RESPONSE of SLOVENIA

ANNEX 1

QUESTIONNAIRE about the socio-economic implications of the placing on the market of GMOs for cultivation

16 July 2009

A – Introduction note

Article 31.7 (d) of Directive 2001/18/EC[1] provides that the Commission should send to the European Parliament and the Council a specific report on the operation of the Directive including inter alia an assessment of the socio-economic implications of deliberate releases and placing on the market of GMOs. These implications are defined in Recital (62) of the Directive as the socio-economic advantages and disadvantages of each category of GMOs authorised for placing on the market, which take due account of the interest of farmers and consumers. In its 2004 report, the Commission noted that there was no sufficient experience to make such an assessment (the Directive became fully applicable as of 17 October 2002 and several Member States had not transposed yet so only little experience of its implementation was available).

Moreover Regulation (EC) No 1829/2003, its articles 7 and 19, asks the Commission to submit a draft of the authorisation decision taking into account, together with the opinion of the Authority in charge of the scientific assessment, "other legitimate factors relevant to the matter under consideration".

At its meeting on 4 December 2008, the Environment Council adopted conclusions on GMOs mentioning among other things the appraisal of socio-economic benefits and risks of placing GMOs on the European market for cultivation. In particular the Council conclusions indicated the following:

"The Council:

7. Points out that under Regulation 1829/2003 it is possible, under certain conditions and as part of a case by case examination, for legitimate factors specific to the GMO assessed to be taken into account in the risk management process which follows the risk assessment. The risk assessment takes account of the environment and human and animal health. Points out that under Directive 2001/18/EC, the Commission is to submit a specific report on the implementation of the Directive, including an assessment, inter alia, of socio-economic implications of deliberate releases and placing on the market of GMO.

   Invites the Member States to collect and exchange relevant information on socio-economic implications of the placing on the market of GMOs including socio-economic benefits and risks and agronomic sustainability, by January 2010. INVITES the Commission to submit to the European Parliament and to the Council the report based information provided by the Member States by June 2010 for due consideration and further discussions.

[1] Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC

This possible consideration of socio-economic factors in the authorisation of GMOs for cultivation has also been raised by several Member States in the Environment and Agriculture Councils of the last months[2].

In order to respond to the invitation of the Council conclusions of 4 December 2008 and to the requirements of the legislation, the Commission invites Member States to submit all information they would consider relevant by January 2010 at the very latest.

In order to help Member States in structuring their responses, the Commission drafted a non exhaustive list of areas and stakeholders which could be concerned. In addition, for each of these categories, we have introduced in the annex a list of leading questions which could be used where considered appropriate.

When preparing their contribution Member States are invited to report *ex post* on the socio-economic impact of GMOs that have been approved in the EU and cultivated in their territory. Additionally, Member States are also invited to assess *ex ante* the possible implications of GMOs of currently pending approvals as well as those which are under development according to the best of their knowledge. One possible source of information in that respect is that recent report produced by the Joint Research Centre titled "The global pipeline of new GM crops" (available at http://ipts.jrc.ec.europa.eu**).**
The submissions must be as explicit and informative as possible and supported by evidence and data. When feasible, the socio-economic analysis – be it *ex post* or *ex ante* – should be quantified. In case documents are attached, they should be accompanied by a summary of the relevant part and a specification about the argument or topic that is being defended.

Where stakeholders are consulted at national level (e.g. farmers and consumers), we would appreciate it if their responses would be incorporated in your submission in an aggregated fashion. The list of stakeholders consulted, as well as any other pertinent information, may indeed be attached to the questionnaire.

Please note that the contributions must only deal with "socio-economic implications of the placing on the market of GMOs including socio-economic benefits and risks and agronomic sustainability" for each category of GMOs. These contributions should cover cultivation of GMOs and placing on the market of GM seeds.

If you choose to fill in the annexed questionnaire, please consider that answers should be broken down by the purpose of the genetic modification (herbicide tolerant, insect resistance, etc) if this affects the content of the responses.

