US areas is forecast to decrease in 2000. Based on surveys carried out in early March, the USDA estimates that GM corn sowings in major producing States are down by 25% compared to 1999. By contrast, according to various sources, the share of GM Com is forecasted to increase in Argentina, as well as in South Africa. All in all, the world area under GM com in 2000 is estimated to decline to 10.5 Mio ha.

1.2.3. Cotton

First sowings of GM cotton (0.7 Mio ha) took place in 1996 in the USA and represented 12% of their total cotton area.

Table 1.5 Development of GM cotton area

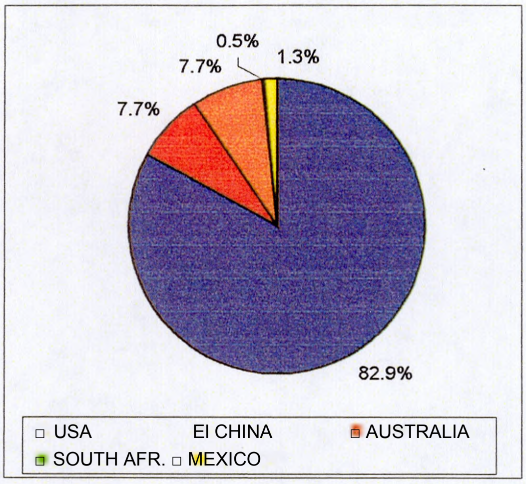
Mio ha	1996	1997	1998	1999	2000 (e)	GM %('99)
USA	0.73	1.23	2.00	3.25		55%
CHINA			0.10	0.30		8%
AUSTRALIA		0.20	0.30	0.30		79%
SOUTH AFR.			0.01	0.02		13%
MEXICO			0.05	0.05		25%
TOTAL	**0.73**	**1.43**	**2.46**	**3.92**	**4.9**	**38%**

In 1999, GM cotton sowings accounted for nearly 4 Mio ha or nearly 10% of total GM sowings. With this area, GM cotton represents about 12% of world total cotton area and 38% of area of countries producing GM cotton. Most of the area is located in USA (3.2 Mio ha or 55% of US cotton), 0.3 Mio ha in China, 0.3 in Australia (three quarter of Australian cotton) and less than 0.1 Mio ha in Mexico and South Africa. Figure 1.8 shows the geographic breakdown of GM cotton area in 1999.

A Member of the European Parliament (MEP) has recently raised questions[6] about GM seeds being included in import consignments of traditional cottonseed. No authorisation has been granted so far for placing GM cotton on the EU market. Hence imports or growing of GM seeds are not allowed in the EU. The question raised by the MEP deserves further checks and should be addressed in the process of revision and completion of the EU seed regulation.

6 **Oral Question H-0345/00 and written question P-l 169/00**

Figure 1.8 Geographic breakdown of GM cotton area in 1999



More than 40% of the 4 Mio ha is herbicide tolerant, one third is BT cotton and the remainder (more than 20%) contains both genes.

In 2000, the GM cotton area is forecast to increase up to nearly 5 Mio ha. Most of this expansion is expected to take place in China, where there has been a three-fold increase. In the US, the USD A has observed significant increases in yields for Bt cotton, and its profitability also appears to be higher. Based on March surveys, the USD A foresees a decrease in the share of areas under GM cotton in major producing States, but a high rate in other producing States. In addition, a 5% increase in total cotton plantings is expected. These developments lead to a significant increase in the area under GM cotton, both in China and in the US (+25% world-wide).

1.2.4. Rape seed

First sowings of GM rapeseed[7] took place in 1996 exclusively in North America, 0.1 Mio ha in Canada and less than 0.01 Mio ha in USA and represented respectively 3% and 5% of their rapeseed area.

Table 1.6 Development of GM rapeseed area

Mio ha	1996	1997	1998	1999	2000 (e)	1999 in %
USA	0.01	0.02	0.03	0.06		15%
CANADA	0.10	1.40	2.40	3.40		61%
TOTAL	0.11	**1.42**	**2.43**	**3.46**	**3.1**	58%

In 1999, GM rapeseed sowings accounted for nearly 3.5 Mio ha or about 8% of total GM sowings. With this area, GM rapeseed represents about 13% of world total rapeseed area. The area is located in Canada (3.4 Mio ha or two third of Canadian rapeseed, ie Canola), and in the USA (0.06 Mio ha or 15% of US rapeseed).

All GM rapeseed is herbicide tolerant.

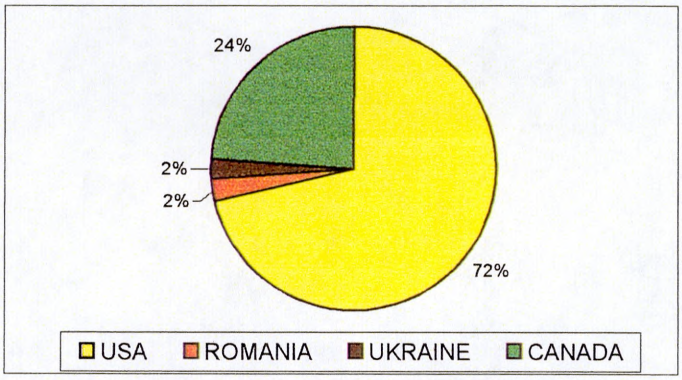
[7] The North-American rapeseed varieties are called canola.

For 2000, the share of GM rapeseed is expected to rise in the US (alongside with a significant increase in total rapeseed plantings) and to remain at its 1999 level in Canada. As total sowings in Canada are down, this translates into a decline in GM areas to 3 Mio ha.

1.2.5. Potatoes

GM potatoes represented in 1999 about 40 000 ha. Sowings took place in the USA (30 000 ha), Canada (10 000 ha), Romania (1 000 ha) and Ukraine (1 000 ha). The GM potato contains either a virus or an insect resistance trait.

Figure 1.9 Geographic breakdown of GM potato area in 1999



1.2.6. Tobacco

GM tobacco is exclusively sown in China and contains a virus resistance trait. The area reported is about 1 Mio ha or 2.3% of total GM area.

1.3. In the pipeline: quality/output traits crops

In the short term, the main improvement will result from inserting 2 genes in one cell ("stacked traits"). This is already the case for GM crops containing both the insect resistant and the herbicide tolerant genes.

In the medium term, traits will still be input-oriented, but they should be extended to new varieties, of which sugarbeet, rice, potato and wheat. New virus-resistant varieties are expected to be introduced on the market in particular for fruit, vegetables and wheat. Also fungus resistant crops are in the pipeline and this concerns fruit and vegetables, potato and again wheat. Nevertheless, in the medium term, the same crops as today will have the lead, that means soybeans, corn, rapeseed, cotton, tomato and potato.

In the longer term, new value-enhanced or output-oriented traits are likely to develop among field crops, mostly created through biotechnology. However to succeed, the products must be able to deliver not just improved quality, but also good agronomic performance. By contrast with first generation GM crops where farmers expected a direct impact on their use of pesticides and herbicides (in order to diminish their input costs), the adoption rate of the new generation may proceed more slowly. In addition, some of the value enhanced GM crops will be limited to niche markets (see chapter 4).

Nevertheless, the new generation of GMs is developed in order to provide benefits for food processors and/or for consumers. Hence, the adoption by the consumers could be less conflictory.

GMOs also have potential in the non-food sector. One innovative example is that of *Cynara Cardunculus-thistle* grown in Spain for electricity generation. Also GM poplars have been developed in France for paper production which demand less energy and produce less waste during processing. Oil and carbohydrate crops also offer opportunities in the chemical sector. An example is high-erucic rapeseeds used for fuel, lubricants and plastics.

The table below provides an overview of some leading developments. Of course, this list is not exhaustive.

Table 1.7 Quality traits in the pipeline

Soybeans 1. *high oleic soybeans* **: this variety contains less saturated fat than conventional soybean oil. Moreover, this variety is more stable and requires no hydrogenation for use in frying or spraying. For that reason, this variety has a "health" image.** 2. *soybeans with improved nutritional traits for animals* **: this variety contains higher levels of 2 amino acids (lysine and methionine) which will reduce the proportion of higher cost protein meals in the preparation of feed mixes.** 3. *high-sucrose soybeans* **: this is one of the new varieties introduced to improve food quality. This variety has a better taste and a greater digestibility.**
Rapeseed/Canola 1. *High-lauric variety* **produces an oil containing 40% of lauric acid for chemical and cosmetic purposes.** 2. *High-stearate variety* **produces oil high in stearic acid, solid at room temperature without hydrogenation. It would be used for baking, margarine and confectionery foods that cannot use liquid oils.**
Corn **Several researches, both conventional and biotech, aim to produce** *value-enhanced corn* **that will offer improved nutritional traits for livestock. Since grain is fed primarily as a source of energy, many of the new value-enhanced varieties aim to increase the content or availability of energy . But some new varieties will also include more protein and better amino acid balances, which would reduce the need to buy supplemental feed ingredients.**
Cotton *Coloured cotton* **is already available on a niche market basis. This trait would reduce the need for chemical dyes.** *Fibre quality improvement,* **such as polyester-type traits, would make sturdier fabrics.** **Chinese researchers are breeding a new strain of cotton that includes** *rabbit keratin.* **Fibres of this cotton are longer and more resilient and they have an increased ability to maintain warmth.** **Research is also carried out to develop** *wrinkle-resistant* **cotton and even** *fire-retardant* **qualities.**
Nutraceuticals **The real bright prospect for GM is to produce varieties that could provide immunity to a disease or improve the health characteristics of traditional food, like** *canola oil with high-beta carotene content* **or** *vitamin A supplemented rice.* **This 3rd generation of GM called nutraceuticals or "functional foods" is designed to produce medicinal qualities and/or food supplements within the plant.**

2. BIOTECH COMPANIES: A SUPPLY-ORIENTED STRATEGY

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 amplify biotechnology for agriculture.

2.1. From start-ups to global ''life sciences" companies

Joly (1998) has analysed developments in the strategy of agri-biotech firms, from the early eighties up to 1998. Based on his approach, three stages can be identified, as illustrated in the following summary table.

Table 2.1 Stages in development of the agri-biotech industry

Years	Stage	Developments
1983-1994	Exploratory	Spin-off, from Universities to SME's start-up SME's late 80/early 90. economic and financial difficulties.
1994-1998	Consolidation	Emerging life sciences trans-national companies progressively buy: a) biotech SME's b) seed companies.
1998-?	Adding value	Biotech industry seeking new agreements: a) with research/development partners b) with food processors

Source: based on Joly, 1998

2.1. 1. 1983-1994: the Pioneers

The first successful breakthroughs in agri-biotechnology were achieved in the mid-nineteen eighties. Small and medium sized enterprises (SME), acting as start-ups, have had an active role in initial developments, both in the United States and in Europe. Due to financial (1987 Crash on Wall Street) and economic (Early Nineties in EU) crisis, these SME's had experienced difficulties in finding sources of financing. Many of them have been bought up by the emerging "life sciences industries. A typical example is Plant Genetic Systems (PGS), a European (B) small enterprise, which succeeded in 1985 to integrate Bt genetic material into a tobacco plant. In 1996, AgrEvo, the newly formed merger between Hoechst and Schering bought PGS.

2.1.2. 1994-1998: Consolidation across the board

Life sciences industries had experience in biotechnology, but for most part, this was limited to pharmaceutical applications. They were, however, able to transfer this knowledge to the area of agri-biotechnology and/or to take on board the experience of the start-up SME's. In addition to creating common platforms for research and development, they were in a position to implement and amplify agri-biotechnology, on the basis of their plant protection activity. While pharmaceutical markets are more or less narrow, with national specifications, the markets for agro-chemicals are wider and trans-national, even if authorisation procedures are somewhat different from one country or group of countries to another. Experience of the life sciences industries in **authorisation procedures, in patenting and also in introduction to the market** has been another key factor for the extension of their biotech activities.

Authorisation procedures for medicines, pesticides and GM crops are very different. According to Seralini (1998), if tests on mammals were required in the authorisation procedures for GM crops, as it is the case for pesticides, GM crops would not be profitable for biotech firms. For the sake of improved safety assessment, Seralini pledges for systematic tests on mammals, as GM crops which are on the market or which are under scrutiny for authorisation are mainly pesticide-like crops, ie herbicide tolerant or insecticide-producing crops.

Patenting and origin of biotechnology

Patenting of agri-biotechnology and the breakdown between private and public research have become new issues. Like previous agricultural innovations (mechanisation, chemicals...), biotechnology is industry-driven. However, biotechnology uses and modifies living organisms. It has been developed by life science industries, while impetus in conventional breeding had been initiated by public research. This translates into new patenting rules on plants: patents on GMOs are very different from traditional "obtainers' rights". Crop varieties obtained through conventional breeding can only be produced and sold by their "obtainers", but other seed companies can use these crops for further genetic improvement (breeders' exemption).

Patents on biotechnology were first introduced in the US, following a 1980 ruling of the Supreme Court, which authorised patents on living organisms. According to Joly, in 1993, US firms owned 70% of the world patents on plants. Biotech patents apply to the "genetic event", that is to say, to the transformation which has been introduced in the plant. They protect the private origin of the technology. In some cases; technological fees charged by biotech companies when selling their genes or GM-seeds allow for remunerating the new technology or trait.

The legal framework applying to patenting of biotechnology within the EU is complex. The European Parliament and the Council adopted in June 1998 a Directive addressing the legal protection of biotechnology[8]. This Directive foresees several exemptions, in particular for human body, plant varieties and animal breeding. It also takes over farmers' exemption: farmers are allowed to save GM seeds for the purpose of own production. In principle, no patent can be obtained for plant varieties, only for inventions (transformation event) relating to them. Plant varieties are covered by a specific regulation which includes breeders and farmers' exemption. However, the European Patent Office has recently indicated that patents on plants and animal are not excluded by the European Patent Convention. This issue is controversial and deserves further analysis.

Firms considered that patents were not protective enough, because of possible overlaps. For example, there are many types of Bt transformation events. As a result, in addition to patents, registered trade names are usually used to further protect and identify the new technology. Quite often trade names of GM seeds refer to corresponding agro-chemicals, in particular for herbicide tolerant crops. Typical examples are Liberty Link and Round Up Ready crops. Patents on herbicide tolerance are often seen as a way to prolong the effect of expired patents on herbicides. These examples of combined products illustrate the importance of another synergy between biotech and crop protection activities. Many biotech firms are selling both the GM technology/seed and the agro-chemical product to which it is combined. It allows for "technology-package" or combined marketing, including adjusting prices of both products and using the existing distribution and consulting channels for crop protection products.

Beginning in the last quarter of 1995 up to the first half of 1999 the life sciences sector has been characterised by a large number of mergers, acquisitions and joint ventures.

Four of the important factors that are driving this consolidation process 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.

*** Directive 98/44/CE OJ L 213 of 30.7.1998**

- Closely linked to the above point are economies of scale in research and development in the area of agrigenomics[9], 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.

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. Concentration has diffused from the agro-chemical sector to the seed sector as key "life science" players have become leaders in both fields, (see section 2.2).

2.1.3. 1998- ? Preparing for adding value

While carrying out further research on second-generation GM plants, which will include quality traits, biotech firms have adopted a commercial strategy for preparing the introduction of these new generation plants.

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. The food industry is in a key position. In Europe, many food processors are trying to avoid GM ingredients because of consumer reluctance.

Significant changes in the biotech sector have occurred in 1999. Growing consumer concern, extended public debate and food suppliers' initiatives have had a feed-back effect on the biotech industry. There has been a gradual slowdown in mergers and a shift towards joint ventures or agreements with genomic research firms or institutes. Some biotech companies have also offered to make their technology or experience available to public research centres, in particular for developing countries (several examples with GM rice). By doing so, these firms are trying to respond to public criticism and to improve their strategy and image.

Another significant change is the separation of the pharma and agri-biotech activities of some leading biotech companies. This might represent the start of a new phase in restructuring the agri-biotechnology sector, the move away from a "global life sciences" strategy.

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[9] **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.**

AstraZeneca PLC and Novartis AG have agreed to spin off and merge "Zeneca Agrochemicals" and "Novartis' Agribusiness" to create Syngenta. If implemented, this agreement will effectively mean a departure from the life sciences strategy that had been pursued by both companies and a move in the direction of "pure play" agribusiness with a high priority given to programs in gene technology and agrigenomics.

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.

The separation between pharma- and agri-biotech businesses echoes the gap in public acceptance between these two areas of biotechnology. It also echoes the difference in profitability and can mean that synergies between pharma and agri-businesses might not be as optimal as expected.

2.2. Biotechnology has increased concentration throughout the agri-food sector

2.2.1. Crop protection was already a highly concentrated sector

Generally, the share of biotechnology in the agri-business part of life sciences industries is not indicated in financial reports or in publications. The share of **agriculture in life sciences activities provides a first identification of agro-**chemical and agri-biotech companies, as indicated in table 2.2.

Table 2.2 Importance of agriculture within ''life sciences" business

Company	Estimated % of total sales for the agri-business section, 1998
AgrEvo	100%
Monsanto	47%
Novartis	26%
Rhone-Poulenc	19%
Astra-Zeneca	18%
DuPont	13%
Dow Chemical (agri subsidiary is Dow Agrosciences)	9%

Source : own compilation, based on financial reports of the firms

These seven companies are the main players for agri-biotechnology as well as for crop protection. Novartis, Monsanto, DuPont, Zeneca, AgrEvo and Rhône-Poulenc (which have now merged to create Aventis) form the top 6 of crop protection sales, as shown in table 2.3.

Table 2.3 Top 10 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.

According to RAF I (Rural Advancement Foundation International, 1999), these top 10 companies accounted for as much as 80% to 90% of the world market for agro-chemicals in 1997/98.

2.2.2. With biotech, concentration has spread to the seed market

In the early nineties, the concentration rate in the seed sector was not as high as for agro-chemicals. According to Joly, in 1994, the Top 12 of the seed industry accounted for 20% of the world market in seeds. RAFI estimates that the Top 3 now controls 20% of the market. The commercialisation of GM seeds that began in 1996 resulted in a series of mergers, acquisitions and alliances between gene providers and some of the major seed companies. Many of the major agri-biotechnology companies now have access to the seed market in which they can market their biotech products.

Based on Investext Broker reports (in Roberts, 1999), table 2.4 provides a brief overview of the major seed companies acquired by large agri-biotechnology companies. As can be seen from the table, DuPont and Monsanto have the broadest access to the seeds markets. At the opposite end of the spectrum, Rhône-Poulenc's strategy has been to invest heavily in the genomics in order to develop traits without making the costly investment in acquiring a seed company.

Table 2.4 A selection of agri-biotechnology companies with access to seed markets in 1999

Agri-biotech company	Seed company acquired	Corn	Soy beans	Other oilseed	Cotton
AgrEvo	Cargill	X			
	Metía Pesquisa	X			
	Sementes Ribeiral	X			
	Sementes Fartura	X		X	
	Biogentic Technologies B.V. (BGT)	X			
Zeneca	Garst (50%)	X			
Novartis	Northrup King	X			
	Eridania Beghin			X	
DuPont	Pioneer	X	X	X	
	Protein Technologies International		X		
Dow	Mycogen	X	X	X	
Monsanto	DeKalb	X	X		
	Asgrow	X	X		
	Holden's	X	X		X
	Delta & Pine Land [10]				X
	Calgene				X
	Stoneville				

Source: Wood Me Kenzie, Merill Lynch in Roberts, February 1999

Biotech firms have adopted different strategies with regard to commercialisation of seeds. Some are mainly commercialising their GM-products via their seed subsidiaries. Others have concluded agreements with seed companies. In the framework of such agreements and generally against payment of a technological fee, biotech companies are selling their GM-products to seed companies. The latter integrate the genes of interest in the germplasm of their leader varieties, via conventional breeding or back-crosses. This allows for further improvements in the performance of GM-crops. The availability of germplasms with characteristics which are adapted to local conditions or demand is also a key factor. In this respect, breeders as well as small and medium-sized seed companies still have a role to play. For this reason, many agreements concerning seeds are implemented on a regional/national basis. While there is a global consolidation in the seed sector, there is still a regional/national dimension.

The case of Limagrain, a French group which ranks among the world top-5 of seed companies, is illustrative. While being a world leader in seeds, this group has kept a strong regional implantation (Centre France). It has developed on the basis of a 50 year-old farmers' co-operative and is independent from the main life-sciences players. It holds various subsidiaries. Limagrain Genetics international is active in seed business in Europe and Northern America for arable crops and another subsidiary (Vilmorin) is a leader for vegetable seeds. Other subsidiaries of Limagrain produce food

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[10] **In early 2000, Monsanto announced that it would give up this acquisition plan, following an examination under the anti-trust law. and/or in the context of its merger with Pharmacia UJ.**

ingredients and bread. Limagrain has developed biotechnology as a mean to meet processor and consumer specific needs, in the framework of organised supply chains. In response to demand for non-GM seeds and crops in Europe and in Japan, Limagrain has also organised non-GM maize supply chains. Limagrain sells GM seeds in Northern America, but not yet in Europe. (Limagrain, 1999).

Biotechnology has increased concentration in the seed sector, as if the existing concentration in the agro-chemical sector had spread to the seed sector. Table 2.5 gives a breakdown of the sales of the worlds major seed corporations. Care should be exercised when interpreting the figures as these can change quite rapidly as consolidation continues apace. At the beginning of 1999, according to RAFI, the Top 10 of the seed industry controlled around 30% of the world market.

Just four companies (DuPont/Pioneer, Monsanto, Novartis and Dow) controlled at least 69% of the North American corn seed market. The same four companies control 47% of the American soybean seed market.

Table 2.5 The World's Top 10 Seed Corporations by Sales Value (1997 Revenue US Millions)

(1) DuPont/Pioneer Hi-Bred International (US)
Sales US $1,800
DuPont now has a 100% stake in Pioneer Hi-Bred

(2) Monsanto (US)
Sales US $1,800 Estimate
Estimate of total sales volumes of all Monsanto seed acquisitions made by October 1998

(3) Novartis (Switzerland)
Sales US $928
Formerly Ciba Geigy and Sandoz

(4) Groupe Limagrain (France)
Sales US $686
French co-operative

(5) Advanta (UK and Netherlands)
Sales US $437
Owned by AstraZeneca and Royal Van derHave

(6) Agri Biotech, Inc. (US)
Sales US $425
The company has completed over 30 acquisitions (forage and turfgrass) since 1995

(7) Group Pulsar/Seminis/ELM (Mexico)
Sales US $375
Pulsar is a giant agro-industrial corporation that owns Empresas La Moderna, majority shareholder of Seminis, Inc.

(8) Sakata (Japan)
Sales US $349
Vegetable/flower/turfgrass

(9) KWS AG (Germany)
Sales US $329
Major sugar-beet seed company

(10) Takii (Japan)
Sales US $300 (estimate)
Privately-held

Source: RAFI

As a result of this consolidation process driven by biotechnology, there is an increased concentration on the input side of the farming sector. Life sciences companies form an oligopoly for supplying inputs for crop production, furthermore after having completed mergers or agreements with seed companies.

2.2.3. Various strategies: from input to output-oriented

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. The importance of agriculture within the life sciences business provides a first view of the position of the agri-biotech firms. Further elements have been taken into account to establish profiles and to assess the strategy of each of them. In particular, they have been considered from the upstream/downstream perspective with regard to agriculture. The aim is to assess whether firms had an input- or an output-oriented strategy. For example, if a company has built on the basis of an experience in crop protection and has heavily invested in the seed market, it is considered to be more input-oriented. Farmers are key customers for these firms. Conversely, if a firm has already developed quality-traits crops and has substantially invested downwards in the food chain, it is seen as output-oriented. Food processors are key customers, but farmers remain partners for growing the crops.

About profiles of the main biotech firms (see Appendix A)

The profiles of the main biotech-players have been established on the basis of key financial indicators (e.g. sales, acquisitions...) and factual information (e.g. products) available in their annual reports, on their internet sites, or in various press releases. Each single source is not quoted, but references to articles or publications analysing the strategy of biotech firms can be found in the bibliography.

There is no clear-cut border between input-oriented and output-oriented strategies.

In recent years, most of the biotech firms have implemented an input-oriented strategy, focused on the farm sector rather than on the food- processing sector. In their global life sciences strategy, they have failed anticipating differences in perceptions of science in various countries. They have overlooked the question of consumer acceptance and have underestimated the reactions of retailers and food processors. Market structures and organisation play a significant role. Retailers have a strong market power, in particular in Europe. The food processing industry is concentrated, in particular in the US.

The downstream side of the food chain will be of key importance for the next generation of GM crops. Many biotech firms already have quality-traits crops in their pipeline, and rely in the long run on an output-oriented strategy. Some quality-traits crops are already on the market. They are of interest for the feed and livestock industries as well as for the non-food sector. The US meat industry is already concentrated. Biotech is inducing further integration on the upstream side of this industry, acting as a possible vector between the crop and the livestock sector, via GM feedstuffs or animal health products **like vaccines.**

Heffeman (1999) analysed the "emerging clusters of firms that control the food system from gene to supermarket shelf[1]. He considered several clusters.

- Cargill/Monsanto. Cargill did not have access to GM seeds, thus it formed a joint-venture with Monsanto. In addition, Cargill enters a merger with Continental grain, one of the 4 major grain elevators in the US (together with Cargill, ADM and Bunge). This merger will bring them in a key position for exports, hence it is also illustrative of globalisation. Together, these three firms own a complete food cluster.
- Another cluster is the Novartis/ADM connection. It was established through the joint-venture between Novartis and Land O'Lakes to develop speciality com hybrids.
- Conagra provides the emblematic example of wide ranging clusters, "with diversified interests ranging from farm gate to dinner plate". Conagra is a leader in the US for grain milling, feeding stuffs, slaughtering and meat processing. One of its subsidiary, United Agri Products, is a leading distributor of crop production inputs: fertilisers, crop protection and seeds, including GM ones.
- A similar case is DuPont, a trans-national firm for which the activity spectrum is even wider, from "dirt to dinner plate", dirt referring to the chemical business of DuPont.

Biotech has already generated increased concentration on the input side of the crop sector. Considering the emerging "gene to supermarket" clusters, biotech finally appears as a driving force for vertical integration and for further consolidation throughout the agri-food sector, from the upstream to the downstream side. The position of farmers in this rapidly consolidating context is an issue of concern.

2.3. Consequences for farmers: increased dependency

With the development of biotech, farmers more and more depend on a limited number of suppliers for crop protection. In addition, farmers adopting biotechnology are confronted with several constraints.

GM seeds are often sold in the framework of contracts which generally preclude seed-saving by farmers. Some biotech companies have taken action against producers who attempt to save seeds, on the basis of "infringement of intellectual property rights" (Monsanto, 1998). Saving seeds for further sowings is a long-established tradition, at least for crops allowing for doing so (e.g. wheat, soybeans-25% of soybean seeds are estimated to be farm-saved).

Biotech firms have developed technologies that render GM crops sterile. The initial name, "Technology Protection System" has been turned into "terminator technology" by NGOs that have denounced the costs for farmers and the loss of independence. Faced with overall criticism, Monsanto announced in late 1999 that it would not implement the terminator technology. The Technology Protection/Terminator System had also been supported by public research (including by the USDA). Various reasons for justifying sterility of GM crops have been put forward, in particular protecting the research-value of GM seeds and limiting gene-flow into the environment.

When selling their technology, some biotech companies are charging a "technological fee". The technological fee is presented as a coverage for research costs and allows for a margin of profitability for biotech firms. 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.

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 com between biotech/seed firms and farmers. For Bt com, "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 com" and that "the likelihood of monopolistic pricing of the technology appears limited". For HT com, 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 for biotech firms. 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. The downstream side of the food chain is also quite concentrated, either at the level of food processors or at the retailing industry. In this context, farmers risk being "squeezed" between two (more or less) oligopolistic industries.

Heffeman (1999) 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 often 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. Farmers had strong expectations on the profitability of GM crops, in particular as regards yield and/or cost savings. However, as shown in section 3.2, GM crops do not prove to be significantly more profitable than conventional counterparts. Other factors than profitability play role. They are reviewed in section 3 .3.

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) com. Two Canadian studies on HT Canola[11] have also been taken into account.

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[11] 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.

3.1. Adoption of biotechnology by farmers: strong expectations

3.1.1. Profitability expectations mainly based on yields

Many surveys and studies have been carried out to assess reasons for adopting GM crops. They have confirmed that adoption of GM crops by farmers has been driven by profitability expectations.

According to an USDA survey (1997), the majority of farmers (50 to 75%) cited increase in yield as first reason for adoption. Savings in costs appear to be the second reason, mentioned by 20 to 40% of the respondents. This survey was conducted in 1997, only one or two years after the introduction of the first GM seeds on the US market. Therefore, it addressed farmers' expectations.

The quick rate of adoption in the first years is explained by the strong expectations of farmers as regards profitability. Whether they definitely adopt the new technology then depends on their degree of satisfaction, and in turn, on the effective profitability of the crop. Biotech firms have published encouraging results on the satisfaction rate of farmers having adopted GM crops (Monsanto, 1998).

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. Where labour or time is a restriction, this convenience effect has an economic impact. In the medium term, it should translate into increased labour productivity and savings in labour costs. In the long run, it might have an impact on farm restructuring, alongside with many other factors which play a role in this process.

The effective profitability of a GM crop can only be properly assessed on the basis of several years of cultivation and commercialisation. Several years have to be considered for two main reasons. First, many other factors have an impact on profitability. In particular, there are important yearly fluctuations in yields and prices. Second, effective profitability depends on developments on the supply and on the demand side.

The first generation of GM crops is input-oriented. The primary effects of this new technology were expected and observed on the supply side.

Bullock and Nitsi (1999) consider five possible effects of technical changes in the field of plant breeding:

1. Increase in the maximum yield
2. Increase of the economically optimal yield
3. Input-switching technical change, lowering the cost but yield neutral
4. Quality-enhancing technical change
5. Risk-reducing technical change.

According to these authors, Bt com falls under category 2, while Herbicide-Tolerant soybeans rather have a type-3 effect. Both types of effects imply a shift in farmers supply functions. Under given prices, farmers produce more. If the demand function remains unchanged, prices drop. Only type-4 technological change induces a structural change in the demand function, and possible increases in prices. When assessing the profitability for farmers and the economic impact of biotechnology on agri-food markets developments in supply and in demand have to be considered together. However, it appears that this has not always been the case, neither for farmers, nor for the leading biotech firms. Their approach has been supply-oriented.

3.1.2. The effect of agricultural policy: limiting price risk

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 com. The area under soybeans is expected to reach a record level in 2000, while prices are low. By mid-November 1999, the USD A 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.

3.1.3. Comparing the profitability of GM and non-GM crops proves difficult

Profitability is defined as the margin left over to farmers when costs have been deduced from receipts. The profitability of a GM crop is judged against corresponding conventional crops. Comparing the performance of both types of crops raises several methodological issues.

3.1.3.1. On the cost side: the input-effect of GM crops

Generally the cost comparison of GM crops and their conventional counterpart is limited to crop-specific costs, assuming that fixed costs are more or less the same.

GM seeds are sold at a higher price than conventional ones. The price wedge is mainly attributable to the value of GM technology or to the "technological fee". According to a Monsanto communication (1998), the technological fee reflects "the insect, weed, disease control value of the inserted gene, and a significant part of the fee is used for further research". This difference also reflects the fact that markets for GM and conventional seeds are separate. Furman Selz (1998) reports about premia observed on the US market in 1998: US $ 30 per bag of seeds for GM com and US $ 5 for GM soybeans seeds, which represents a 30% price-premium compared to non-GM seeds. They also give an indication on the average technological fee paid by seed companies to gene providers: US $ 27 (30% of GM seed price) per bag of com seeds and US $ 4.25 (21% of GM seed price) for soybean seeds. Despite of the technological fee, GM seeds appear to be more profitable than conventional ones for seed companies.

The above-mentioned convenience effect of GM crops allows for reduced or more flexible working requirements. However, the related savings in labour costs have not always been properly assessed. The valuation of family work is rarely broken down on a crop-specific basis. On the other hand, growing GM crops requires new management skills, growing practices and possible constraints. GM seeds are generally sold and sown in the context of contracts. These changes entail transaction and management costs, which are not easy to assess.

GM crops are expected to allow for cost-savings through reduced insect and weed control and/or to achieve higher yields. Under the assumption that the price of non-GM and GM crops is the same[12], the latter will become more profitable for farmers if the increased seed costs are offset by savings in weed and/or pest control costs and/or by higher yields.

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

3.1.3.2. On the receipt side: yields and prices

Yield is a key factor for profitability expectations and results. In fact, available figures on crop-specific costs are often broken down on an area basis, while prices are paid on a quantity basis. Based on yields, costs and prices are brought on a common basis, often per acre/ha. In other words, the effect of possible increase in yields is taken into account on the receipt side.

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. In other words, referring to Bullock's classification, they do not induce a type 1 (maximum yield) technical change. 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. Data about yields of GM crops are widely available, however, often specifications on factors which influence yields are missing, such as temperature[13], weed control applied etc.

The USD A (1999) has examined different factors affecting the adoption of GM crops. These include farm size, education and experience, location of the farm, use of production or marketing contracts. In the case of herbicide resistant soybeans, the USD A has concluded that "larger operations and more educated operators are more likely to use herbicide tolerant soybean seeds". 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. This study on factors of adoption served as a first step for assessing the impact of GM crop on farmers' returns and on the environment. It allowed for controlling statistically these exogenous factors and carrying out multivariate regressions for assessing aggregate impacts of GM-crops on yields, profitability and the environment. Results of this USD A study are indicated below, for each type of GM crop.

Another key factor on the receipt side is the market price of GM crops. In many profitability studies, prices of GM and non-GM crops are assumed to be equivalent. Most of the available studies are based on 1997 or 1998 data. In these first years of commercialisation of GM-crops, their impact on commodity prices has not been manifest or is difficult to assess. Different pricing developments between GM and non-GM crops have only been observed in 1999. However, very few market reviews report on a regular basis about such developments. The question of price premiums/discounts will be addressed in chapter 5.

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[13] **Glyphosate-resistant soybeans seem to be more vulnerable to high temperature than conventional or other GM soy varieties. BT-Cotton also seems to be sensitive on high temperature.**

A further issue would be the full assessment of costs and benefits of GM crops, including effects on welfare as well as non-market effects, particularly risk assessment and management. However, the studies reviewed below only cover on farm profitability in the short term.

3*2. Costs and benefits for farmers for selected GM crops

The results of various North-American publications on the profitability of GM crops are summarised hereafter. The review is limited to the two main crops under cultivation, respectively Herbicide Tolerant (HT) soybeans and Insect Resistant (Bt) com. In addition, some Canadian studies on rapeseed/Canola have also been included.

3.2.1. Herbicide Tolerant Soybeans

Three different types of GM soybeans have been authorised in the US. Two of them are tolerant to different herbicides. Soybeans tolerant to glyphosate, Monsanto's "Round up Ready"(RR) soybeans, have been on the market since 1996 and are the most widely grown (estimated 80% share in GM soybeans). The third one is a high oleic soybean variety.

3.2.1.1. Lower yields

One of the reasons for the rapid adoption of GM soybeans has been the expectation of a higher yield than for non-GM soybeans. A number of US research projects have addressed this issue. Results seem to indicate the reverse: in most field trials the GM crop shows lower yields than the non-GM crop, as indicated in the table below, in the case of Roundup Ready (RR) soybeans.

Table 3.1 Differences in yields between conventional and GM soybeans

States	Yield (t/ha)		Difference in % (RR- conventional)
	Conventional	Roundup Ready	
Illinois	3.90	4.04	+3.5%
Iowa	4.10	3.83	-7%
Michigan	4.44	4.30	-3%
Minnesota	4.44	4.10	-8%
Nebraska	3.90	3.43	- 12%
Ohio	4.04	3.90	-3%
South Dakota	3.30	2.96	- 10%
Wisconsin	4.77	4.64	-3%

Source: Benbrook, 1998, based on Oplinger

Similarly, according to Benbrook (1998) in South Minnesota, average performance of top yielding Roundup Ready soybean varieties was 3% lower than the top yielding conventional varieties, yet in Central Minnesota the yield drag was as much as 13% and in Southern Wisconsin 6%. While indicating lower yields in each case, these sub-regional results point to the great variability in yield performance.

In Kansas, the yield drag varied between 2 and 11% in favour of non-GM soybeans, as indicated by Hofer *et al.* (1998):

Table 3.2 Differences in yields between conventional and GM soybeans, Kansas

Location	Yield (bu/ac)		Yield (t/ha)		Difference (%)
	Conventional	Roundup ready	Conventional	Roundup ready	
Ashland Bottoms	57.1	52.1	3.84	3.50	-9%
Manhattan	35.6	34.8	2.39	2.34	-2%
Belleville	35	31.2	2.35	2.10	- 11%

Duffy & Ernst (1999) conducted a "cross sectional survey" among 800 farmers in Iowa, based on interviews and field observations. It was not a side by side observation of GM and non-GM crops and should provide reliable estimates at state level. The average yield reported was 3.43 t/ha for those farmers who grew non GM-soybeans versus 3.29 t/ha for those who grew GM-soybeans.

The USD A estimated, on the basis of the 1997 data, that the increased use of HT soybeans produced only a small global increase in yields.

One of the explanations given for the lower yield of GM-crops is that the GM-traits were initially not introduced in the top yielding varieties of soybean. Seed companies are now incorporating these traits in their yield-leading varieties. If this is indeed the case, then the yield drag should diminish in the coming years.

3.2.1.2. Reduced herbicide use and costs

In the 1960s herbicide use started to replace tillage and cultivation practices as a primary means of weed control. At that time, these were mainly pre-emergence herbicides.

The use of post-emergence herbicide in the production of soybean has been rising steadily since they became available in the 80s. In 1988, 44% of soybean acres were treated, by 1994 this share had risen to 72%. Quite often, they were used in combination with pre-emergence herbicides.

However these classical herbicides had a number of drawbacks:

- difficult management
- risk of crop damage
- **development of herbicide resistant weeds**
- some herbicides limit the possibility of crop rotation.