DEADLINE FOR CONTRIBUTIONS: January 2010

[2] Environment Council of 2 March 2009, Agriculture Council of 23 March 2009 and Environment Council of 25 June 2009

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C – Areas and stakeholders on which Member States are invited to comment

1 - Economic and social implications: influence on concerned economic operators

Upstream

1.1. Farmers

For each question, answers can be broken down by the range of stakeholders:

- *farmers cultivating GM crop;*
- *and/or conventional crops;*
- *and/or organic crops;*
- *beekeepers;*
- *seed producers producing GM seeds;*
- *seed producers producing conventional seeds;*
- *seed producers producing organic seeds;*

…

1.2. Seed industry

For each question, answers can be broken down by the range of relevant stakeholders, including:

- *plant breeders;*
- *multiplying companies;*
- *seed producing farmers;*
- *seed distributors;*

…

Downstream

Consumers;
Cooperatives and grain handling companies;
Food and feed industry;
Transport companies;
Insurance companies;
Laboratories;
Innovation and research;
Public administration.

Economic context

Internal market;

Specific regions and sectors.

2 - Agronomic sustainability

Biodiversity, flora, fauna and landscapes
Renewable or non renewable resources
Climate
Transport / use of energy

3 - Other Implications

ANNEX
Lead questions per area and stakeholder

For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

Introductory remarks

Slovenia is aware of the importance of socio-economic considerations concerning placing GMOs on the European market for cultivation. We are also acquainted with the ongoing discussion following Council Conclusions regarding socio-economic criteria its definition and evaluation on the basis of those criteria. Meanwhile, the Dutch COGEM formulated nine themes and associated criteria which could serve as building blocks in an assessment framework on the socio-economic aspects of GMOs.[3] This could be a starting point for thorough discussion on wide EU level concerning open questions on socio-economic implications related to e.g. criteria definitions and relevance for GMOs cultivation.

In that view, Slovenia appreciates the efforts of the Commission to collect the experiences of Member States regarding socio-economic implication caused by GMOs cultivation. In general, in the EU we have still limited experience with the cultivation of GM crops.

In addition, we emphasize that in Slovenia at the moment we have no cultivation of GMOs. Therefore, questions as they were phrased in the questionnaire were very difficult to answer because we have no experience or sound data, what conduct us to assess possible socio-economic implications which are likely to be caused by GMO cultivation. However, we put our best effort and in the process of answers preparation for the questionnaire the 39 stakeholders (NGOs, associations, industry, insurance companies, institutes, faculties, and government) in Slovenia were consulted at the national level. The list of stakeholders consulted and their replies are attached to the questionnaire.

<u>1. - Economic and social implications</u>

Upstream

1.1. Farmers

For each question, answers can be broken down by the range of relevant agricultural stakeholders farmers
- *farmers cultivating GM crops;*
- *and/or conventional crops;*
- *and/or organic crops;*

[3] COGEM Report CGM/090929-01 (2009). Socio-economic aspects of GMOs building blocks for an EU sustainability assessment of genetically modified crops.

- *beekeepers;*
- *seed producers producing GM seeds;*
- *seed producers producing conventional seeds;*
- *seed producers producing organic seeds;*

…

Has GMO cultivation an impact regarding the following topics? If so, which one?

- farmers' revenues (output prices and agricultural yields);

Available information indicated that cultivation of GMOs could have an impact on output prices and agricultural yields.

- higher (Brookes and Barfoot, 2009)[4] or marginal (Gurian-Sherman, 2009)[5] agricultural yield;
- higher impute prices (expensive GM seeds from the patent-owner companies) (Benbrook, 2009)[6].
- possible loss of income in the "organic" farming sector and occasionally also in "conventional" owing to product contamination by GM crop.

- farmers' production costs;

Available information indicated that cultivation of GMOs could have an impact on farmers' production costs.

- reduction of farm production cost linked with reduced e.g. pesticide use (Brookes and Barfoot, 2009);
- increase of farm production cost because of e.g. higher impute prices (expensive GM seeds from the patent-owner companies) (Benbrook, 2009) and because of cost, and environmental and health risk will rise in step with the total quantity of pesticides applied on GM crops[7].

- labour flexibility;

Available information indicated that cultivation of GMOs could have an impact on labour flexibility.