The emergence of GM-soybeans which are tolerant to glyphosate ("Roundup") has a significant impact on the use of other herbicides. For instance, the use of imazetaphyr ("Pursuit"), one of the most widely used post-emergence herbicides has declined from 44% of soybean acres in 1995 to 17% in 1998. The main advantages of using Roundup on HT soybeans are:

- a wider window of application, both in terms of stage of growth of soybeans and effective control of larger weeds,

- the easier management of weed control programs,

- the fact that there is no carry over, thus giving growers more rotation options.

The use of this product has increased drastically. In 1990, about 10% of all soybean acreage were treated with Roundup (at that stage used only as "bumdown" treatment). This figure has risen to 45% in 1998 (Carpenter & Gianessi* 1999). According to the USD A, the use of other synthetic herbicides have declined by a larger amount, and the net impact of increased cultivation of HT soybeans is a decrease in overall herbicide applications.

The cost of a program of Roundup on HT soybeans was 14.7 €/acre (36.6 €/ha) in 1998, compared to 12€/acre (29.8 €/ha) for a conventional program with pre-plant treatment alone, or 22.3€/acre (55.2 €/ha) for programs using other combinations).

However, due to emergence of resistance in the future additional treatments may be needed. From 1998 to 1999, an increase from 15 to 25% in terms of average pounds of Roundup/acre was observed. Benbrook reports an increase from 24 ounce/acre to 32-48 ounce/acre in the dose of Roundup Ultra required to gain adequate control of velvetleaf and ragweed species. This would clearly have an impact on the cost of GM crops.

Nevertheless, in the short term, the cost saving effect seems to be dominant. In the Duffy report, farmers who used GM crops reported spending nearly 30% less than those who grew non-GM soybeans. Reduced herbicide costs was listed by 27% of farmers as one of the reasons for planting GM crops. Furman Selz reports a 33 to 35 €/ha lower herbicide cost for HT soybeans.

Moreover, following the introduction of GM crops, there is a notable reduction in the price of weed control programs for non-GM crops. A University of Illinois study revealed that compared to 1995, the least expensive non-glyphosate herbicide program was between 4.5-6 €/acre (11-14.9 €/ha) cheaper in 1999. As indicated by Bullock *et al.* (1999), this means that non-adopters of HT crops might also benefit from an induced effect on cost savings.

3.2.1.3. Convenience effect

It is difficult to quantify the convenience effect of choosing HT crops. However, there are some clear advantages. For example:

- The ease of the glyphosate-herbicide use and the large time window for spraying, which increases flexibility.
- HT crops make the adoption of no-till or conservation tillage easier. According to Monsanto, in 1997, nearly half of the acres planted in RR soybeans are not tilled anymore. The absence or limitation of tillage implies lower use of crop-specific resources (labour, fuel etc). It is also considered to be more environmental friendly, in particular as it reduces soil erosion.

Indeed, in a survey by Duffy and Ernst, 12% of the farmers listed increased planting-flexibility as a reason for going for GM soybeans.

3.2.1.4. Increased seed price

Because of the "technology fee", seed for GM soybeans is more expensive than conventional seed. The Duffy and Ernst study showed a seed cost of 57 €/ha for GMO soybeans, versus 42 €/ha for non-GMO soybeans. This difference corresponds to the technology fee of 15 €/ha reported by Carpenter & Gianessi (1998). Other sources report somewhat lower figures, but still in the same order of magnitude 13.5 €/ha (University of Illinois, 1999) and 14 €/ha (Furman Selz, 1999). This means that, in average, GM soybeans seeds are 35% more expensive than conventional seeds.

3.2.1.5. No significant profitability effect?

At this stage, there are two counterbalancing elements in the growing of GM soybeans. On the one hand, seed prices Of GM crops are higher while yields (and thus, in a hypothesis of the same price for both variants, income) are lower, on the other hand, input costs are lower as well.

The Iowa survey (Duffy *et al*1999) showed that differences in costs and yields between GM and non-GM varieties do not result in significant differences in return on land and on labour (at price 5.27 US $/bu =172.9 €/t).

However, if HT soybeans allow for savings in labour through their convenience effect, the same return for less labour means an increase in income per working hour.

Table 3.3 Comparison of returns for GM and conventional soybeans

Crop	Yield (t/ha)	Seed Cost (€/ha)	Total cost (excluding land/labour) (€/ha)	Return on land/labour (€/ha)
GMO	3.295	57	254	320
Non-GMO	3.430	42	274	322

The costs (total costs excluding land and labour) for non-GM in the Duffy study are reported to be 8% higher than for GM-crops. However, these higher costs are offset by the higher yields.

Similarly, in simulations of the University of Illinois, the variable costs/acre for non-GM crops were estimated to be 6 to 8% higher than for GM crops. However, the assumption of no-yield drag made in this study seems not to hold, taken into account the results of different studies as indicated above.

The USD A has found no evidence of a significant change in variable profits in 1997, following the dramatic increase in GM soybeans sowings.

Before drawing definitive conclusions, the comparison of profitability between herbicide-tolerant and conventional soybeans systems deserves further analysis, in particular on the following elements:

- Efficiency of different weed control systems: prices, herbicides quantities, management constraints versus convenience.
- Will the yield drag close following the insertion of herbicide tolerant genes into top yielding varieties?
- Are there divergent price developments between GM and non-GM soybeans?

3.2.2. Bt corn

Profitability studies are mainly available for Bt-com, which is the leading GM-com and has been grown on a wide basis for two or three years.

3.2.2.1. Evidence on yield gains

By their stalk tunnelling action, com borers are significantly damaging to com crops. During one growing season, up to three generations of com borers can affect a given crop. To be effective, insecticide applications have to be carried out at the appropriate stage of development. Hence they require scouting, or in other words, farmers have to follow developments regarding population and to make their applications decision on this basis, in due time. For cost/effectiveness reasons, uses of insecticide sprays against com borers vary greatly from one production region to another, or even, from one grower to another.

A soil bacterium, the Bacillus thuringiensis (Bt) produces toxins that kill the European Com Borer. Bt com includes gene material from the Bt bacteria, which allows own production of insecticide during the growth stage of the plant. Hence it is expected to have a yield and convenience advantage against non-Bt com. A survey carried out in Iowa has shown that 80% of Bt-com growers had chosen this option because of the expected yield advantage (Duffy, 1999).

Several studies have found evidence on yield gains for Bt com. Based on 1996-1998 data of the Agricultural Resources Management Data, the USD A has observed that adopters of Bt com had obtained higher yields than non-adopters. This might however been partly explained by performance differences between these two groups of farmers. Gianessi and Carpenter (1999) report about average gains of 0.73 t/ha in 1997 and 0.26 t/ha in 1998, respectively, + 9% and +3% compared to 97/98 average yield for com.

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 (i*like Alexander and Goodhue, Hyde and al., 1999*) show the sensitivity of Bt performance to these two factors.

3.2.2.2. No clear savings in input costs

According to an USD A case-study, insecticide treatments are significantly lower for Bt com than for conventional com. Globally, insecticide use for com was lower in 1998 than in previous years. However, as previously mentioned 1998 had been a low infestation year. It is difficult to assess the role of Bt-technology in this reduction.

Other studies (Rice, 1999) give more details on farmers' practices: an increasing percentage of farmers (13% in 1996, 26% in 1998) having adopted Bt com indicate that they use less insecticide. Insecticides were not used at all by 50% of farmers. However, it is not clear whether the absence of applications results from Bt technology or if it was already the case with conventional varieties. Some farmers still spray insecticide on Bt com, because its performance against second or third generation infestation is more limited. In addition, insecticide may still be needed against other pests.

Considering that most of the farmers do not apply insecticide for controlling ECB, Furman Selz (1998) conclude that the value of Bt com is not insecticide cost savings, but rather yield protection.

The net effect regarding insecticide use and price is not clear-cut. Based on the 1998 Iowa survey[14], Duffy (1999) reports reduced applications but increased insecticide costs: "Farmers applied insecticides in 12% of their Bt com fields at an average cost of 17US $/acre. They applied insecticides to 18% of their non-Bt com fields at an average cost of 15US $/acre". In this case, the advantage of Bt com is not significant.

In addition, Duffy observed that Bt fields required slightly higher weed control (+ 6 €/ha) and fertiliser (+11 €/ha) costs.

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14 **"Cross sectional survey", based on interviews and field observations, which should provide "statistically reliable estimates at the state level". It is not a side by side comparison of GM and non-GM crops. It covered corn/maize and soybeans (see also section on soybeans).**

3.2.2.3. Refuges imply two-tiers crop management

To prevent resistance in ECB populations, farmers planting Bt crops have been advised to keep "refuges" with non-Bt crops next to the Bt-fields. In early 2000, the US Environmental Protection Agency specified requirements which have to be observed in this respect. Refuges should cover at least 20% of the area planted in Bt com. Where Bt com is grown near Bt cotton, refuges have to cover an area equivalent to 50% of the Bt area. This should translate into increased cultivation constraints.

It has been argued that resistance to Bt could raise problems for organic farming, which traditionally uses sprays or granulates of Bt preparations within pest control programmes.

Furthermore, since findings on sensitivity of the Monarch Butterfly to Bt toxin have been published and debated, the effect of this toxin on insects other than com borers has become an issue.

3.2.2.4. Increased seed price

GM seeds are more expensive than conventional ones. This reflects both the technological fee charged by some biotech firms and the fact that GM and conventional seeds are sold on different markets. Alexander and Goodhue (1999) report on GM-seed premiums for 20 GM com varieties ranking from 3 €/ha for high yield varieties to 35 €/ha for some Bt varieties. The figure of 22 €/ha can be found in the Furman Selz paper (1998) as well as in the Gianessi and Carpenter publication.

3.2.2.5. Contrasted results on profitability

As explained by Hyde *et al* (1999), the profitability of Insect resistant crop will depend on whether the "value of the protection" is less or more than the highest seed price. Results obtained by this research team for Indiana suggest that this is generally not the case. However, results depend on the level of infestation. Hyde and al have found that "when the probability of infestation increases from 25 to 40%, Bt com value increases by about 69%". Therefore, Hyde considers that in areas where infestation is more likely or where average yields are higher, Bt com should be profitable.

Several other studies show that profitability of Bt is higher where infestation is high. The calculations carried out by Furman Selz (1998) are summarised in the following table.

Table 3.4 Farmers economics for Bt corn, various infestation scenarios

	Units	Degree of infestation		
		Light	Medium	Heavy
Yield loss if untreated		5%	10%	20%
Price	€/tonne	98.4	98.4	98.4
Yield gain	t/ha	0.471	0.941	1.883
Gain in receipts	€/ha	46.3	92.7	185.3
Additional cost	€/ha	21.8	21.8	21.8
Net gain/loss	€/ha	24.5	70.9	163.5

Source: Furman and Selz

Compared with other studies, Furman and Selz calculations on income gain appear over-estimated, in particular, the relative high yield gains under the medium and heavy infestation scenario.

Different results are outlined in table 3.5 Gianessi and Carpenter have assessed net gains/losses for the years 1997 and 1998. They have assumed that there was no cost-saving effect for lower insecticide applications. Results obtained by Duffy for Iowa are also summarised in the table.

Table 3.5 Net gains and losses for Bt corn

		Gianessi&Carpenter		Duffy
Bt Maize	Units	1997	1998	1998
Price	€/tonne	84.5	68.6	66.8
Yield gain	t/ha	0.73	0.26	0.80
Gain in receiDts	€/ha	62.0	18.1	53.2
Additional costs				
seed	€/ha	21.8	22.1	21.3
insecticide	€/ha	not available		-1.3
weed	€/ha			6.2
fertiliser	€/ha			11.1
others	€/ha			7.2
Gain/losses	€/ha	40.20	-3.99	8.8

The results of the two studies are not directly comparable. As already mentioned, Duffy has estimated the insecticide, weed and fertiliser effects, while Gianessi and Carpenter have not.

In the Gianessi and Carpenter study, the combined effect of lower yield gain and com prices in 1998 resulted in net losses for Bt-com growers. These first results show that profitability of Bt com is highly dependent on the extent of yield gains and on prevailing market prices for com. This also explains the gap in the results of different types of calculations.

Taking into account differences in variable costs, Duffy concludes that there have been no cost savings. However, as a result of yield gains, Bt-com has been slightly more profitable than conventional corn. Duffy nevertheless considers that the 9 €/ha gain is not significant.

The cost of GM seeds is also a key factor in the relative profitability of GM crops. Alexander and Goodhue have examined the relationship between seed price and profitability, as well as the likely breakdown of profitability between firms and farmers for various types of GM com in Iowa. They found that the ranking of net revenue performance matched the ranking of seed costs. Under their simulations, Bt com appears to be the type of GM com most likely to allow profits for farmers. A possible factor of explanation might be the number of Bt Com types on the market (7 transformation events have been authorised in the US). There is a competition between these types of Bt, which are later incorporated into various hybrids. Hence, the authors consider that the likelihood of monopolistic pricing of the technology appears more limited.

However, as explained in chapter 2, biotech companies are considered to form an oligopoly on the input-side of the farm sector, furthermore after having acquired seed companies or concluded agreements with them. Their margin of manoeuvre as far as prices of GM seeds and associated agro-chemical products are concerned is a key factor in the breakdown of profitability of GM crops. Farm-gate profitability of GM crops is very sensitive to input prices.

To quote again Alexander and Goodhue, "analysis provides suggestive rather than conclusive evidence". There is evidence on yield gains of Bt com, compared to conventional varieties, which are exposed to com borers. The extent of the gain and hence, the cost-effectiveness of Bt technology, depends on the degree of infestation. The decision to plant Bt com or conventional is a complex one, as it has to take into account the likelihood of infestation and various adjustments in crop management.

3.2.3. Herbicide Tolerant Canola

Canola is a type of rapeseed which has been developed and is grown in Canada. It is a registered trademark, corresponding to specified low contents in erucic acid in oil and in glucosinolates in meals. It has initially been obtained through conventional breeding, but in recent years, GM herbicide tolerant varieties have been developed.

The importance of Canola has increased drastically: barely grown twenty years ago, it became the third most important crop in Canada in 1994, its value representing 29% of all grains and oilseed receipts (Agricultural Institute of Canada, 1999). Canola production in Canada is mainly limited to the provinces of Alberta, Manitoba and Saskatchewan. These three provinces produce more then 98% of the Canadian Canola output.

The production of GM Canola has risen spectacularly over the last years: In 1996, it represented only 4% of the output, in 1999 it was estimated by Fulton & Keyowski at 69%.

3.2.3.1. Contrasted results on yields

Canola yields have gone up throughout the 1980s and 1990s, for example, in the province of Ontario yield has doubled between 1983 and 1996' .

Yield data comparing herbicide tolerant (GM) Canola to conventional Canola does not prove to be convergent. Estimations in Alberta vary between 15% lower to 15% higher yields for GM crops than for conventional crops, depending on region and variety. Manitoba figures show higher yields (up to 15%) in most cases.

3.2.3.2. A convenience effect

Typically, the production of Canola requires two herbicide applications: one pre-emergent and the other post-emergent, the latter controlling only for a limited spectrum of weeds. The characteristic of herbicide resistance offered by GM Canola therefore improves potential in two ways:

- removing competition for moisture and nutrients between Canola and weed.
- eliminating costs for additional machine movements over the field (Fulton & Keyowski, 1999).

3.2.3.3. Unclear results on costs and profitability

Comparing costs and margins of conventional and GM canola is not a .straightforward exercise. Based on 1998 accountancy data, the production economics and statistics branch of Alberta Province carried out a comparison between different Canola varieties grown on two types of soil, black and brown ones. There are two species of conventional Canola with different agronomic characteristics: "Argentine" Canola provides good performance under frost-free conditions, while "Polish" Canola is more resistant to frost and drought, but more vulnerable to diseases. The yield of Polish Canola is generally lower than for Argentine Canola. The result of the comparison between these varieties and GM ones on the two types of soils are outlined in table 3.6.

Table 3.6 Costs and returns of different Canola varieties (in €/ha)

Type of Soil	Black soil			Dark brown soil	
Type of Canola	HT	Argentine	Polish (*)	HT	Argentine
Gross return	342	379	307	278	259
Crop sales receipts	328	353	296	240	255
Insur. receipts	7	5	0	29	0
Misc. receipts	4	8	7	9	2
Govt, programs	2	9	4	0	3
Straw/Grazing	0	4	0	0	0
Variable costs	182	190	185	181	184
of which seeds	36	18	36	27	21
of which fertilizer	42	44	43	36	48
of which chemicals	32	51	25	31	35
Capital costs	75	92	102	66	63
Total Prod, costs	257	281	287	248	247
GROSS MARGIN	131	163	76	84	48
Yield (Bu/acre)	27	29	24	20	21
yield (bu/Ha)	67	71	59	50	53
Avg area (Ha)	86	65	70	102	73

(*)= number of observations lower than 10

Source: Alberta Simulations, 1998

This table illustrates the difficulty of comparing profitability of these varieties, due to the number of factors which might have an effect.

- Black soil areas allow for higher yields.

- In the dark brown zone, there is no significant difference in yields and in total costs between the Argentine and the HT variety. Differences appear on the receipt side, lower sale receipts for HT crops, but higher insurance revenue.

- In the black soil area, there are significant differences in yields, costs and receipts. The "Argentine" variety achieves the highest yield, with the HT variety coming close to that level. Total costs for HT Canola are lower than for conventional varieties, and this is mainly the result of reduced capital costs. However, due to higher receipts, Argentine Canola turns out to be more profitable.

Although variable costs of HT and conventional Canola are broadly equivalent, even from one zone to another, the breakdown is different. While costs are higher for GM seeds, those for fertiliser and herbicides are lower for HT than for "Argentine" Canola. The convenience effect of HT Canola is reflected in the lower labour and fuel costs.

As illustrated in table 3.7, the Fulton & Keyowski study seems a bit more prudent and stresses the fact that whether or not it is economically advisable to grow GM Canola varies from farm to farm. This points to a possible, source of bias in the Alberta study: the average size of plots sown in HT Canola is higher than for conventional varieties. The Fulton & Keyowski assumption that HT Canola has lower costs and lower yields than conventional varieties appears to be confirmed by the Alberta data.

Table 3.7 Conventional and GM canola production systems

Canola product line: a system comparison, 1999				
	Roundup Ready	Smart Open Pol	Liberty Hybrid	Conventional Open Pol
Costs				
Total system costs	84	97	102	94
Of which. Seed €/ha	40	40	53	29
Herbicide	11	57	49	65
Yield (bu/ha)	82	78	88	88
Commodity price	18	18	18	18
Expected Gross	571	545	618	618
Less System Costs	-84	-83	-102	-95
Gross Return	487	462	515	523

Source: Fulton & Keyowski - the producer benefits of herbicide resistant canola

There again, no clear-cut conclusion regarding the effects of the use GM canola can be drawn. There is only limited availability of data and all simulations start from different premises. Results depend on varieties compared, on growing and marketing conditions. However, the rapid adoption of GM Canola indicates that the variety is very attractive to the farmer.

3.3. Mixed outcome, many factors, longer-term assessment needed

The results of different studies on profitability of the main GM crops can be summarised as follows:

- Herbicide Tolerant soybeans allow for cost savings thanks to reduced use and cost of herbicides. This could offset the higher seed price. However, the yield of GM soybeans is still lower than for conventional varieties. When comparing returns per ha or per labour unit, no significant difference appears between the two types of crop. In this context, the convenience effect of HT crops appears to be the main driving force.

- For Bt-com, significant yield gains have been observed. However the cost-effectiveness of Bt com depends on growing conditions, in particular on the degree of infestation in com borers. Applications of insecticide have decreased globally. Some studies show increased total costs for Bt-technology, first for seeds but also for weed control and fertiliser. Results regarding profitability are contrasted, none can be considered as significant.

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

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

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

The convenience effect seems to be a significant advantage, in particular for herbicide tolerant crops. This benefit does not directly translate in terms of profitability, but rather in terms of attractiveness of GM crops for efficiency purposes. This convenience effect has to be further assessed in particular, the valuation of the labour effect. In the longer run, it should imply increased labour productivity and savings in crop-specific labour costs. Further efficiency assessments, including price and use of herbicide over a longer time frame, would also be useful.

The profile of adopters of the new technology also plays a role. First adopters were mainly young, educated and well-performing farmers, established on large holdings. The adoption of biotech crops is not size neutral. The higher than average farm size of adopters might be a factor explaining, amongst others, the dramatic increase in areas sown to GM crops. Theoretically, more benefits are accruing to early starters. Those already having adopted the **technology are likely to have gained from it.** In **the case** of HT **crops, gains** in efficiency should translate into improved labour productivity. In the case of Bt com, yield gains mean enhanced productivity of land. Under given prices, enhanced productivity leads to an increase in supply. 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. This may lead to a drop in prices. Hence, gains for late adopters are expected to be lower than for early adopters. In the long run, enhanced productivity will have an impact on farm restructuring, alongside with other factors playing a role in this process.

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. As a result of consumer concerns and preferences, 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 might change the outset as regards profitability of GM versus non-GM crops.

Policy measures, in particular the eligibility of GM crops under various support schemes, have reduced the price risk of the new technology. Until recently, no significant differences in prices between GM and non-GM crops have been systematically recorded, expect on niche markets. Hence, growers have mainly based their planting decisions on expected farm-gate performance, on cost-efficiency of inputs. In other words, they had an input-oriented approach.

The marketing strategy developed by biotech firms must also be considered. It has been focused on farmers, the first customers interested in input traits. In the case of herbicide tolerant crops, the marketing strategy was based on the concept of "technological package" (the GM seed and the product to **which it is resistant), which allows for "combined pricing". Benefits of GM** crops have been extensively advertised throughout key production areas (Com Belt). Biotech firms have been present up to the field, providing commercial and technical assistance to farmers, whether directly or through their subsidiaries. They have shaped famers'expectations.

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

The demand can be analysed at the level of consumers, the retailing industry, and food processors. Of these three actors, the retailing industry has a pivotal position by amplifying consumer preferences and relaying them to the food industry. Whether retailers choose to label products containing GMOs, eliminate GM ingredients from own-label food, or go GM-free, their approach has cascading effects on food processors, grain companies, and ultimately on farmers. Today, the organisation of the world food market more and more reflects the variable public opinion and power of civil society groups from one region to another and their unequal influence on supermarket chains.

The main argument of this chapter is that the global food market is undergoing a reorganisation which transcends the European context, where public awareness and debate of GMOs first emerged. European retailers' restrictive stance on GMOs is giving birth to a bifurcated market leading food processors to adapt their products to regional conditions, and US grain elevators to segregate commodities.

The chapter first surveys consumer preferences in different regions of the world through an overview of available public opinion studies and mobilisation campaigns (section 4.1). The second section explores the strategy of the retailing industry as evidenced by their degree of anticipation and the nature of their reactions (section 4.2).

4.1. Consumers : moving fast

It has become customary to contrast North American consumers' perceptions of GMOs with those of European consumers. 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 (degree of faith in science, relation to food...), historical (recent food scares in Europe), and political (degree of trust in public/private actors).

This dichotomy reflects clear regional cleavages, yet needs qualifying for at least three reasons. First, civil society groups have early on organised global, transregional mobilisation campaigns against GMOs. 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.

4.1.1. Mobilisation campaigns

Public controversy over GMOs crystallised in the middle of the 1990s, as the first GM crops were being harvested. Mobilisation emerged at the global level around the "Pure Food Campaign," later known as the "Campaign for Food Safety." At the core of these campaigns, international NGOs such as Greenpeace, Friends of the Earth, RAF I and others co-ordinated the movements and set up discussion fora and comprehensive GMO databases on the internet (Examples can be found in the internet database referred to in the bibliography). At the local level, grassroots participated in the campaign: women's networks, environmental groups, consumer associations, farmers, and youth.

The "Global Days of Action Against Gene-Foods" organised in the spring 1997 evidenced the transnational, and multi-faceted character of mobilisation. Table 4.1 illustrates the regional and political diversity of this campaign. According to the organisers, "activists from twenty-seven nations organised actions and press events against gene-foods and genetic engineering" (Pure Food Campain 1997). In addition, the interests represented in this campaign ranged from the promotion of sustainable development, to the protection of consumers, through the advancement of ethical considerations with regard to genetic research.

Table 4.1 Global Days of Action Against Gene-Foods, April 13-27,1997
{source: Pure Food Campain, 1997)

Regions	Countries	Groups (not exhaustive)
Africa	Ethiopia	Institute for Sustainable Development
Asia	Australia	Australian GeneEthics Network Australian Consumers Association
	India	Research Foundation for Science, Technology, and Natural Resource Policy
	Japan	Network for Safe and Secure Food and Environment Consumers Union
	Malaysia	Third World Network Consumers Association
	New Zealand	Natural Food Commission Greenpeace
	Philippines	Center for Alternative Development Initiatives
Europe	Austria	Global 2000
	Belgium	European Farmers Coordination (CPE) Pesticide Action Network
	Croatia	Green Action
	Denmark	Ecotopia
	France	Ecoropa
	Germany	Green Party Greenpeace Gen-Etisches Network AntiGen
	Georgia	Greens Elkana
	Greece	Greenpeace
	Hungary	ANPED Sustainable Production and Consumption Project Energy Club ETK Biokultura
	Italy	n/a
	Netherlands	Dutch Coalition for a Different Europe Natuurwetpartij ASEED
	Norway	GATT WTO Campaign Ungdom for Bonder Mat-helse-miljo-alliansen Dovefjellaksjonen Vi og Vaart
	Poland	Green Federation
	Spain	AEDENAT
	Sweden	Greenpeace
	Switzerland	No Patents on Life
	United Kingdom	Women's Environmental Network
Latin America	Brazil	Brazilian Institute for Consumer Protection
North America	USA	Consumers' Union Greens Learning Alliance Noclone Greenpeace Institute for Ag and Trade Policy COACT Pure Food Campaign Safe Food Link Food not Bombs
	Canada	Council of Canadians GreenpeaceNatural Law Party

Global mobilisation against GMOs has continued ever since, sometimes with spectacular actions. A second "Global Days of Action Against Genetic Engineering" took place in October 1997. In February 1998, the "Physicians and Scientists Against Genetically Engineered Food" issued a declaration in which they demanded a "moratorium on the release of Genetically Engineered organisms and the use of GE-food" (Physicians and Scientists Against GE Food 1998). In September 1999, activists from thirty countries (Latin America, North America, Asia and Europe) launched a lawsuit against major biotech companies, claiming a multi-billion dollar compensation for monopolistic practices (Financial Times, 13 September 1999). A month later, Monsanto CEO Robert Shapiro announced the decision of his company "not to pursue technologies that render seed sterile." The decision, a testimony to the power of organised movements, was "based on input from you and a wide range of other experts and stakeholders, including our very important grower constituency" (Open Letter from Robert Shapiro, 4 October 1999).

NGO mobilisation on issues raised by biotechnology was also strong in the context of the WTO Ministerial meeting in Seattle in November/December 1999. Specific actions were organised in Montreal in January 2000 in the event of the conference for the Protocol on Biosafety (see chapter 5).

While protest against GMOs acquired a global dimension, interest groups and NGOs intensified their pressure in three regions: in Europe, in Australasia, and in North America. The most notable differences between these regions pertain to the timing of mobilisation—Europe was the first mover—and the degree to which counter-mobilisation has organised (table 4.2). Counter-mobilisation was stronger in North America where it centred around the agri-food business and some scientist communities. On the other hand, there was little counter-mobilisation in Europe.[15] This difference appeared clearly in the public hearings on GE foods organised by the FDA this year, where participants described the European "scientific establishment...[as] less protective of genetic engineering... [than] their US counterparts" (Congress Daily, 1/12/99).

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[15] **Counter-mobilisation emerged in Australia, probably explaining why Australia has moved a bit slower on labelling than New-Zealand despite the fact that both are members of the ANZFA.**

Table 4.2. Sample of Recent GMO Actions in Europe, North America, and Australasia

	Europe	North America	Australasia
Mobilisation	1997: DUTCH SUPERMARKET SUED The Dutch Natural Law Party files a suit against Dutch retailer Albert Heijn for misrepresenting GM food. DEC. 1997: FGSO CAMPAIGNS AGAINST GMOs The Federation of Greek Supermarket Owners (FGSO) and Greenpeace launch a campaign against GE food. Greenpeace and FoE organise actions against supermarkets and food processors. APRIL 1997: ANTI-GM PETITION IN AUSTRIA 1,226,551 Austrians (20% of eligible voters) sign a petition opposing GM food, the release of GMOs in the country, and life patenting. SEPT. 1997: UK PETITION AGAINST GM FOOD 16,000 people sign a petition opposing GM food. MAY 1999: UK DOCTORS DEMAND BAN The British Medical Association calls for a ban on GE foods and crops and judges that "antibiotic resistant genes in GE foods is a completely unacceptable risk."	MAY 1998: LAWSUIT AGAINST FDA A coalition of scientists, religious leaders, chefs, health and consumer groups files a lawsuit against the FDA' testing and labelling procedure. Alliance for Bio-Integrity; and the International Center for Technology Assessment coordinate the action. JUNE 1999: PETITION ON GE LABELLING 500,000 US citizens sign a petition to demand the mandatory labelling of GE foods. The Natural Law Party submitted the petition to House Minority Whip David Boniors (D-MI), as well as the US President, the USD A, the FDA, and the EPA. SEPT. 1999: ACGA RECOMMENDATIONS The American Corn Growers Association recommends that farmers buy non-GM non-GM seed. OCT. 1999: CWB STRESSES CAUTION Canadian Wheat Board Chairman Greg Arason declares "the customer is always right, even when they might be scientifically wrong" and recommends caution towards GM crops which "have only limited consumer acceptance" (SCI 28/10 and 9/11).	MAY 1999: GM-FREE FOOD LIST The list contains "100 foods in NZ claimed to be genetic-engineering free." It is used by the Green Party, RAGE, and St Martin's New World. JULY 1999: SUPERMARKET ACTION Green Party of New Zealand, together with RAGE, and Safe Food Campaign initiates a week of action against supermarkets selling GM food. SEPT. 1999: WAFF'S OPPOSITION The Western Australian Farmers Federation opposes "the release of 'Genetic Modificaiont' of both livestock and other farm produce and... continues to promote R&D of those products by natural means" (PSRAST 15/10/99).
Counter-mobilisation	May 1999: UK farmers' & industry initiative SCIMAC (Supply Chain Initiative on Modified Agricultural Crops) an initiative of farmers, seed trade, plant breeders, and biotech companies. It seeks to establish a code of practice for the introduction of GM crops, in particular, to provide information for consumer choice.	OCT. 1999: BETTERFOODS CAMPAIGN The Grocery Manufacturers of America (GMA), the American Farm Bureau, and 30 US companies launch a campaign to restore public confidence in GM food. Nov. 1999: SCIENTISTS DEMAND SUPPORT A coalition of over 100 Canadian scientists demand more active support for biotechnological research.	MAY 1999: AGRIFOOD ALLIANCE The National Farmers' Federation, Grains Research and Devel. Corpor., the seed industry... launch the Agrifood Alliance in Australia to increase public acceptance of biotechnology.

4.1.2. Evolving Public Opinions

Mobilisation campaigns at the global and at the regional level display the salience of biotechnological issues among interest groups and NGOs. Yet, the level of activism on GMOs is an imperfect indicator of public perceptions as knowledge and concerns may not reach the larger public. Public opinion polls and surveys show that the global mobilisation around GMOs masks contrasting “moods” in North America and Europe. While consumers in Europe and Australasia are unambiguously suspicious of genetic engineered food, North American consumers’ perceptions are much less clearly characterised. Until recently, the global mobilisation around GMOs was thus anchored on more fragile bases in North America. There, the discourse against transgenic food found only limited resonance with the public at large for reasons which have yet to be researched. However, one must be cautious as the public debate is emerging in the US and may be moving closer to the European debate.

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:

- High level of concern: A large majority of Europeans is 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.[16] 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).

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[16] **March 1997: a survey conducted by the University of Lancaster for Unilever finds “significant unease about the technology as a whole... and much such unease is latent rather than explicit.” August 1997: a survey conducted by Market Measures Ltd. for Sainsbuiy’s reveals that UK consumers do not favor GM foods because they are “unnatural”; “Over half of those aware of genetically engineered food said they would ‘probably not’ or ‘definitely not’ buy such food.” (AgBiotechNet 1997). March 1998: a Gallup poll commissioned by Iceland shows that 63% of respondents who are aware of GM food have reservations. Yet, a MORI poll indicated a lower degree of distrust of GE food in Britain: 53% would not eat GE food, against 63% of Danes, 65% of Italians and Dutch, 77% of French and 78% of Swedes** (wu’w.centerfoodsafetv.orR/facts&issues/polls.htm).

- Knowledge and perception: Perceptions tend to "crystallize" with the degree of knowledge. Both pessimism and optimism increase with the degree of knowledge of respondents (Eurobarometer, 1997). This is consistent, with a recent survey showing that "the level of knowledge and familiarity with [biotechnology]... are not so decisive in shaping general attitudes" (Menrad, 1999). According to the 2000 Eurobarometer, the use of biotechnology in food production is the most commonly known application. However, 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%).

- If knowledge is not a key variable, "cultural factors seem to prevail in shaping personal attributes towards modem biotechnology... the attachment of consumers to their national food traditions is seen as an important factor in the process of acceptance of food technology" (Menrad, 1999).

- 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 stem from the USD A, Novartis (1997), **Time magazine (1999), the International Food Information Council (1999)** and some Canadian organisations. Two broad tendencies emerge:

- Eroding trust in GM food: A 1995 USDA study of 604 New Jersey residents found that 60% would "consider buying fresh vegetables if they were labelled as having been produced by genetic engineering" (Center for Food Safety, 1999). In 1997, Novartis found that only 25% of Americans "would be likely to avoid labelled GE foods". Yet 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 show a certain erosion in the consumers' trust in GM food [17].

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[17] **In contrast with the results of the Time magazine poll, IFIC President Sylvia Rowe declared in October that "The vast majority of American consumers still place a great deal of confidence in the benefits of, and current regulatory climate for, agricultural biotechnology" (IFIC 1999). In the October 1999, 51% of the respondents declared they would be likely to buy a "variety of produce... [which] ha[s] been modified by biotechnology." Yet, the question was framed as follows: "All things being equal, how likely would you be to buy a variety of produce, like tomates or potatoes if it had been modified by biotechnology to taste better or fresher?" (IFIC 1999) (emphasis added).**

- 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 favored it in the 1995 USDA study; 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 is sufficient to stress the contrast between European and North American perceptions of agricultural biotechnology. While Europeans are critical of GM foods and wish to keep them at bay as long as detailed studies of the risks have not been conducted, North American consumers have placed greater confidence in agricultural biotechnology. Recently however, changes have been visible in US consumers' perceptions. North American consumers have lent a more critical support of this research, and they have clearly mandated GE labelling. The recent public hearings on GE labelling organised by the FDA have kick-started the public debate. The turn-out was high (Financial Times, 18 November 1999), and debates have shown "little middle ground" between the representatives of civil society, the industry, and scientists (Detroit News, 19 November 1999). Protesters have staged media-oriented demonstrations outside the conferences, and seized the coincidence of the second FDA hearing with WTO ministerial meeting in Seattle (November, December 1999) to attract world media coverage. These' trends have put pressure on retailers and the food industry.

4.2. Retailing industry: following and shaping the demand

The retailing industry is the linchpin in the food market due to its proximity with consumers. Over the last years, a global concentration process has increased the market power of retailers. The first point of contact between consumers and the food industry, retailers do more than simply transmitting consumer preferences to food processors and grain elevators. They amplify or moderate market signals, contain or anticipate consumer expectations. Whatever their strategy, it has cascading effects on the rest of the food industry at home and abroad.

The contrasts in regional mobilisation described above have had direct consequences on the strategy of retailers. While European and Australasian retailers have early on been faced with vehement protest against GM food, their North American counterparts have not been exposed to direct consumer pressure. As a result, European retailers have moved to meet and shape the **demand for** non-GM **food,** in **contrast with** the **"wait-and-see" approach** adopted by the bulk of North American retailers.

4.2.1. Amplifying consumer preferences

Supermarket chains first moved in the UK, where Friends of the Earth organised in 1997 a campaign against the introduction of GM foods in supermarket (see Friends of the Earth Supermarket Letter). Given the absence of regulation of GM food, retailers were pressed to take quick actions, probe consumer preferences, and anticipate the development of a non-GM food market. Sainsbury's commissioned a consumer survey in the very early stages of **grassroots** mobilisation. This move earned the retailer "congratulations from Friends of the Earth] on carrying out and publicising this timely and valuable research" (AgBiotechNet, 1997). Food and Biotechnology Campaigner for Friends of the Earth Adrian Webb declared: "Sainsbury's promotes itself on providing 'good food'... All the major retailers should now act on these findings" (Friends of the Earth, Press Release 1997). This domino effect did take place and UK supermarket chains unveiled their plans on GM food one after the other, starting with Sainsbury's and Iceland (May 1998), Tesco (September 1998), and other major food chains. In fact, a leaked Monsanto report showed that the move towards adopting a restrictive stance on GMOs was well under way at the end of 1998, retailers being determined to resist the introduction of GM foods.[18]

The movement spread to continental Europe in 1999. In March, Sainsbury's announced the formation of a consortium with six European supermarket chains to organise the supply chain: Carrefour (France); Delhaize (Belgium); Esselunga (Italy); Marks & Spencer (UK); Migros (Switzerland) and Superquinn (Ireland) joined in. In May, Spain's biggest retailer, Pryca, announced its policy, followed by Rewe in July; Edeka (under the pressure of Greenpeace) in August; and Aldi in October 1999 (the list is not exhaustive).

In the Netherlands however, the biggest retailer, Albert Heijn, is a notable exception to this trend. In 1997, the Dutch supermarket chain took a proactive stance to enhance consumers' acceptance of GMOs. In one of its free monthly brochures, the chain advertised GM soya as having the same quality as conventional soya. The Dutch Natural Law Party brought the case before the Advertisement Code Commission for "false and misleading advertisement" (Campaign to ban genetically engineered foods, Press Release 1997) and won it. On that occasion, the environmental organisation noted that "In contrast with the food retailers in some other countries the Dutch branch forms a closed front, which in fact is against the interests of its customers" (Campaign to ban genetically engineered foods, Press Release 1997).