- Increased management flexibility (e.g. HT-GMO - ease of use associated with broad-spectrum, post-emergent herbicides and the increased/longer time window

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[4] Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk

[5] Gurian-Sherman, G. 2009. Failure to yield - Evaluating the Performance of Genetically Engineered Crops. Union of Concerned Scientists. http://www.ucsusa.org/assets/documents/food_and_agriculture/failure-to-yield.pdf

[6] Benbrook, Ch. 2009a. The magnitude and impacts of the biotech and organic seed price premium. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf

[7] Benbrook, Ch. 2009b. Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf

for spraying (Brookes and Barfoot, 2009)[8] while IR-GMO - less time being spent on crop walking and/or applying insecticides (Brookes, 2002));

- Example from Argentina showed that because of labour-saving effect the small farm holders have been driven away from their land as the GM crop monocultures advanced through the country. It was estimated that this labour-saving effect means that only one new job is created for appr. 500 ha of land converted to soybeans. The same amount of land, devoted to conventional food crops on moderate-size family farms, supports four to five families and employs at least half a dozen people (Benbrook, 2005).[9]

- quality of the harvest (e.g.mycotoxines);

Available information indicated that cultivation of GMOs could have an impact on quality of the harvest.

Reports indicated that IR-GM crops improved grain quality from reductions in the levels of mycotoxines found in the grain and HT-GM crops improved weed control from reductions in the harvesting costs for farmers. (Brookes, 2005 and 2008);

At the moment there is no GMOs available that improves the nutritional values of the crop. Contrary, studies have shown that e.g. organically grown fruits and vegetables are richer in beneficial components (e.g. essential vitamins and minerals, and fatty acids, antioxidants) and contain significantly less pesticide residues[10].

- cost of alternative pest and/or weed control programmes;

Some information indicate that increased use of a single pesticide (e.g. glyphosate or glufosinate) on HT-GM crops have lead to the emergence of numerous weed species that are resistant to the herbicide. These uncontrollable weeds will force farmers to increase the amounts and toxicity of herbicides used on the fields (Benbrook, 2005).

- price discrimination between GM and non-GM harvest;

Based on the economy of production and on the freedom of choice for consumers the price discrimination could be expected.

- availability of seeds and seed prices;

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[8] Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk

[9] Benbrook, C. 2005. Rust, resistance, run down soils, and rising costs: problems facing soybean producers in Argentina, AgBioTech InfoNet, Technical Paper No. 8, Jan. 2005. http://www.aidenvironment.org/soy/08_rust_resistance_run_down_soils.pdf .

[10] Cleeton, J. (2004). Organic foods in relation to nutrition and health key facts. Published in "Coronary and Diabetic Care in the UK 2004" by the Association of Primary Care Groups and Trusts (UK). http://www.medicalnewstoday.com/articles/10587.php .

Regulation in the EU should facilitate different seeds availability (conventional, organic or GM);

- dependence on the seed industry;

Farmers should have the possibility to select the production type and should have free access to seed.

- farmers' privilege (as established by Article 14 of Regulation (EC) No 2100/94 on Community plant variety rights) to use farm-saved seeds;

This should still apply to conventional and organic seeds. Contrary, use of GM seeds is restricted by contracts;
Cultivation of GM crops could result in higher risk of contamination for non-GM crop farmers what could hinder in a way farmer's privilege to use farm-saved seeds.

- the use of agriculture inputs: plant protection products, fertilisers, water and energy resources;

Some information indicated decrease of pesticide application (James, 2009)[11] and reduces consumption of fuel (Fawcett and Towery, 2002).[12]
On the other hand some information indicate that increased use of a single pesticide (e.g. glyphosate or glufosinate) on e.g. HT-GM crops have lead to the emergence of numerous weed species that are resistant to the herbicide. These uncontrollable weeds will force farmers to increase the amounts and toxicity of herbicides used on the fields (Benbrook, 2005).

- health of labour (possible changes in the use of plant protection products);

In the EU the regulation on use of plant protection products is relatively strict and there is low likelihood of health problems in existing practices. However, there could be some changes in using plant protection products when HT-GM or IR-GM crop are in question.
Some information from Latin-America indicated that spreading (use e.g. helicopters) of the herbicide on GM crops cannot be properly controlled: it lands on natural habitats, field boundaries, water streams and also neighbouring houses, sheds and villages. Such practice could cause health problems more evident in the future.[13]
Some information also indicate that in case of resistant weed species emerge, farmers could switch to more toxic herbicides, even those which have been banned in other parts of the world, such as the EU.

[11] James (2009). ISAAA Briefs No. 39-2008: Global Status of Commercialized Biotech/GM Crops: 2008.

[12] Fawcett and Towery (2002).Conservation tillage and plant biotechnology: how new technologies can improve the environment by reducing the need to plow, Conservation Technology Information Center. http://croplife.intraspin.com/Biotech/papers/35%20Fawcett.pdf .

[13] See for example: http://americas.irc-online.org/am/6254

- farming practices, such as coexistence measures and clustering of GMO and/or non-GMO production;

In Slovenia the “Act on Co-existence of Genetically Modified Plants with other Agricultural Plants (OJ RS, 41/2009)” was adopted. The implementation regulations are in the process of adoption.
There are relatively high expectations regarding segregation of GM and non-GM crops.
In addition, it is essential to expose specificity of Slovenian agriculture and farming conditions. The lend holding and parcel structure are exceptionally dispersed and fragmented, and the agricultural lend approx. 85 % falls within the category of less-favoured area for agricultural activity. The clustering is therefore, taken into account to making possibility of founding of “GMO free” or “GMO” production in consensus with all farmers in concerned territory. No practical experiences have been gained yet.
The major problem from the point of view of agriculture could be also the risk of outcrossing and the contamination of other crops as well as resulting questions of liability. As a consequence, the marketability of the harvested products (particularly organic products) could be also jeopardised.

- cost of coexistence measures;

The farmers who wish to grow GM crops, it is appropriate to be liable for the coexistence measures and their cost.
The co-existence legislation in Slovenia regulates also issue of liability for GMO contamination but it has not applied in the practice, as there has been no GMO cultivation in Slovenia so far. The compensation fund for farmers who will cultivate GM crops is envisaged, and it will be filled with special fee for unintentional presence of GM crop in other products.

- conflicts between neighbouring farmers or between farmers and other neighbours

In Slovenia the conflict potential in the case of GM crops cultivation would be considerable because land ownership is highly fragmented and fine tune communication or organisation between farmers is needed.
To avoid latter conflicts as much as possible the co-existence legislation in Slovenia envisaged an agreement among neighbouring farmers with the GM crop production. But it has not applied in the practice, as there has been no GMO cultivation so far.

- labour allocation

No experiences because there has been no GMO cultivation in Slovenia so far.

- insurance obligations;

The insurance possibility is the market strategy of the insurance company. No experiences because there has been no GMO cultivation in Slovenia so far.

- opportunities to sell the harvest due to labelling;

The consumers' rights should be respected and therefore, must have the freedom of choice among different products. GMOs products must be labelled according to the regulation.

- communication or organisation between the farmers;

As the conflict potential in Slovenia could be important the fine tune communication or organisation between farmers will be probably the question of interests and "stakes in the game".

- farmer training;

In our co-existence regulation, the obligatory farmer training for farmers who wish to grow GM crops is foreseen. For other farmers the advisory service is available.

- beekeeping industry.

Beekeeping is an old tradition in Slovenia. In practice, they are very sceptic on coexistence of beekeeping and GM crop cultivation because of possibility of contamination of honey with GMO pollen. As a consequence, the marketability of such a honey could be jeopardized (e.g. labelling).

Any other impacts you would like to mention:

To ensure effective control systems to protect producers and consumers rights could detrimentally influence cost of products of conventional and organic producers.

1.2. Seed industry

For each question, answers can be broken down by the range of relevant stakeholders, including:

Slovenia has a long tradition in seed production, particularly in cereal seeds, where we are almost self-sufficient. Nevertheless, Slovenia covers in average less than 25 percent of its seed demands in maize, we produce no rape seed. Most of the imported seed comes from EU countries. Slovenia performs monitoring of seed to check maize and rape seed for GMO presence on a yearly basis.

- *plant breeders;*
- *multiplying companies;*
- *seed producing farmers;*
- *seed distributors;*

And/or:

- *GM seeds;*
- *conventional seeds;*
- *organic seeds;*

And/or:

- *industrial / arable crops;*
- *vegetable crops…*

Has GMO cultivation an impact regarding the following topics? If so, which one?