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18 The report describes the retailers' "resentment of Monsanto for badly mismanaging the introduction of biotechnology in Europe and for allowing the issue to be decided in the supermarkets" (Friends of the Earth 1998).

By the end of 1999, many European supermarket chains have thus adopted a restrictive policy on GM food. Contrary to common views, they did not align on a single non-GM model. Rather, they adopted various types of actions.

4.2.2. Types of supermarket actions

Faced with legal uncertainties on GM food labelling[19] and growing popular pressure to phase out GMOs, retailers have adopted different strategies. Table 4.3 illustrates the variations that currently exist between chains' policies on GM food [20]. Some supermarket chains, like Sainsbury's and Marks & Spencer, have adopted fairly comprehensive strategies whereby they commit themselves to phase out GE ingredients from their own-label products and eventually to sell non-GM fed meat. Other supermarkets, like Asda and Safeway, have chosen narrower policies to eliminate GE ingredients in their own-brand products, but also label own-brand products for which they have not been able to do so.

Table 4.3 Some Examples of Supermarket Actions on GMOs

"Consortium on GM-fed meat"	"GM-free working group"	"Consortium to eliminate GE ingredients from own-label foods"	Individual actions to eliminate GE ingredients from own-label products	Label own-brand products containing GE ingredients
Sainsbury's; Marks & Spencer; Safeway; Northern Foods;	Adeg; BML Group; Hofer; Spar (Austria)	Sainsbury's; Delhaize; Carrefour; Superquinn; Esselunga; Migros; Marks & Spencer	Auchan; Système U; Aldi; Edeka; Spar (Germany); Tengelmann; Pryca; Coop; Iceland; Tesco; Leclerc	Asda; Safeway

This table combines three axes along which supermarket chains' actions can be differentiated:

- <u>group v. individual initiatives</u>: Group initiatives, such as the Sainsbury consortium 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.

- <u>GM labelling v. non-GM labelling</u>: some chains have opted for labelling products containing GMOs (Safeway; Asda), others for labelling non-GM products (Leclerc).

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[19] See section 5.2.2 on EU legislation.

[20] The typology adopted in table 4.3 does not reflect current legislative work (see juridical differences between "GM-free" and "non-GM'). Notably, it is difficult to know whether the "GM-free" products advertized by the operators contain no GMOs, or a feeble amount of GMOs.

- Choice v. no choice: some supermarkets allow GM-labelled foods (Safeway; Asda); others will not sell products labelled as containing GMOs (Adeg; BML; Hofer). Yet, other like Aldi and other discount chains do not officially exclude GM labelled foods, but give the consumer little choice as own-label products, from which they have eliminated GMOs, represent 90% of their product range.

Given the current state of affairs, this review is necessarily incomplete. Yet, it displays the variety of actions deployed by European supermarket chains. Options exist beyond the "choice", "no choice"; however, the general tendency of chains is to phase out GM food. Given the transnational character of supply chains, the restrictive stance of European supermarkets **has triggered** a **reorganisation that transcends Europe. 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, has been dominated by demand factors, such as food safety concerns. In the EU, consumer demand for a continuous supply of agricultural raw materials and processed products at a certain price and a certain quality is seen as the underlying force for the agricultural sector to adapt and to innovate production techniques. Furthermore, the recent reforms of EU Common Agricultural Policy provide several incentives to adapt production quantities to **market demand and to put emphasis on quality aspects, both** of **products and** production methods.

Further technological developments and continued increase in GM crop production could affect the future competitiveness of conventional non-GM production. Nevertheless, consumer reaction to GM food has given rise to uncertainty about market developments, in particular the short term prospects for GM products. As a result to consumer concerns, the regulatory framework concerning GMOs has developed and is partially still under review not only in the EU but also in many other countries including the USA.

Labelling has been recommended as a tool to enable consumer choice between products and to avoid further market and trade disruptions. However, labelling systems in which consumers have confidence would require at least segregation of product lines throughout the processing system. Moreover, Identity Preservation would be required to distinguish the different types of products according to their contents of GM material or the way they have been produced whether using GM technologies or not. Segregating and Identity Preservation are attempts to create and establish a separate market for a "new" product, a specific crop. The success of such attempts will depend on supply and demand concerning the new product.

GM crops with enhanced quality traits are most likely to supply niche markets. They are addressing a specific demand and the opportunities for supply are highly dependent on innovations, e.g. new varieties, which provide enhanced quality. On such markets competition and market transparency are generally less advanced than for commodity markets.

Since segregation and Identity Preservation appear to be means to offer choice between GM and non-GM products to the consumer, this chapter will start with a discussion of the key features of these systems compared to the commodity trade system (section 5.1). Three systems for Identity Preservation and labelling in the GMO context, based on current EU legislation, will be identified in section 5.2. The available studies and information about additional costs of IP have been summarised in section 5.3. Furthermore, the distribution of these additional costs along the food production chain is discussed in section 5.4. The following section 5.5 provides some background information about EU markets for soybeans and corn, about the supply to serve potential non-GMO demand and about the different stance on food and feed use. Finally, some trade issues are briefly outlined in section 5.6.

5.1. Key features of agricultural trade systems

Trade of agricultural products today is based on the commodity system. Any system of identification which goes beyond the common specifications would require additional handling effort and would thus create additional costs. Segregation and Identity Preservation are possible responses to consumer demand for specific products.

5.1.1. Commodity System

The bulk commodity system 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.[21] Usually, commodities from different origins are blended to meet specific grades. For example in the case of wheat protein content, moisture, falling number, specific weight and percentage of extraneous material are taken into account. On its journey to a milling plant, the wheat can be sampled and blended several times and there is no traceability back to the producer. Commodity prices are fixed on spot markets, futures markets or by contracts.

International trade of agricultural products, in general, is based on the commodity system, which covers about 200 Mio t of grains per year. In the oilseeds sector about 50 Mio t of soya, sunflower and rape seed are traded annually across borders, in addition to 13.5 Mio t of oil from the different seeds and 43 Mio t of meal. Furthermore, many more millions of tonnes are traded on domestic markets under the commodity system.

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21 **Commodities have been defined as substances sold in very large quantities, such as raw materials or foodstuffs such as com, rice, butter (Dictionary of agriculture 1990).**

Bulking up the produce of many producers means that transport and handling costs can be reduced. For example, Cargill has calculated that ocean transport from the US to Europe may only add 13 € to the price of a tonne of soybeans (180 - 225 €) if 50 000 tonnes are shipped at a time. The total cost of transportation from a US mid-west farm to European harbours is estimated at 10% of the farm-gate price of soybeans (Cargill, 1999).

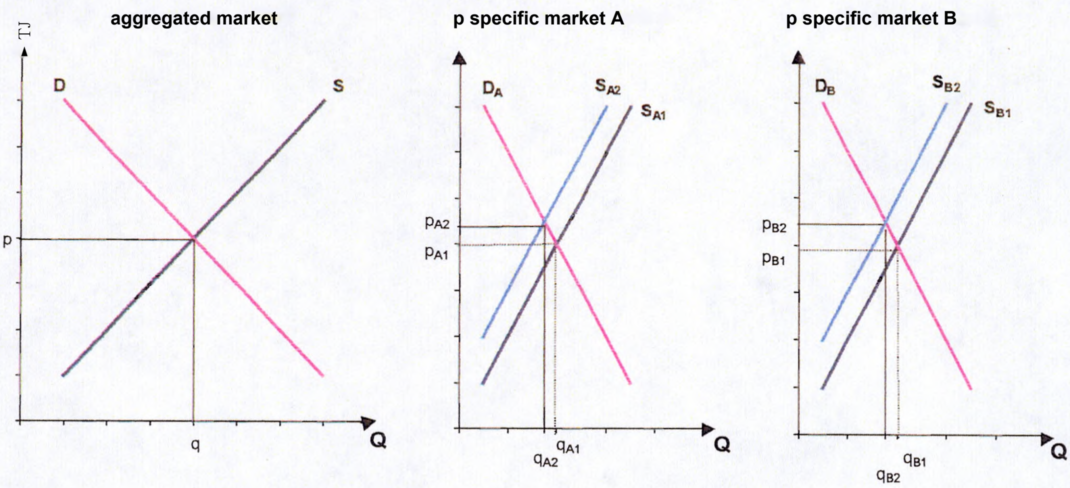
Furthermore, bulk transport enables a continuous flow for processing, since taking a processing plant down and firing it up again can be time consuming and costly.

5.1.2. Segregation

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).

Segregation is an attempt to create and establish separate markets for differentiated products or to set up a "new" market for a "new" specific product. This corresponds to a dis-aggregation of the supply and demand. Some possible economic effects of market segregation are shown in figures 5.1 and 5.2.

Figure 5.1: Economic Effects of Market Segregation



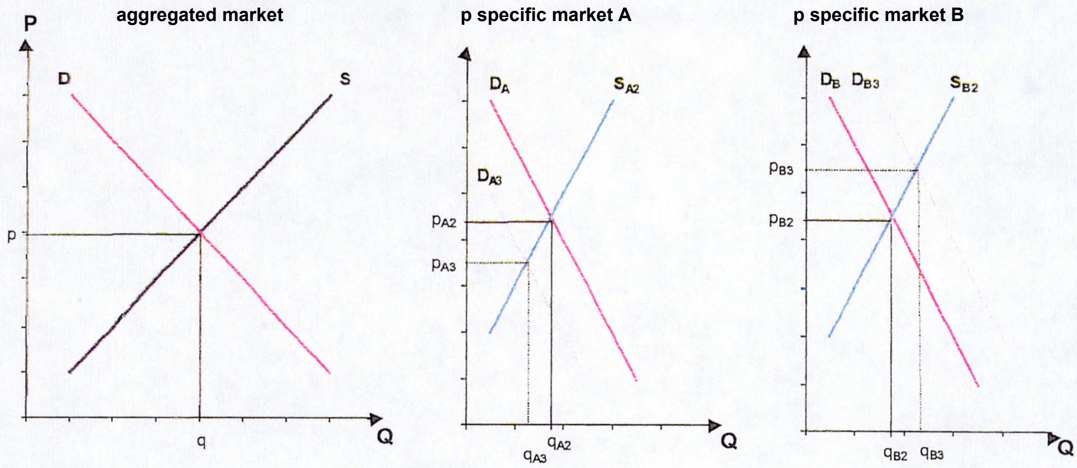
In figure 5.1 it is assumed for simplicity reasons that the aggregated supply for a certain crop would be subdivided equally among the specific markets A and **B** (dotted lines S_Ai and S_Bi). Assuming further that demand would follow the same pattern for both sub-markets (D_A = D_B), the price on market A should be the same than on market **B** (p_Ai = pBi).

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_{Ai} to S^ and from S_Bi to S_{B2}. The effect will be a reduction of quantity produced (q^ and q_{B2}) and an increase in prices on both markets (from p_Ai to Pa_2 and from pei to pB_2). In general, losses in economic welfare can be expected because the potential for trade and specialisation gains will remain partially unused.

Moreover, the assumption of equal pattern of demand on both sub-markets will be unrealistic. More realistic would be the situation as shown in figure 5.2 with different demand functions on the respective sub-markets (Da_3 and Dbs)-

In our example, the price increase caused by segregation would be outweighed by a price reduction due to a low demand on specific market A. This effect would be accompanied by a reduction in quantity supplied compared to figure 5.1. On specific market B, a high demand (D_B3) would lead to a further increase in price to pB_3 and an increase in quantity supplied to q_{B3}.

Figure 5.2 Different demands on segregated markets



In addition, the application of new cost-saving or output enhancing technologies on one of the specific markets would result in a rightward shift of the supply curve. New technologies thus result in price reduction and in higher equilibrium quantity on that specific market. Biotechnology is expected to provide such technological effects, at least in the long-run (see chapter 3).

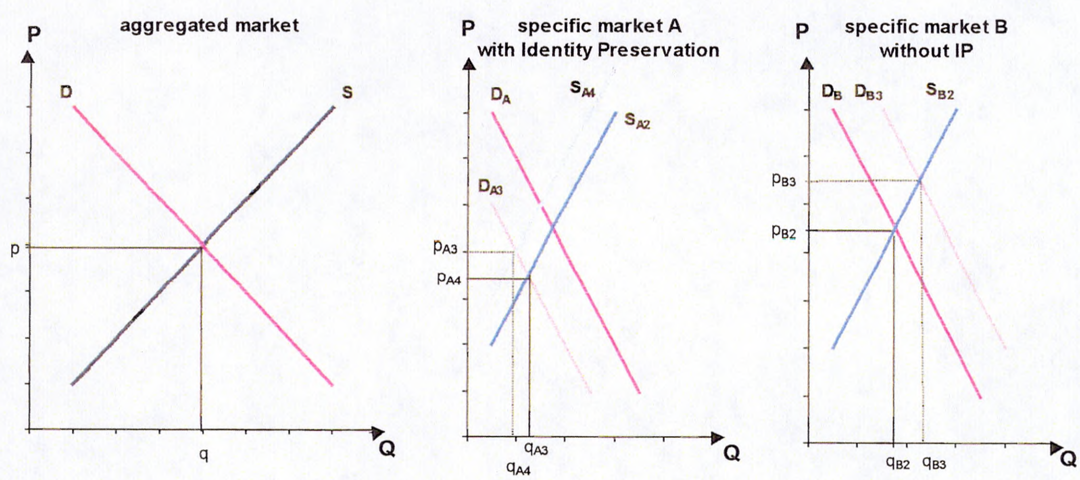
Segregation implies that specific crops and products are kept apart, but does not necessarily require traceability along the production chain. In the GMO context, this may pose major problems of liability and consumer confidence. A French investigation identified the absence of labelling requirements at all the stages of a production chain to be the most important difficulty to apply segregation along the production chain and to operate the current labelling requirements for GMOs (Ministère de l'Economie, des Finances et de l'industrie, 1999).

5.1.3. Identity Preservation Systems

Marketing experts have stated that "Identity Preservation programs are the best alternative and the most economical way to meet customer and regulatory requirements" (Young, 1999). 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). Thus it goes beyond segregation, since it implies a stronger positive desire to know about the origin of a crop or a product.

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. Thus, IP causes additional cost in supply which are illustrated in figure 5.3.

Figure 5.3 Economic effects of Identity Preservation cost



Introducing Identity Preservation on specific market A would result in a further shift of the supply curve from S_{A2} to S_{A4}. The effect will be a reduction of quantity produced from q_{A3} to q_{A4} and a reduction in price to p_{A4} on market A.

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, EP 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.

A common example of an IP grown crop under contract is the production of certified seed. Contamination by foreign pollen or other seed varieties has to be avoided and inspections take place to verify purity. The premium for seed wheat production is about 15-20% of the price of a normal wheat crop. This premium should cover the extra work involved for identity preservation.

Other examples for IP systems already in place are related to high erucic acid rapeseed, grown for technical use, waxy com for starch production and flint com for breakfast cereals. Identity preservation systems have also been established for certain other specialised (niche) markets, organic produce for example or special varieties of soybeans for tofu production. These products are transported in smaller quantities, reserved trucks or reserved holds of smaller ships.

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%, often less than 1%, in most EU Member States (Michelsen *et al.,* 1999). The highest market shares are obtained for dairy products in Denmark (14.2%) and in Austria (8-10%).

In the US, about 100 000 tonnes of soybeans are identity preserved, compared to 75 Mio t harvested under the commodity system (Rawling, 1999).

However, variety choice through IP is seen as contributing more than any other factor to improve the market value of grains (Clarkson, 1999). A comparison of recent US prices shows that the premium paid for certain quality traits and for organic products is much higher than the current premium for conventional non-GM crops (s. annex). In the health food sector the price for IP grains and soybeans is about 200 - 300% of the commodity price (Cargill, 1999).

The following analysis will concentrate on IP systems since their degree of compliance with consumer concerns appears to be higher than for segregation.

5.1.4. Some specific issues of Identity Preservation Systems

<u>Testing and control:</u> An important element to establish IP systems is the technical possibility to test samples for the preserved identity (e.g. its physical or chemical contents). Random or regular tests can be carried out for the final product delivered to the consumer or the processor. To enhance the performance, control mechanisms might be applied not only to the final product but also at different stages of production and transportation.

For IP relating to production methods or regional origin, testing of the final product is generally not possible and the consumer has to rely on the integrity of the supplier and the robustness of the IP system (Buckwell *et al.* 1998). Controls would then have to verify this integrity at different stages of production in order to establish consumer confidence.

<u>Tolerances:</u> Ensuring absolute purity of a food product would be related to prohibitively high costs in practical processing and handling chains. The principle of fixing a tolerance level (threshold) in purity standards is therefore a long-established feature for IP systems throughout the food industry.

Tolerances have for instance been fixed for organic food. Because of the difficulty of eliminating all commingling throughout the production chain, a 5 % tolerance level of non-organic material is allowed in some processed food derived from and labelled as being made from organic ingredients.

The costs of an IP system can be expected to increase with a reduction of the tolerance level. Thus, the setting of a certain tolerance level will be an important factor to determine the costs of an IP system.

Contracts: Identity preservation often involves advance contracts with farmers who commit themselves to keep the crop separate during harvesting or to produce only under certain rules (quality labels, organic farming). Furthermore, seed varieties, growing specifications, chemical treatments or handling and storage requirements may be subject to specific contracts. With an increasing degree of specification for an agricultural product, which is reflected by a price difference, the likelihood of establishing a contract can be expected to rise.

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

This section first summarises the reasons to consider IP systems in the GMO context, then reviews the current EU legislation on labelling and finally - with this background - identifies three approaches for IP related to the introduction of GMOs.

5.2.1. Reasons to consider IP systems in the context of GMOs

The fear of consumers that GMOs could have negative impact on their personal health can be a reason to require traceability. This would allow the identification and if necessary eradication of a harmful modification or product and could be a way to increase confidence in the new technologies.

Most crops are living organisms which are able to reproduce a plant. Biosafety considerations require traceability of GM crops to avoid uncontrolled gene transfer and possible danger for biodiversity, (see box on Biosafety Protocol in section 5.6).

There is a need for processors and traders to meet emerging mandatory GMO-labelling requirements in certain countries, in particular the EU, but also in Switzerland, Australia, New Zealand, Japan etc. The tolerance levels for labelling may differ among countries or still have to be decided. EU legislation on labelling is summarised in the following section.

The set of GMOs approved in different countries is not the same. For instance, some corn varieties grown in the US include transformation events not yet approved in the EU. Thus, IP could help to avoid trade disruptions due to differences in the approval status.

Consumer demand for non-GM or GM free food provides an economic incentive for farmers, processors and distributors to supply such products which require IP to be accepted by the consumer.

Furthermore, with the development of the second and third generation of GMOs, i.e. specific traits addressing the consumer and the procession industries, IP will become necessary to ensure providing the specific traits to the consumer and to enable a premium for the enhanced value.