- employment, turn over, profits;

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made.

- the production of seeds (easiness/difficulty to find seed producers, easiness/difficulty to find areas to produce these seeds…);

The quality of seeds is a prerequisite for ensuring coexistence between GMO, conventional and organic production. In general, good professional practice has already been established in the production, processing and packaging of seed. But it should be complemented with specific measures needed for handling GMOs: wider isolation distances, separate mechanisation for cultivation, separate transport and storage facilities. Consequently, production of GM seeds would not be interesting for smaller producers, which are predominately in Slovenia. Production of GM plants would also affect the production of conventional seeds, because it would be more difficult to assure appropriate conditions for seed production (e.g. small producers, small parcels, etc.)

- marketing of seeds;

Additional inspection and control (for adventitious presence of GM seed in conventional or organic seed) could be expected; in case of certain crops (*Brassica* sp.) there would be higher

possibility that seed would contain GMOs, and therefore more seed lots would need to be controlled.
In addition, it would be necessary to adopt Community rules to control GMOs in seeds.

- the protection of plant breeders rights;.

- the protection of plant genetic resources

In case of generative propagation of plants seeds are reproduced by a factor of between 40 and 1000 depending on type. Seeds may in some cases remain in the soil for long periods. GM seeds and pollen can thereby be dispersed across great distances and may in case of certain species threaten conservation of plant genetic resources 'in situ'. Additional measures will also have to be taken by the plant gene bank during multiplication of accessions in species with GMO cultivation.

Does the marketing of GM seeds have an impact on the seed industry and its structure in the EU (size of companies, business concentration, competition policy)? Please specify per sector.

- for plant breeders;
- for seed multiplication;
- for seed producers;
- for the availability of conventional and organic seeds;
- creation/suppression of barriers for new suppliers;
- market segmentation.

Any other impact you would like to mention:

Downstream

1.3. Consumers

Has GMO cultivation any impact regarding the following topics? If so, which one?

- consumer choice (regarding quality and diversity of products);

Slovenian consumers advocate for non-GM products. Considering quality of product the GMO cultivation could have positive impact (e.g. less mycotoxines), but on the other hand, there could be also problems related to presence of GMO in conventional and organic products allowed. This could on a long run jeopardize consumer's freedom of choice.

- the price of the goods;

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made.

- consumer information and protection;

In the EU all product produced from and with the GMO must be subject of labelling. However, Slovenian consumers' attitude towards GMO is negative. GM food and feed products are not considered beneficial, and more then three quarters of consumers declared in a surveillance that would not buy a GM food products even if it were 30% cheaper.
Furthermore, around 40% of consumers believe that the only benefit of GMO is the profit of the corporations, and only 30% of them consider smaller use of pesticides as a benefit to the quality of food products and environment. There is also negative consumers' attitude towards GMO cultivation in Slovenia (88% - 2007, 69% - 2002). Additionally, concerning food safety controls and good, near 50% of the consumers believe that are good but over 60 % believe that local, Slovenian foods are better then imported ones. Concerning GMO, consumers advocate that there is not enough long term research concerning effects on health and environment, thus more research is needed as well as better transparency in information flow.

Any other impact you would like to mention:

1.4. Cooperatives and grain handling companies

Has GMO cultivation any impact regarding the following topics? If so, which one?
- work organisation;
- handling and storage;
- transport;
- administrative requirements on business or administrative complexity.

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made. However, compliance with the existing threshold value of 0.9% GMO in conventional and organic food and feed products will demand more stringent thresholds in the early steps of production. The production of GM and conventional plants should be separated; quite a lot of logistical problems are foreseen.

Any other impact you would like to mention:

1.5. Food and feed industry

Has GMO cultivation any impact regarding the following topics? If so, which one?
- range of products on offer;
- employment, turn over, profits;
- work organisation;
- crop handling (drying, storage, transport, processing, etc...);
- administrative requirements on business or administrative complexity;

Cultivation of GMO will have an impact on food and feed industry because of necessity to ensure non-GMO raw materials for production and of product which do not contain GMO. As a consequence, food and feed industry must design their production processes allowing segregation and traceability between GM and non-GM supply chains for final products.

Any other impact you would like to mention:

1.6. Transport companies

Has GMO cultivation any impact regarding carriers (insurance, cleaning, separate lines...)? If so, which one?

To ensure threshold demand and to avoid adventitious presence of GMO the enhanced quality management system regarding carriers must be applied which could be expected; as a consequence leads to higher costs.

1.7. Insurance companies

Does the GMO cultivation have any impact regarding insurance companies (e.g. in terms of developing new products)? If so, which one?

There is no obligation of any insurance of GM crops production in Slovenian legislation. Because of lack of experience with GMO cultivation in Slovenia the insurance product for GMO is probably not interesting to our big insurance companies due to small number of GM crop likely producers. There is no information on other companies.

1.8. Laboratories

Has GMO cultivation any impact regarding the following topics? If so, which one?

- employment, turn over, profits;
- feasibility of analyses;
- time necessary to provide the results;
- prices of the analyses.

At present, there is no GMO cultivation in Slovenia. However, Slovenian national reference laboratory every year performs monitoring of GMO presence in samples of seed, food and feed products. In event of GMO cultivation the cost of monitoring would increase due to control of the coexistence measures. The main burden to the laboratories would markedly rise up when more GMO products will be on the market. Increased number of GMOs demanded monitoring (not only for cultivation, but also for food and feed) and constant improving or introduction of new detection methods.

Any other impact you would like to mention:

1.9. Innovation and research

Do GMO cultivation and the technology spill over have an impact on the following topics? If so, which one?

- investment in plant research, number of patents held by European organisations (public or private bodies);
- investment in research in minor crops;
- employment in the R&D centres in the EU;
- use of non-GM modern breeding techniques (e.g. identification of molecular markers);
- access to genetic resources;
- access to new knowledge (molecular markers, use of new varieties in breeding programmes, etc.).

To date, there have been no experimental releases of GM plants in Slovenia. GMOs research is therefore comprises exclusively work in closed systems. At the moment cultivation of GMOs in EU is also very limited. However, it could be expected that investment in plant research and agricultural technologies will increase, if there will be more relaxed attitudes to GMOs among Europeans, what could stimulate also the investments resulting in more patents. It would be also possible that there will be investments in research in minor crops, but depends on its importance in the future. Further, increase of employment in the R&D could be expected, if GMO will continue to be regulated owing to the number of GM plants is rising. Notwithstanding, due to low acceptance of GMO in EU, more investment is given to other techniques and development of new methods. It could be also possible, that non-GM breeding techniques will develop intensively since approval of the products seems to be less laborious.

1.10. Public administration

Has GMO cultivation any impact regarding the actions of the national public administrations and the necessary budget (national and local level) for example policing and enforcement costs

In the event of GMO cultivation it could be expected that the administrative cost will rise up in particular as regards to preliminary procedures specially related to coexistence. With respect to the Act on coexistence the cultivation of EU authorized GMOs should be registered at the competent authority. The GMO-free area could be also registered. Further, the compensation found is a part of the public budget. Part of the information and publicity is also a part of the national public administration as well as research projects which are also financed by the Government.

Any other impact you would like to mention:

Economic context

1.11. Internal market

Does the placing on the market of GMO seeds have an impact on the functioning of the EU internal market on seeds? If so, which one?

Regarding this issue, the new regulation foreseen (e.g. thresholds).

Does it have an impact on the internal markets for services (if so which impact and which services), for agriculture products and on workers' mobility? If so, which one?

Increased demand for agriculture inspection is expected.

Does GMO cultivation have an impact on monopolies? If so, which ones (emergence/disappearance)?

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made.

Does it provoke cross-border investment flows (including relocation of economic activity)?

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made.

Any other impact you would like to mention:

1.12. Specific regions and sectors

Answers can be broken down on the purpose of the level (national, regional, local) and according to region.

Has GMO cultivation any regional and local impact in those regions regarding the following topics. If so, which one?

- agriculture incomes;

Could have but cannot be predicted (dependent on the farming system);

- farms' size;

Available information indicated that cultivation of GMOs could have an impact on farms' size.

- the farm production practices (e.g. increase or decrease of monoculture);

Available information indicated that cultivation of GMOs could have an impact on the farm production practices particularly if specialized for GMO.