5.2.2. EU legislation concerning GMOs, in particular labelling

The release of GMOs in the environment and their placing on the EU market are governed by Directive 90/220. GMOs can only be introduced onto the market after having been assessed and authorised to this end. In February 1998 the Commission tabled a proposal to amend this Directive, which is subject to the co-decision procedure between the European Parliament and the Council. The main objective of this revision is to increase the efficiency and the transparency of the decision-making process whilst ensuring a high level of protection for human health and the environment. With this view, Member States will be required to ensure labelling and traceability of GMOs at all stages of the placing on the market.

Sector-based legislation covers products derived from GMOs, in particular GM food. This legislation has to be further specified and extended, in line with the revision of Directive 90/220. The Commission will table a proposal on Novel Feed, including GM feedstuffs, in the second half of 2000. The White Paper on Food Safety[22] identified a number of actions to re-establish public confidence, in particular completing and harmonising labelling requirements.

- The Novel Food Regulation[23] and the seed legislation[24] already provide for mandatory labelling of food and seeds containing or consisting of GMOs. Two GM varieties, one of com and one of soya, and their derived products were already on the EU market before the Novel Food Regulation came into force. Therefore these two varieties were not subject to additional labelling requirements. In order to ensure the labelling of these varieties it was necessary to ensure the appropriate labelling through a specific regulation.[25]

With the adoption of this labelling regulation, the Council invited the Commission to study the practicability of setting down a de minimis threshold which takes account of the problem of adventitious contamination. In response to this request the Commission has adopted a regulation[26] which fixes a tolerance level of 1% for each single ingredient on the condition that the operator has taken appropriate steps to avoid the use of GMOs as a source.

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22 **COM(99)719 of 12/0 J2000.**

23 **Regulation (EC) No 258/97.**

24 **Commission Directive 98/95/EC.**

25 **Regulation (EC) No 1139/98.**

26 **Regulation (EC) No 49/2000.**

A (non-exhaustive) list of food ingredients or foods comprising a single ingredient in which neither protein nor DNA resulting from GM is present, shall be drawn up. The negative list is a concept applicable to processed GM products in which no genetically modified material can be detected any more. These products would be exempted from compulsory labelling.

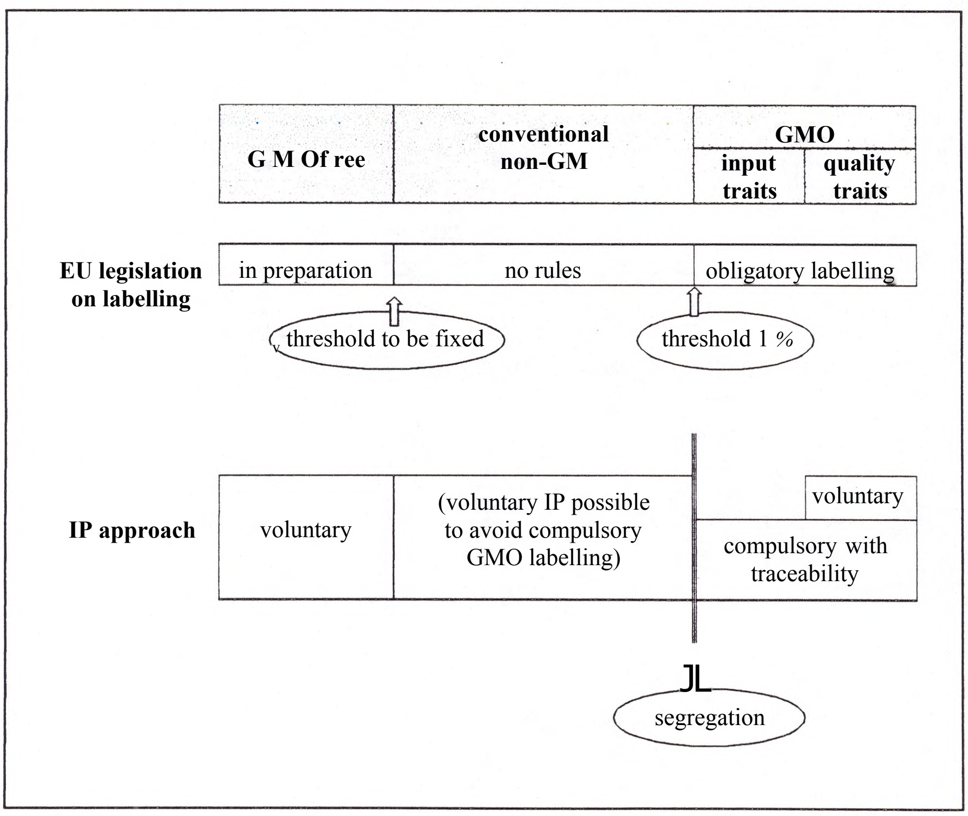
In January 2000 the Commission also introduced labelling requirements for additives and flavourings that have been genetically modified or have been **produced from GMOs.**[27]

The Commission White Paper on Food Safety proposes the harmonisation of labelling rules for food, additives, flavourings, clarification of the authorisation procedures in the Novel Food Regulation and the establishment of a legislation concerning food and food ingredients produced without genetic engineering.

5.2.3. Three approaches to labelling and Identity Preservation in the GMO context

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 .4).

Figure 5.4 Labelling and Identity Preservation



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[27] **Regulation (EC) No 50/2000.**

1. Voluntary IP of specific GM **traits:** IP systems are common practice for crops that have a specific value to their consumer, for example through improvements in nutritional value, colour, texture, flavour or processing properties. With the development of new traits by biotechnology, 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.

Testing: The economic viability of a GM product with consumer oriented traits will depend largely on the ability to identify these specific values in a cost efficient way. In general, detection and quantification of modified DNA and protein depend on the availability of appropriate reference material (Lipp ***et al.,*** 2000).

Tolerance: GMOs offering specific qualities to the producer and the final consumer will only be accepted if these qualities can be guaranteed within a certain tolerance level. Tolerances will have to be fixed in accordance with the purity expectations of the buyers of these products.

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 5.4).

Some European food trade companies which are trying to serve the non-GMO market niche are claiming that they are supplying non-GMO products. However, the explanations and guarantees given to the consumer sometimes lack a sufficient transparency. A Wall Street Journal article (October 26, 1999) stated both confusion and legal risk in the current labelling which can be found in supermarkets. An investigation of 94 companies by the French Ministère de l'Economie, des Finances et de l'industrie (1999) revealed that more than 50% of the enterprises had modified the composition of their products to avoid GMO labelling. Most of them had attestations by their suppliers, 14 enterprises were able to present traceability documents and 19 got analytical certificates.

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 GM food, some conventional raw material would enter into GM-labelled final products.

<u>Testing:</u> Reliable testing will be necessary to prove that a product does not contain or contains only a limited percentage of GM material. A workshop on GMO research perspectives held in the context of the EU Fifth Framework Programme identified the "development of rapid, reliable detection methods for GM foods and their derivatives" as one of the top priorities for further research in the GMO context (External Advisory Groups, 1999).

For international trade a standardised test would help to avoid liability conflicts and trade distortion in case of different labelling requirements and approval status (Brookins 2000). The American National Grain and Feed Association, for instance, has called for the introduction of an accurate, repeatable and low cost test to distinguish between conventional and GMO **products.** USD A **has recently announced that it will establish a reference** laboratory to evaluate the validity of analytical procedures and to establish sampling procedures for use in testing bioengineered grains and oilseeds (USDA, 2000).

The more expensive testing for GMO, the more likely will be arrangements based on declaration of honour concerning the GMO-free status of a product. This would imply a certain system of field and production control to satisfy consumer confidence.

Example for IP **system based on producer declarations and testing: Champagne céréales, non-GM corn** (Oustrain 1999)

- GMO survey among suppliers: to be completed by all the com producers before their first delivery;
- **at reception: control of the declaration of the supplier (checking** GMO survey);
- without signed commitment:
  - on the spot signature of the requested commitment and acceptance of the shipment;
  - refusal of the supplier to sign any commitment (or detection of GMOs): isolation of this shipment outside the silo or directing to a dedicated dryer;
- representative testing of all silo compartments, strict and detailed sampling plan.

<u>Tolerance:</u> Most crops can easily be contaminated with other material by pollen drift or by mechanical commingling during harvest, storage or transportation.

The debate about tolerance levels has raised other questions concerning the non-GM status of a plot or farm on which GM crops have been grown. The argument is that inherited modified genetic sequences are likely to persist on the farm - for example in the case of rape - even after the crop has been harvested and sold. Standards for non-GM or GM-free lines will have to address this question.

Contracts: To sell IP crops farmers will have to agree on terms of contract with their trading partners. Such contractual arrangements always imply the question of liability. Some proposed voluntary certification procedures have been developed for producers wishing to segregate non-GMO commodities in response to a premium offered.

Currently most US extension services have warned farmers to be careful when signing a contract to supply non-GM or GMO-free products, since accidental contamination cannot be excluded (Charpentier, Hazouard, 1999).

3. **Compulsory IP for GM products (GM traceability):** Trading GM crops as part of a commodity system would result in losing their track 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[28] traceability will be required: "It is necessary to ensure traceability at all stages of the placing on the market of GMOs ..." (Common Position, recital No. 40). Member States are invited to ensure traceability at all stages.

Testing: In general the testing requirements for GMO traceability would be the same as for GM-free products. However, the objective will be to detect the presence of specific modifications and not to measure the quantity versus a threshold. Reference material and genetic sequence information will be needed to develop reliable tests.

Tolerance: The tolerance approach can be expected to be very strict if the objective is to ensure traceability. Every bunch containing only a minimum trace of a certain GMO would have to be identified.

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

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. However, the magnitude of IP costs will depend on several factors which will be summarised at the end of this chapter.

Many opportunities for mixing and contamination exist along the production, processing and distribution chain of an IP product. Thus, IP costs arise on different stages of the chain: seed production, farm, transport, further storage, processing, labelling and distribution. The following overview of additional costs corresponds to the structure suggested by Buckwell ***et al.*** (1998). Some empirical experience has been added to illustrate the magnitude.

5.3.1. IP costs for seed production

Already under conventional systems basic and certified seed is normally distributed separately bagged and labelled. No difference would occur for an IP system.

The two main sources of mixing seed varieties are through pollen and through other seeds. Avoiding such contamination is a usual feature of seed breeding. The EU has fixed minimum distances from neighbouring crops of different varieties or inbred lines of the same species (table 5 .1). For instance, certification of basic seed requires a minimum distance of 400 m for cross-pollinating oilseeds, 300 m for rye and of 200 m for com.

The minimum varietal purity for basic seed of oats, barley, wheat, spelt and rice has been fixed at 99.9% and at 97% for soybeans. Several other purity criteria are provided by the seed directives concerning the minimum germination rates, analytical purity and the maximum content of seeds of other plant species.

Purity criteria applied for seed multiplication (certified seed) are partially less restrictive than for basic seed (table 5.1). The cordon sanitaire for the production of certified oilseeds for instance amounts to 250 m for certified rye seed and to 200 m for corn and for cross-pollinating oilseeds. The minimum varietal purity for oats, barley, wheat, spelt and rice has been fixed at 99.7% for first generation certified seed and at 99% for second generation.

At least for certified seed of soybeans and beets, the current EU standards for varietal purity might conflict with the tolerance levels for GMO labelling. For soybeans, the EU seed marketing standards require a minimum purity of 95%. This means that seed could contain up to 5% of other varieties, possibly including GM varieties. During the last years, the EU has imported soybean planting seed from the US, where the purity norm for soybean seed runs about 98% (Blumenthal, 1999). For beet seeds, the varietal purity has been fixed at 97%.

Table 5.1 Selected EU Standards for seed production

Crop	Category	Minimum distance from neighbouring crops	Minimum varietal purity (%)	Source
Com	basic seed certified seed	200 m 200 m		Directive No 66/402/EEC
Rye	basic seed certified seed	300 m 250 m		Directive No 66/402/EEC
Oats, Barley, Wheat, Spelt	basic seed certified seed 1. generation 2. generation		99.9 99.7 99.0	Directive No 66/402/EEC
Cross-pollinating Oilseeds	basic seed certified seed	400 m 200 m		Directive No 69/208/EEC
Soybeans	basic seed certified seed		97 95	Directive No 69/208/EEC
Sugar and fodder beet *)	basic seed certified seed	1000 m 600 m	97 97	Directive No 66/400/EEC

***) Distance from other subspecies of Beta vulgaris. Minimum distances from other types and varieties of sugar beet are lower.**

The crucial variable to determine the additional costs in seed production is the tolerance level applied for IP. Currently farmers obtain a premium of 15 to 20% for the extra work required for the production of wheat crop for seed compared with growing normal wheat crop for commercial sale (Cargill, 1999). 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.

5.3.2. IP costs on the farm

Four potential sources of mixing GM and non-GM crops on a farm have been described by Dale (1999):

- contamination of seed used by the farmer (within the limits of genetical purity);
- crop mixing with volunteer GM plants that are already present in the soil when the crop is sown;
- mechanical commingling in sowing, harvesting and storage;
- cross pollination with other varieties which varies with the distance, sexual compatibility between crops and the method of pollen transport **(wind, insects).**

The farmer will be able to control the likelihood of volunteer plants, mechanical commingling and the distance to avoid cross pollination.

The number of volunteers can be reduced by cultivation practices or by herbicides. In fields where rapeseed has been grown, volunteers are likely to grow during a period up to seven years. Volunteers of herbicide tolerant variants should be treated by alternative non-selective herbicides (SCIMAC, 1999).

To avoid mechanical commingling, the planting and harvesting equipment must be thoroughly cleaned before use. Furthermore, the on-farm storage facilities must be cleaned or new facilities must be provided to separate IP crops. The costs of cleaning, in particular the amount of time spent on this mainly depends on the required tolerance level. Due to cleaning breaks, there may be additional cost associated with a reduction in work time during which the harvest machine is operational. Moreover, a particular low tolerance could require the use of separate machinery for each crop.

Physical distance between the pollen donors and the crop is the most important factor to avoid cross pollination among specific varieties. The amount of cross pollination also depends on the amount of outbreeding in the crop, the overlap of flowering periods and the area of the crops grown (Moyes and Dale, 1999).

In the UK context, SCIMAC has set up guidelines for good agricultural practice for growing herbicide tolerant crops which provide minimum distances from certified seed crops, organic crops and conventional crops of the same species. Basic guidelines for growing GM crops with specific **agronomic traits** are **currently under development** (SCIMAC, 1999). **On** the other hand, the standards for organic farming provided by the UK Soil Association require minimum distances from GM crop plantings which are significantly higher than the SCIMAC provisions (Soil Association, 1999).

Cross pollination furthermore may affect the relationship between neighbour farms. GM cropping on one plot may affect the non-GM status of another plot, and more controversially, the GM status of other farms. The possibility of litigation with neighbours could also influence the economic considerations of a farmer (Griffiths, 1998). SCIMAC's guidelines propose that "the onus lies with the GM grower to notify neighbouring farms in writing of his planting intentions." This issue is of particular importance if the neighbour is growing organic food, where GMOs are prohibited in general. Failure to reach agreement must be notified to SCIMAC and has to be solved by further consultation or through normal legal channels (SCIMAC, 1999).

Cross-pollination and commingling raise a number of legal and economic issues concerning the coexistence of three production systems: GM, conventional, and organic.

IP products would be very likely to be grown at a contractual basis. Contracting requires certain transaction costs for all contracting parties involved, such as the time devoted to negotiations and probably some fees.

Keeping accurate records is essential to ensure IP and traceability. Record keeping might result in additional work for the farmer. Cargill (1999) has pointed out that farmers growing IP crops also face additional price risks and their options for selling the crop might be reduced.

Table 5.2 indicates some examples for additional cost at the farm level and the available information about premia currently paid to farmers. However, the premia may not only reflect the additional costs of segregation but also the additional value of a certain trait or a certain production system.

The examples for soybeans indicate that US producers have received a premium of 5 - 9 €/t for non-GM soybeans in the last years. This amount corresponds to the IP costs for GM soya with specific traits and represents about 4% of the farmgate price. More recent sources signal a lower premium level of 3 - 7.5 €/t which corresponds to 1.5 - 4.4% of the average price received by US farmers. European farmers are offered a slightly higher premium of 11 - 12 €/t for non-GM soya and in 1998 some buyers also seemed to be willing to pay a premium up to 24 €/t above the conventional US price to get Brazilian non-GM soya.

However, according to US grain handlers, the premium paid for food quality soya was much higher than the non-GM premium. The average price of food use was estimated to be 35 €/t higher than the commodity price for soybeans (Bender ***et al.***, 1999). In autumn 1999, the IP premium for quality traits ranged from 20 €/t for medium high protein contents to more than 140 €/t for sugar balanced soybeans compared to an average commodity price of 170 €/t (Clarkson, 1999).

Table 5.2 Soybeans: IP costs and segregation premia at the farm level

IP approach	**country**	**Year**	**IP cost/ premium**	**% of price*)**	
GM quality traits: low linolenic, high oleic, low saturate, high protein, high sucrose	USA	**(1997)**	**8 - 9 €/t**	**4%**	(1)
non-GM herbicide resistant (DuPont STS programme)	USA	**1998**	**5 - 8 €/t (premium)**	**(2.4-3.8%)**	(2) (3)
non-GM herbicide resistant	**Brazil**	**1998**	**24 €/t **)**	**10%**	(1)
non-GM	**France**	**Spring 1999**	**11 - 12 €/t (premium)**		(4)
non-GM herbicide resistant (ADM)	USA	**1999**	6 - 7 €/t **(premium)**	**(3.5-4%)**	(3)
non-GM commodity grade US#1	USA	**Autumnl999**	**7.5 €/t (premium)**	**4.4%**	**(5)**
non-GM	USA	**Sept 99 Feb 00**	**3.6 €/t 2 - 3 €/t (premium)**	**(2%) (1 -1.5%)**	(6)
non-GM	USA	**(1999/ 2000)**	**3.8 - 5.7 €/t (premium)**	**(2-3.2%)**	(7)

***) farmgate price (percentages in brackets have been calculated by DG Agriculture)**
****) due to higher average price for Brazilian soybeans**
Sources: (I) Buckwell et al. 1998; (2) Bender et al. 1999; (3) Deutsche Bank Alex. Brown 1999; (4) Circuits culture 1999; (5) Clarkson 1999; (6) Brookins 2000; (7) Lin 2000

The premium for organic soybeans was estimated at 245 €/t (commodity quality). This means producers of organic soybeans received 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 organic farming in order to realise the higher market price.

In contrast, GM soybeans (without specific quality traits) are being discounted by up to 10% of the farmgate price in many parts of the USA because foreign buyers and some US companies have announced not to buy GM material. Therefore many grain elevators are discounting not only GM varieties but all varieties because they cannot separate due to a lack of facilities to handle both types.

While quality trait premia (high oil contents) for com 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 com. 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 com compared to conventional varieties (see chapter 3).