- the reputation regarding other commercial activities of the region/localities.

Available information indicated that cultivation of GMOs could have an impact on reputation hampered in both directions, positive and negative, e.g. GMO cultivation in an organic region may lower reputation of organic farms, on the other hand, in specialized GMO region – increase reputation for GMO farming.

Any other impact you would like to mention:

2. - Agronomic sustainability

2.1 Agricultural inputs

Does the cultivation of EU approved GMOs for cultivation have an impact regarding the use of pesticides against target insect pests (i.e. corn borer)?

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made. However, it is expected that in the case of corn borer (not treated by insecticides in Slovenia) it is not an issue, but will have impact in the case of other pests (e.g. root worm).

Does the placing on the market of GMOs have an impact, and if so which ones, regarding the use of pesticides or/and on the patterns of use of chemical herbicides?

Due to the lack of experience with GMO cultivation in Slovenia, no concrete statements can be made. However, available information indicated that cultivation of GMOs reduce the use of pesticides and herbicides. But there is also information, which indicated problems of using only one herbicide. Further, some studies also indicated more pesticide use for GM-crop farming than in case of conventional farming[14].

2.2. Biodiversity, flora, fauna and landscapes (other impacts than the ones considered in the environmental risk assessment carried out under Directive 2001/18 and Regulation (EC) No 1829/2003)

In Slovenia, no GMOs are cultivated, therefore, concrete information about the possible impact on biodiversity, flora, fauna and landscape cannot be provided.
However, many factors that affect biodiversity are directly and indirectly related to agriculture (e.g. out-crossing, agricultural practices, loss of cultivar biodiversity, ..). The effects on biodiversity could according to Dolezel et all, 2009[15] relate to GM crops or GM crop-wild hybrids which may become agricultural weeds, and thus compromising current weed management systems. It may invade natural habitats changing their biodiversity value, and may replace wild genes (genetic assimilation) and reduce genetic diversity of a recipient population. Furthermore, lower fitness of GM crop-hybrids may drive wild populations to extinction (demographic swamping), contrary higher fitness of hybrids may lead to increased invasiveness replacing wild populations and other species, while gene flow from GM crops may contaminate seed pools and reduce seed quality to be expected.

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[14] Benbrook C. 2009b.

[15] Dolezel. at all 2009. Standardising the Environmental Risk Assessment of Genetically Modified Plants in the EU. Final Report for the Federal Agency for Nature Conservation (BfN) Germany, Bundesamt für Naturschutz (BfN) Federal Agency for Nature Conservation, Bonn.

With that regards, some information reported that GMOs could enables farmers to limit any negative impact on biodiversity (Ammann, 2009, 2009a) [16, 17] while according to other negative effect on biodiversity are to be expected (Dolezel, 2007)[18].

Does the cultivation of EU approved GMOs have an impact regarding the number of non agriculture species/varieties?

Does GMO cultivation have an impact on agriculture diversity (number of plant varieties available, agriculture species, etc?)

Does GMO cultivation have an impact, and if so which one, regarding:
- protected or endangered species;
- their habitats;
- ecologically sensitive areas;

Does GMO cultivation have an impact, and if so which one, regarding:
- migration routes;
- ecological corridors;
- buffer zones.

Does GMO cultivation have an impact, and if so which one, regarding:
- biodiversity;
- flora;
- fauna;
- landscapes.

Any other impacts you would like to mention:

2.3. Renewable or non-renewable resources

In Slovenia, no GMOs are cultivated, therefore, concrete information about the possible impact of GMOs on renewable or non-renewable resources cannot be provided.

Does the placing on the market of GMOs have an impact, if so which ones, regarding the use of renewable resources (water, soil…)?

Does the placing on the market of GMOs have an impact, if so which ones, regarding the use of non-renewable resources?

Any other impacts you would like to mention:

[16] Ammann K. 2009. The impact of agricultural biotechnology on biodiversity – a review. http://www.efb-central.org/index.php/forums/viewforum/26/

[17] Ammann K. 2009a. Biodiversity and the debate on GM crops. http://www.botanischergarten.ch/AF-11-Biodiversity/AF-11-Biodiversity-Biotechnology-20091123-web.pdf

[18] Dolezel, 2007. Umwelt und naturschutzrelevante aspekte beim anbau gentechnisch veränderter organismen, REP-0122, Umweltbundesamt GmbH, Wien.