Table 5.3 Corn: segregation premia at the farm level

IP approach	country	year	IP cost/ premium	%of price *)	
Quality trait (conventional) high oil contents	**USA**	**1997**	**5.3 €/t (premium)**	**5%**	(1)
Quality trait (conventional) high oil contents	**USA**	**1998**	**4.2 €/t** (premium)	**(5%)**	(2)
Quality trait (conventional) high oil contents (Optimum Quality Grain)	**USA**	**2000**	**6.1 €/t (premium)**	**(7.5%)**	(7)
Non-GM	**USA**	**Autumn 1998**	**1.8 - 2.8 €/t (premium)**	**(2.5-4%)**	**(3)**
Non-GM commodity grade US#2 yellow	**USA**	**Autumn 1999**	**5.6 €/t (premium)**	**(9%)**	**(5)**
Non-GM	**USA**	**(1999/ 2000)**	**2 - 4 €/t (premium)**	**(3-4.5%)**	(7)

***) farmgate price**
Sources: (1) Buckwell et al. 1998; (2) Bender et al. 1999; (3) Deutsche Banc Alex. Brown 1999; (5) Clarkson 1999; (7) Lin 2000

As well as for soybeans, the premium for com used for food was much higher than the non-GM premium. In 1998 the food use premium was more than 12 €/t, i.e. more than double the non-GM premium. For very high protein contents US farmers could receive a premium of 50% of the commodity price, which was at about 75 €/t in autumn 1999 (Clarkson, 1999). The premia for organic com ranged from 75 to more than 110 €/t.

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). However, a Canadian example for GM herbicide-tolerant oilseed rape (Canola) shows that farmer's costs for separate storage and handling can be as low as 0.5% of the farmgate price.

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.

5.3.3. Costs for testing

The easiest and probably cheapest way to segregate different grain varieties would be to use grain confetti for identification. Nevertheless, qualitative and quantitative testing may be required to control for particular specifications and GM contents. 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: a PCR (Polymerase Chain Reaction) test based on DNA detection and the ELISA (Enzyme Linked ImmunoSorbent Assay) test based on protein detection. Validation programmes for both methods are currently exercised by the EU Joint Research Centre (Lipp *et al.* 2000).

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. In the latter, the method is laborious and costly. PCR requires little reagent development time compared to immuno-logical assays, 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. Antibodies are soluble proteins produced by the immune system of animals in response to exposure to a foreign substance (called antigen). For GMOs, the antigen can be the newly synthesised protein. 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. Similar to PCR, the ELISA method requires trained personnel and specialised equipment. 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.

The DNA-based PCR test takes 1-3 days, at a cost of 104 - 310 € per test. The ELISA test takes only 2-8 hours and may cost up to 10 € per test. A faster and simpler ELISA dipstick test to provide a "yes or no" result takes 5-10 minutes and costs only 3.6 € per test (ACPA 1999, Lin 2000).

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 com 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 required to determine if a shipment is free of biotech material, in particular for com. 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).

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). A 1996 Canadian IP example for herbicide resistant GM oilseed rape indicates a total cost for testing, administration and monitoring the IP system of 2.9 €/t (Buckwell ***et al.*** 1998, p.65). 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, for example, on the spot testing of commodities for GMO contamination or specific traits.

5.3.4. IP costs for transportation andfurther storage (merchandising)

Additional costs will occur with the need to find separate storage at local elevators and with possible restrictions in the delivery schedule. An IP system for non-GM crops would require traditional elevators to handle at least four types of grains - two types of corn (more likely three incl. high oil com) and two types of soybeans. This reduces their capacity to quickly and efficiently receive grain at harvest time and will reduce their effective storage capacity. If transportation and storage facilities in silos, trains, trucks or ships cannot be fully used by IP crops, further costs might occur per unit.

Table 5.4 Some examples for IP costs at the elevator level

Crop	IP approach	country	Year	IP cost €/t	% of price*)	
Soybean	GM quality traits: low linolenic, high oleic, low saturate, high protein, high sucrose	USA	(1997)	1.6 - 3.3 €/t	0.6-1.3%	(1)
Soybean	Non-GM STS herbicide tolerant	USA	1998	6 €/t		(2)
Soybean	Non-GM (ERS estimation)	USA	2000	20.6 €/t **)		(7)
com/ maize	Quality trait (convent.) waxy maize	Europe	(1997)	3.2 - 8.0 €/t	2 - 5%	(1)
com/ maize	Quality trait (convent.) high oil content	USA	1997	1.0- 1.8 €/t	1.0-1.7%	(1)
com/ maize	Quality trait (convent.) high oil content	USA	1998	2.1 €/t		(2)
com/ maize	Non-GM (ERS estimation)	USA	2000	9 €/t **)		(7)
Oilseed rape	GM traceability herbicide resistance	Canada	1996	4.7 - 6.9 €/t	2.8-4.1%	(1)
Sun-flower	Quality trait high oleic	USA	1997/ 1998	1.6 - 3.3 €/t	0.6-1.3%	(1)
*) farmgate price **) marketing cost from country elevator to export elevator, incl testing *Sources: (1) Buckwell et al. 1998; (2) Bender et'al. 1999; (7) Lin 2000*						

For IP crops the transport and storage means have to be <u>cleaned</u>. Avoiding any co-mingling during the loading or unloading process would require cleaning the equipment and would entail labour downtime costs during cleaning. The costs incurred would mainly depend on the tolerance level.

Another cost element for IP appears for <u>seasonal crops</u>. EU soybean imports generally come from Brazil and Argentina during the summer and from the US in winter. If it would not be possible to set up IP chains both in the US and in South America, some material would require storage to ensure a constant stream of supplies (Cargill, 1999). However, storage would be more expensive than transportation and might add 15 - 25% to the price of the raw material (Cargill, 1999).

US **survey on firms handling speciality crops** (Bender *et al.* 1999)

A spring 1998 survey of 84 US firms trading speciality com and soybeans (of a total of about 200 US firms) reports that 56% of the speciality (IP) crops traded by these firms were from local origin (max. 15 miles away) and only 5% originated more than 250 miles away. The data suggest that as the percentage of speciality crops handled by a firm increases, they must be collected from an increasingly larger radius. On average, 96% of speciality crops were delivered by truck, 3% were delivered by rail, and 1% by other methods.

Speciality crops **handled** include 61% stored on farm, 23% stored at the country elevator, and 14% received at harvest. The average percentage of speciality crops purchased through farmer contracts was 85%. Contracts with country elevators accounted for 8% of specialty crop purchases and only 5% were purchased through the open market. The contracts varied between basic contracts with quality adjustments (26%), flat price contracts (23%), basic contracts (20%), acreage contracts (16%) or forward contracts (12%). Quality tests are made at delivery (93%), at the farm (56%), for the required variety (83%) or at seal bins (18%).

About 80% of the speciality crop was shipped in bulk, 20% in bags, in particular soybeans for food. The primary market for speciality crops was the export market (47%); 33% went to processors (STS soybeans and food com), 6% went to brokers and 7% to livestock feeders (in particular high oil com).

. The additional costs incurred in handling speciality com have been estimated to be 6 €/t. Average cost increase for handling was less for high oil traits (2.1 €/t) than for food use com (13.7 €/t).

For soybeans the additional costs of handling has been estimated to average 15.8 €/t. The additional costs for food use was 20 €/t and for non-GM STS soybeans it was 6 €/t.

Distribution costs to different cost items shows that all of them were higher for speciality soybeans than for com, except for the analysing and testing cost which were at the same level (see table in annex B).

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. Lin (2000) reports the results of an ERS survey that the cost for segregating non-GM crops could be higher than for speciality crops but does not present any data.

The key factors will be the amount of crop traded under the different IP systems and the tolerance level for contamination.

<u>Internet marketing:</u> Several actors are offering trade contracts on their websites. Buyers are thus asked to submit requests in good time to allow farmers to adjust their planting decisions and order the appropriate seed (Young, 1999 for DuPont).

Electronic trading and the internet would shorten the chain from the producer to the end user. This would allow multiple IP and marketing systems to exist.

The internet is also used to call for a buying networks of farmers to combine their negotiation power. Registration of farmers and quantity indication by each member would allow to concentrate selling negotiations and organise transportation needs. (Progressive Ag Marketing 1999).

5.3.5. Additional Costs for the processing industry (feed andfood)

Storage tanks of processing plants have to be cleaned prior to use for IP products. Very low tolerance levels might require dedicated storage facilities. A feed mill would probably not want both GM and non-GM supplies of the same ingredient, because of the difficulty of keeping them apart.

Table 5.5 Some examples for IP costs at the processing level

Crop	GM / non-GM	Country	year	IP cost €/t	%of price*)	
Soybean	Quality trait (convent.): crushing level	USA	(1997)	1.6 - 3.3 €/t	0.6-1.3%	(1)
Soybean	Quality trait (convent.) refining level	USA	(1997)	3.9 - 7.8 €/t	1.5-3.1%	(1)
Com	high oil content (non-GM) milling	USA	1997/ 1998	8.9 €/t		(1)
Sun-flower	high oleic crushing level	USA	1997/ 1998	1.6 - 3.3 €/t	0.6- 1.3%	(1)
Sun-flower	high oleic refining level	USA	1997/ 1998	3.9 - 7.8 €/t	1.5-3.0%	(1)
Oilseed rape	GM: herbicide resistant	Canada	1996	1.7 - 2.9 €/t	1.0-1.7%	(1)

*) farmgate price
Sources: (1) Buckwell et al. 1998

The capacity of larger US processing plants for soybeans and com is between 2000 and 8000 tonnes a day (Cargill, 1999). Normally, they are run continuously except for annual cleaning or repair breaks. Stopping production and cleaning the facilities would cause additional cost. Therefore, the solution for the processing plants could be to use a certain quantity of IP grains to "clean" the plant and to sell the product mixed with non-IP output. Only after a certain period of IP grain use, the IP supplies run through would be guaranteed to retain their identity. The cost of this solution clearly depends on the quantity of IP supplies put through.

The cost of IP processing would 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.

Samples and tests might be necessary to ensure quality specifications or to check for the required level of tolerance. Ensuring correct product labelling would require additional time and costs as well as the re-setting, re-designing and printing of labels.

The examples given in table 5.5 indicate additional costs of 1.5 - 9 €/t, which is about 0.5 - 3% of the farmgate price of the product concerned.

5.3.6. Total costs for IP systems

Summarising the different costs along the production chain allows the total costs of IP to be estimated. According to the examples available, they range from 5 to 25 €/t depending on the different grains and the IP systems. Thus, IP would increases the grain price by 6 - 17% compared to the farmgate price. These results confirm the conclusions of Buckwell ***et al.*** (1998) for quality traits. 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.

For modifications that focus on agronomic traits, Buckwell ***et al.*** stated some difficulties to assess the representativity of the examples. However, the more recent examples confirm a similar range of additional costs compared to IP systems for quality traits.

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

- Tolerance: The more stringent the purity requirements, the more expensive will be the IP system. For the farmer, the size of the premium will also vary with the degree of purity required in the crop (Cargill, 1999). The tolerance level is an important cost factor 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.

Table 5.6 Some examples for total costs of Identity Preservation for GM/non-GM crops

Crop	GM / non-GM	country	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	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 / com	Any type of identiy preservation	USA	1999	4.7-21.4 €/t		(4)
Com	post harvest chemical free	USA	(1997)	14 €/t	16% *)	(1)
Com	high oil content	Europe	1997/9	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

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 on 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 (see also section 5.3.2).

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

Scenario 1: 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)

Scenario 2: 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.

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, p.21). 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 5.7). The degree of self-sufficiency varies between 6% (soymeal) and 18% (soya oil) in 1998/99.

Table 5.7 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	688	741	1 185	1 417
- from imported seed	11 865	11 164	11 067	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	159	171	274	327
- from imported seed	2 738	2 576	2 554	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				

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 (table 5.8). During the last years, soybean imports from the USA have been reduced, while imports from Brazil increased. On the other hand, soymeal imports from Brazil decreased and imports from USA and Argentina increased.

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 5.8 EU imports of soybeans and soymeals (in soymeal equivalents - soybeans = 79% meal)

		1995	1996	1997	1998	1999
Total EU imports	mio t	25.5	22.2	20.8	24.8	23.5
of which **USA**	million t	8.5	7.1	7.2	7.0	4.9
	% of total	*33.1%*	*32.1%*	*34.7%*	*28.2%*	*20.9%*
Brazil	million t	10.0	8.9	8.6	10.2	9.8
	% of total	*39.4%*	*40.2%*	*41.5%*	*41.2%*	*41.5%*
Argentina	million t	5.8	5.2	4.0	6.1	8.0
	% of total	*22.8%*	*23.4%*	*19.1%*	*24.6%*	*34.0%*
others	million t	1.2	0.9	1.0	1.5	0.9
	% of total	*4.7%*	*4.2%*	*4.7%*	*6.0%*	*3.6%*

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 com production, the EU has reached a degree of self-sufficiency which is around 100% (table 5.9). 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 t each year (11-12%), and human consumption for 2.6 Mio tonnes (7%).

Table 5.9 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 com by-products, in particular com gluten feed, surmount the imports of com grains. In 1999, around 4.7 Mio tonnes of com gluten feed was imported by the EU. The value of EU com gluten feed imports from the US (1998: 500 million €) for instance is higher than the value of com imports (1998: 240 million €).

Table 5.10 EU imports of corn

EU imports		1995	1996	1997	1998	*1999*
total	Mio t	3.9	2.7	2.7	2.0	***2.6***
of which **USA**	Mio t	3.3	2.0	1.7	0.2	***0.06***
	% of total	***86%***	*77%*	***64%***	*12%*	***1.1%***
Argentina	Mio t	0.5	0.6	0.9	1.4	***2.0***
	% of total	*14%*	*22%*	*35%*	*74%*	*78%*
others	Mio t	0.02	0.04	0.03	0.4	***0.53***
	% of total	*0.5%*	*1.5%*	*1.3%*	*14.3%*	*20.4%*

Source: European Commission, Comext, 2000

For com the USA is the worlds leading producer and exporter, although only 20% of the US com 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 com have decreased dramatically. The share of US in EU com imports dropped from 86% in 1995 to 12% in 1999. Meanwhile Argentina has become the major supplier for EU imports.

Table 5.11 EU imports of corn by-products

		1995	1996	1997	1998	*1999*
Total EU **imports**	Mio t	7.0	5.8	5.8	5.4	***5.4***
of which **Corn Gluten Feed**	Mio t	6.1	4.7	4.8	4.6	***4.661***
Brewers grains	Miot	0.9	0.5	0.6	0.7	***0.628***
Corn germ cake	Mio t		0.53	0.39	0.10	***0.129***
Source: DG Agriculture /Member States						

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

Soybeans: World production of soybeans is expected to be 153.5 Mio t 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, even if co-mingling is very likely to reduce the available non-GM quantity, 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.

Furthermore, other factors may influence EU 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-GM com crops is uncertain, although the percentage of GM plantings is quite well known. Farmers have been requested to plant alternating stripes of Bt and non-Bt com to provide refuges for com borers and to reduce the probability of building up resistance. Thus some of the non-GM com would be cross-pollinated and co-mingled with the GMO crop during harvest.

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 com and 20% will segregate soya in autumn 2000. One out of ten elevators has declared to offer a price premium for conventional com 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 com (Pioneer Hi-Bred International, 2000).

According to a Reuters[5] 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).

For the USA, some estimations of possible market share have been made: If the entire US food processing industry switched to non-GM com, the market for non-GM com would constitute 8% of the 1998 US com market. If the sweetener and the ethanol (by-product of com) industries joined, non-GM com would constitute 20% of the US com 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 com in the US is 37% (Miranowski ***et al.,*** 1999).

A French research team (Valceschini, 1999) is assessing the economic relevance and the technical feasibility of non-GM supply chains. Preliminary results on consumer reaction with regard to GM food were presented in December 1999. The researchers observed the buying decisions of consumers when choosing between GM and conventional products, the GM ones being properly labelled. Based on the observed sample, one third of consumers reject GM-labelled products, another third would buy them if they were cheaper than presently and a last third does not care and buys them. On this provisional basis, the authors assumed that appropriate labelling of the GM nature/origin of foodstuffs will have a significant impact on consumer demand. However it is difficult to quantify this impact.

It is interesting to note that three consumer groups of the same size are identified. This could echo the three-tiers market previously identified: GM, non-GM and GM-free. The "middle" group of consumers shows a very price-elastic behaviour. If GM foodstuffs are cheaper than presently, which means cheaper than conventional food, these consumers could adopt them. This is another factor suggesting a possible decline in the market share of the non-GM tiers.

5.5.3. Different stance on food andfeed uses

The EU balance sheets for soya and com have shown that the main use of soya and com 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.

In Europe, some operators are already organising non-GM soybean supply chains for animal feed (see box on Soya de Pays). Depending on the quantities needed, the origin is mainly domestic (French and Italian soybean production) or foreign, in particular imports from Brazil. However, these initiatives concern a limited share of the feed market. Most initiatives are taken in the poultry sector. This might echo the attempts 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).

Soya de Pays, France

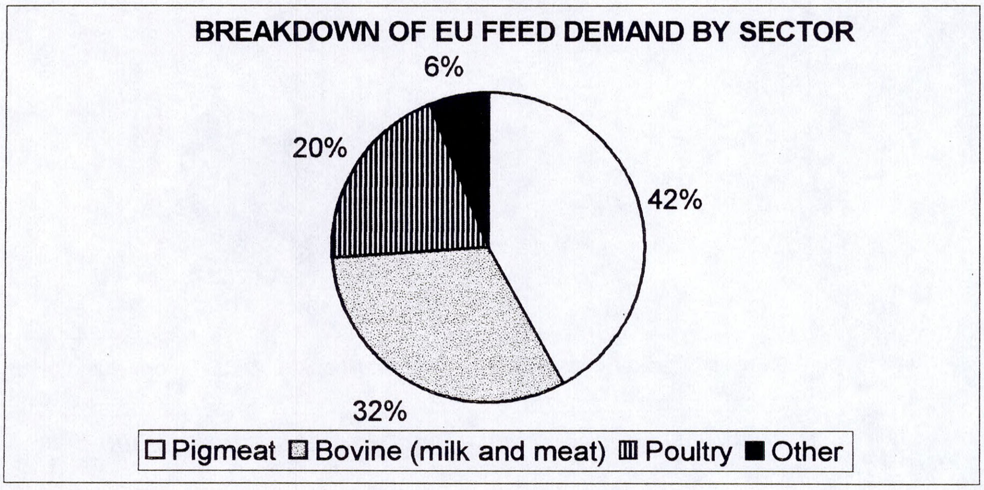
Feed producer Glon Sanders and poultry producer Bourgoin have established a production chain for non-GM eggs and poultry meat production based on French non-GM soya. Participating farmers are not allowed to plant imported US soybean seed, have to enable traceablity back to the producer, respect distance from pollution sources and other requirements.

The costs of IP are entirely bome by soymeals, as non-GM soybean oil cannot be easily valued because of substitution with rapeseed oil. French non-GM soybeans cost 30% more than imported ones. The first chickens fed with non-GM soya ("soja de pays") have been on shelves in April 2000. The first eggs were already introduced in February and their price is 15% higher than standard eggs. Farmers producing chicken said that thanks to the "soja de pays" initiative, they could get a premium of 15 €/t. Based on increasing demand from processing industries, areas under "soja de pays" are forecast to raise from 20,000 ha in 1999 to 60,000 ha in 2000, which represents 60% of the French soybean area.

While poultry is mainly fed with compound feedstuffs, cattle and pigs are both fed with compound and simple feedstuffs. In the EU 42% of the key marketable feedstuffs[29] are absorbed by the pig sector and 20% by poultry. Soymeals also enter in the feed ration of cattle, which accounts 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.

[29] **Marketable feedstuffs do not include green forages.**

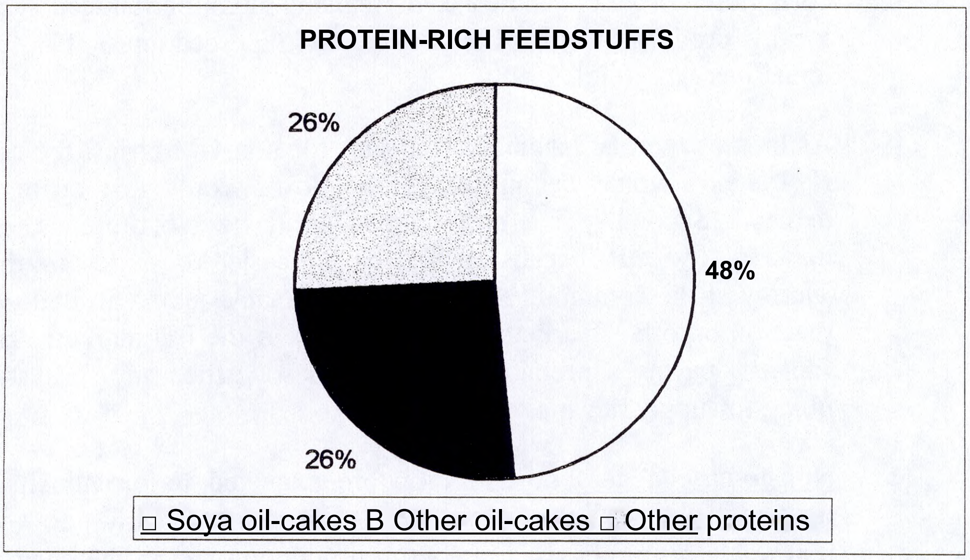
Figure 5.5 Breakdown of demand for feedstuff's in the EU

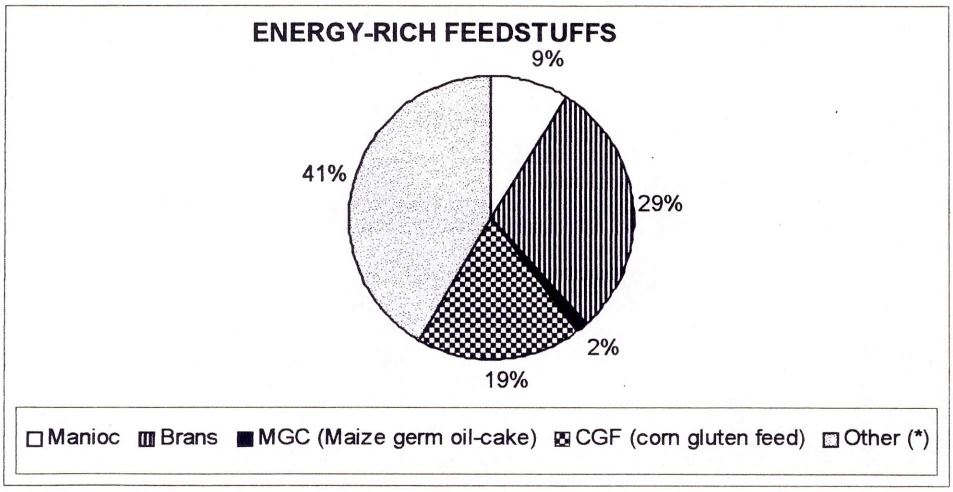


Soymeals, com and its co-products account for key elements in animal feed. Three groups can be distinguished among key marketable feedstuffs:

- cereals (54% of marketable feeding stuffs in the EU);
- energy rich elements (27%),
- protein rich elements (19%).

Figure 5.6 Protein and Energy rich feedstuffs on the EU market





Source for graphs: Commission, own calculations, 2000

Cora, in the form of grain, represents a quarter of cereals used for animal feed. Com Gluten Feed and Com 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 com products and soybeans for energy and protein rich feedstuffs, and to its exposure on GM products.

In short term, segregation of the feed market into GMO and non-GMO stuff would increase feed production costs and thus animal production costs within ■ the EU. Depending on the market development, imports in soybean meal, com gluten products and other ingredients might be reduced and demand for locally produced feedstuffs, particularly rapeseed meal, barley and wheat could increase. (Gill, 1999)

As long as there are significant origins for non-GM crops, the need to set up IP systems would be limited. Trade flows would just adapt to this new demand. Secondly, if a product can easily be substituted, 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, the reaction on other markets will be relevant to the EU market. For instance, if Japan is paying a premium for non-GM soya then any IP system set up is going to supply this market first.

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, 1999 and Eurobarometer, 2000).

However, according to Menrad (1999), non-food applications of biotechnology would need a concerted effort involving science, industry and politics, also taking into account the interests of other groups (eg farmers) to speed up.

5.6. The trade issue/dimension

While accounting for the main producer of GM com 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 com. Between 1995 and 1997, EU imports from the US were worth, on average, 2 billion € for soybeans and soymeals and 0.03 billion € for com. In addition, EU imports of Com 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 USD A 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 com than for soybeans. US com 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 com. On the EU market for com, the share of US has steadily fallen while the share of other partners, in particular Argentina and Hungary, has significantly increased. The USD A considers that the loss of shares on the EU market results from issues related to biotechnology, in particular the differences in regulatory approaches.

While 11 types of GM com have been approved in the US, only 4 have been cleared at EU level (table 5.12), 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.

Table 5.12 Approvals of GM crops in the EU and the US

	US		EU		
GM crops	approved	% sowings	approved	pending	
Com	11	35%	4	5 among which	1 already approved for import s&process 2 are the same GM crop but with different uses
Soybeans	3	50%	1	none	
Rapeseed	3	15%	4	3	only one is same as in US

Source: International Grain Council 1999, expect for % sowings (own estimation)

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 USD A, only a small part of US areas have been sown to non-EU approved com varieties and the EU only accounts for 1% of US com 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 GMOs 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.

Biosafety Protocol

The Biosafety Protocol provides a framework for addressing environmental impacts of bioengeneered products that cross international borders. It was concluded in Montreal in January 2000 by delegates from 138 countries.

"In accordance with the precautionary approach (...), the objective of this [Biosafety] Protocol is to contribute to ensuring an adequate level of protection in the field of safe transfer, handling and use of Living Modified Organisms resulting from modem biotechnology that may have an adverse effect on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focussing on transboundary movements" (Article 1).

The procedures foreseen under the Protocol are different for Living Modified (LM) seeds and commodities.

- **For LM seeds: Advance Informed Agreement procedures shall apply before the first transboundary movement of seeds. Notification of exporter before movement. Accompanying documentation with precise identification and requirements.**
- **For LM commodities used as food, feed or for processing:**
  - **Information sharing on approved LMOs through Biosafety Clearing House. Possibility for developing countries without domestic regulation on LMOs to take decisions on imports under the Protocol, to benefit from assistance (financial, technical, capacity-building).**
  - **Documents accompanying transboundary movements of LMO commodities stating that they "may contain LMOs". Detailed requirements on the identification of LMOs should be adopted within two years after the entry into force of the Protocol (entry into force itself might require 2 years).**

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.

Finally, it is worthwhile noting that Identity Preserved markets are expected to increase in number and market share, with or without GMOs entering the markets. Trade experts have estimated a 25% market share for IP com and IP soybeans by 2005 (Clarkson, 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).

6. APPENDIXES

APPENDIX A

PROFILES OF THE LEADING AGRI-BIOTECH FIRMS

AgrEvo (Headquarters in Germany)

AgrEvo (A company owned by Schering and Hoechst, the latter having merged with Rhône Poulenc to form Aventis) is the fourth largest global agricultural and chemical producer and marketer. A high proportion of sales revenue is spent on research and development (13%) of which 80% is spent on chemicals and 20% is spent on biotechnology. The company has invested heavily on seed activities. In 1999, it acquired three Brazilian seed companies (Mitla Pesquisa, Sementes Ribeiral and Sementes Fartura). All three companies specialise in hybrid corn seed. AgrEvo also completed the acquisition of Biogentic Technologies B.V. (BGT). BGT is a 100% owner of the Proagro Group, which has its headquarters in New Delhi, India. In overall terms, Proagro is the second largest Seed Company in India and is ranked number one in corn, millet and forage sorghum and number two in India in sunflower and grain sorghum.

AgrEvo's investment in genomics has been quite substantial in the latter part of 1998 and continues in 1999 with its 95% acquisition of PlantTec Biotechnologie in September of this year and its acquisition of GeneX (terms undisclosed) in October **1999. The company has extensive agreements with numerous research institutes and** Genomics corporations such as Cotton Seed International Proprietary Ltd, Gene Logic, Center for Plant Breeding & Reproductive Research and Lynx Therapeutics.

Novartis (Headquarters in Switzerland)

Novartis was formed in 1996 as a result of a merger between Ciba-Geigy (agro-chemicals) and Sandoz (pharma) and has core businesses in healthcare, agribusiness and nutrition. It is a lifesciences company and has invested significantly in agricultural biotechnology and genomics. In October 1998 the company announced that it would invest US$600 million in plant genomics. This would involve the formation of the Novartis Agricultural Discovery Institute (NADI) which would be located in San Diego, California. The company is involved in numerous collaborations with agrigenomic partners.

In terms of acquisition of seed companies, Novartis acquired the majority of the seed activities of Eridania Beghin-Say, a company that specialises in breeding, producing and marketing field-crop seeds. The transfer of activities include the majority of the Italian subsidiary Agra, the French Agrosem companies the Spanish Koipesol Semilla company as well as Hungarian and Polish seed activities.

Although Novartis holds participations in the food industry, its strategy appears to be more input-oriented, at least for the time being. Among the partners of Novartis in the food industry, the example of Gerber illustrates the case of non-integration between biotech and food activities. Gerber announced earlier this year that it would not include GM ingredients in its baby food.

Monsanto (Headquarters in the US)

Monsanto spinned off its chemical activities in 1997, and instead acquired biotech firms such as Calgene. It already entered the seed market in 1996 when it formed a strategic alliance with DeKalb Genetics. Continuing on from this, Monsanto purchased a 40% stake of DeKalb in the first half of 1998 for US$2.5 billion. This gives Monsanto an important outlet for its Roundup Ready and YieldGard varieties. In September 1996 Monsanto acquired Asgrow Agronomics for US$240 million. Asgrow Agronomics has 45% of its sales in Soybeans. In January 1997 Monsanto agreed to buy Holden's Foundation Seeds for US $1.02 billion. This acquisition along with other key acquisitions has given Monsanto key channels of distribution for its genetically altered/modified seeds. Then in 1998 Monsanto announced an acquisition plan for Delta and Pineland outright for US$1.9 billion. Delta and Pineland specialises in GM cotton and it already distributes Monsanto's Bollgard, Ingard insect-protected cotton and Roundup Ready Cotton. Monsanto however dropped this plan in early 2000, following both concerns expressed under the Anti-Trust Law and terms agreed under the merger with Pharmacia. Finally in July 1998, Monsanto acquired Plant Breeding International Cambridge (PBI) for US $525 million. PBI, a UK-based company, specialises in the breeding and marketing of winter wheat, barley, rapeseed, potatoes and other crops. Taken together all the above acquisitions give Monsanto a considerable market share of the seed business both in the United States and in South America.

In addition to the above acquisitions, Monsanto also entered into a number of agreements with both seed companies and genomic research institutions. In April 1998 Monsanto obtained licenses to all aspects of GeneTrace's technologies for plant and animal agriculture.

While Monsanto has heavily invested in input-traits and seed activities, it also has a portfolio of second-generation products, which are more oriented towards food processors/consumers. In the early part of this year Monsanto entered into an agreement with Cargill to create and market new products enhanced through biotechnology for the crop processing and animal feed markets.

Dow Agroscience (Headquarters in the US)

Dow Agroscience is a wholly owned subsidiary of The Dow Chemical Company and was formed in 1998 after Dow purchased the remaining shares of its joint partner Elli Lilly. The joint venture between Eli Lilly and Dow was formerly known as DowElanco. Dow's commitment to biotechnology was exemplified by the formation of a new company in September 1998 called Advanced AgriTraits LLC. The strategy of the new company involves developing the company's own technology and forming alliances with other companies to expand its biotechnology base in a cost-effective way. Dow Agroscience formed a strategic partnership and controlling interest in Mycogen in 1996. Mycogen is the sixth largest Seed Company in the United States. Mycogen is the biotech arm of Dow Agrosciences and concentrates on agronomic traits for new plant varieties. Dow Agrosciences also has numerous agreements with many different companies. The agreements are for the most part concerned with crops such as com and canola. At the end of 1997, Dow signed an agreement with Seed Genetics Inc. to develop, market and license high oil com inbreds using DowElanco's technology (now Dow Agroscience), as well as biotech traits as they become available. In 1998 Dow formed an alliance with three major companies, Performance Plants Incorporated, BioSource Technologies Inc. and Illinois Foundation Seeds all of which are in genomics. In the second 1999 Dow formed a joint venture with Danisco to develop new varieties and hybrids that will increase the value of canola to customers.

Zeneca (Headquarters in the UK)

In 1994, Zeneca introduced the first GM-food crop on both the US market, namely an increased pectin tomato. Proceedings for authorising its introduction on the EU market are on-going. Therefore, Zeneca is considered to have an output-oriented strategy. Nevertheless, it also has invested in the seed market, as well as in input-traits. In 1996, Zeneca and Van der Have formed Advanta, which now accounts among the top 5 of the seed industry. It then acquired several biotech companies active in disease resistance and quality traits. In 1998, Zeneca seeds formed an alliance with American Cyanamid, to combine Zeneca's expertise in biotechnology and Cyanamid's one in herbicide tolerance. Cyanamid was the first company to introduce herbicide tolerant com in 1992, however it is not considered as transgenic. This company has searched for ways of naturally incorporating herbicide tolerance into the plant through traditional and hybrid methods of plant breeding.

Rhône-Poulenc (Headquarters in France)

Rhône-Poulenc is a lifesciences company and has over 200 production plants in Austria, Brazil, France, Germany, Italy, Spain, Switzerland, UK and the United States. In December 1998 it announced a merger with Hoechst (owner of AgrEvo, together with Schering) to create Aventis. The merger was effective in December 1999, with the first quotations for Aventis on stock exchanges places. Hoechst and Rhône-Poulenc have agreed to spin-off their chemical activities before merging. As a result, Aventis will focus on life-sciences, in particular on pharma (70% of the turnover). Its agri-biotechnology sector is quite small but is a growing part of the overall operations of the company. The plant and animal health sector contributed 19% of total sales in 1998, which were US $15.5 billion in total. Unlike its counterparts in the United States, the strategy of Rhône-Poulenc has been to focus on joint ventures and research agreements without the cost that would be involved in acquiring seed companies. The company has a number of agreements in the area of genomics, including, Biogemma, The National Agricultural Centre Brazil (which will pursue the development of GM soybeans) and Dow Agroscience where the collaboration will focus on GM traits in com, canola, soybeans, sunflower and cotton.

DuPont (Headquarters based in the US)

DuPont formed a joint venture with Pioneer in 1997 in which DuPont purchased a 20% stake in Pioneer for US$1.2 billion. In November of this year DuPont purchased the remaining 80% of Pioneer for US$7.7 billion. Although DuPont has gained an extended access to the seed market by acquiring Pioneer, it is considered to be more output-oriented. While other companies have focused on input traits i.e. those traits which are of particular benefit to farmers in improving the yield of the crop, DuPont has remained focused on output or value added traits or those traits which are of direct benefit to the processor and consumer. In addition, Du-Pont/Pioneer has also developed quality traits by conventional breeding. Pioneer seeks to improve the output traits of crops and specialises in GM com, soybeans and other oilseeds in order to improve their oil, protein and carbohydrate composition. In January 1998, DuPont acquired Protein Technologies International for US$1.5 billion. Protein Technologies International supplies soy proteins for the food and paper processing firms and has a 75% market share worldwide for soy proteins. DuPont also has a number of agreements with research institutes such as the John Innes Centre and has an agreement with Lynx Therapeutics in which DuPont will have exclusive access to Lynx's DNA sequence analysis technologies for the study of com, soybeans, wheat and rice.

APPENDIX B

Table A.4.1: Commodity versus IP prices for US corn/maize and soybeans (November 1999).

		Price to farmer		
Corn/maize	**characteristic**	**regular**	**non-GMO**	**organic**
US#2 yellow	Commodity grade, not IP	75	81	150
US#2 yellow	high oil	81	NA	150
US#2 yellow	high starch	79	79	150
US#2 yellow	hard endosperm	83	83	150
US#1 white	soft endosperm	94	94	169
US#1 white	hard endosperm	94	94	169
US#1 white	very high protein	113	113	188
US#2 blue	color	311	311	311
		Price to farmer (€/t)		
Soybeans	**characteristic**	**regular**	**non-GMO**	**organic**
US#1	Commodity grade, not IP	169	177	414
US#1	medium high protein	190	190	483
US#1	very high protein	224	224	518
US#1	very high protein and excellent taste	241	241	621
US#1	sugar balanced	310	310	724
US#1	low lipoxygenase	241	241	621

Source: Clarkson, 1999.

Table A.4.2: Comparison of additonal costs of firms incurred in handling specialty corn/maize and soybeans (in €/t).

	Average (n=55)	**Corn/maize**	**Soybeans**
Storage (per month)	1.07	1.11	1.40
Handling/ segregation	3.56	2.22	5.26
Risk management	1.42	0.37	2.46
Transportation	2.49	1.48	4.21
Analysis/testing	0.36	0.37	0.35
Marketing	1.07	0.74	1.40
Other	1.42	0.00	2.10
Subtotal	**11.39**	**6.29**	**16.84**
Purchasing (incl. premium)	16.73	7.03	25.96
Total	**28.12**	**13.32**	**42.79**

Source: Bender et al. 1999.

Table A.4.3: Comparison of additonal costs of firms incurred in handling different specialty crops (in €/t).

	Food corn (n=7)	**HO corn (n=21)**	**Food soybeans (n=26)**	**STS Soybeans (n=10)**
Storage (per month)	1.48	0.37	1.40	0.70
Handling/segregation	7.03	0.74	7.02	2.10
Risk management	0.00	0.37	2.10	2.46
Transportation	2.22	0.00	5.26	0.00
Analysis/testing	0.37	0.37	0.70	0.35
Marketing	3.33	0.37	1.75	0.70
Other	0.00	0.00	3.16	0.00
Subtotal	**14.43**	**2.22**	**21.40**	**6.31**
Purchasing (incl. premium)	12.95	4.44	37.53	5.26
Total	**27.37**	**6.66**	**58.93**	**11.58**

Source: Bender et al. 1999.
HO corn: high oil corn
STS soybeans: Sulfonylurea Tolerant Soybeans

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