2.4. Climate

Does GMO cultivation have an impact regarding our ability to mitigate (other than by possibly reducing CO_2 emissions from fuel combustion – see next section) and adapt to climate change? If so, which ones?

In Slovenia, no GMOs are cultivated, therefore, concrete information about impact of GMOs cultivation regarding ability to mitigate and adapt to climate change cannot be provided. However, available information indicate that GM crops contribute to lower levels of greenhouse gas emission (GHG) through two main sources: reduction of fuel use from e.g. less frequent herbicide or insecticide application and the use "no-till" and "reduced-till" farming systems (Brookes&Barfoot, 2009). Considering climate change, it could be also reasonable to emphasis on extending tolerance to both biotic (e.g., pests) and abiotic (e.g., water stress) traits using GM crop which could be relevant to future needs. GM plants may have a sustainable contribution to make in some environments just as ecological agriculture might be a superior approach to achieving a higher sustainable level of agricultural productivity. Further, in the context of changing climate, climate change mitigation, food security, soil and water restoration, improved crop stress tolerance etc. the option could be also multifunctional agriculture (including conservation of biodiversity, animal welfare, cultural and historical heritage values and the liability and viability of rural communities) as outlined by the International assessment of agricultural knowledge, science and technology for development (IAASTD).

Any other impacts you would like to mention:

2.5. Transport / use of energy

Does the cultivation of EU approved GMOs have an impact regarding energy and fuel needs/consumption? If so, which ones?

In Slovenia, no GMOs are cultivated, therefore, concrete information about impact of GMOs cultivation regarding energy and fuel needs/consumption cannot be provided.

Does the cultivation of EU approved GMOs have an impact regarding the demand for transport in general terms? If so, which ones?

In Slovenia, no GMOs are cultivated, therefore, concrete information about impact of GMOs cultivation regarding the demand for transport in general terms cannot be provided.

Any other impacts you would like to mention:

3 - Other Implications

APPENDIX 1

Organizations consulted[19]

1	Adriatic Slovenica – insurance company	Adriatic-Slovenica
2	Agricultural Chamber of Slovenia	Kmetijsko gozdarska zbornica
3	Agricultural Institut of Slovenija	Kmetijski inštitut Slovenije
4	Agroruše d.o.o.	Agro-Ruše
5	Agrosaat - seed	Agrosaat
6	BASF	BASF
7	Bee-keeping Association of Slovenia	Čebelarska zveza Slovenije
8	Biotechnical Faculty	Biotehniška fakulteta
9	Chamber of Commerce and Industry of Slovenia	Gospodarska zbornica Slovenije
10	Chamber of Craft and Small Business of Slovenia – Section for Transport	Obrtno prometna zbornica Slovenije - Sekcija za promet
11	Consumer Association of Pomurje	Zveza potrošnikov za Pomurje
12	Consumer Association of Slovenia	Zveza potrošnikov Slovenije - Društvo
13	Consumer Protection Office of the Republic of Slovenia	Urad za varstvo potrošnikov(MG)
14	Federation of Organic Agriculture	Zveza za ekološko kmetijstvo
15	Generali – insurance company	Generali
16	Government Office of Climate Change	Služba Vlade RS za podnebne spremembe
17	Greenpeace	Greenpeace
18	Institute ''Jožef Stefan''	Inštitut Jozef Štefan
19	Institute for Sustainable Development	Inštitut za trajnostni razvoj
20	Institute of Public Health Maribor	Zavod za zdravstveno varstvo (MB)
21	Intercorn Trading - seed	Intercorn Trading
22	Jata Emona d.o.o.	Jata Emona d.o.o.
23	KPC Jable	KPC Jable
24	Merkur – insurance company	Merkur
25	Ministry of the Environment and Spatial Planning	Ministrstvo za okolje in prostor
26	Ministry of Agriculture, Forestry and Food	Ministrstvo za kmetijstvo, gozdarstvo in prehrano
27	Ministry of Higher Education, Science and Technology	Ministrstvo za visoko šolstvo, znanost in tehnologijo
28	National Institute of Biology	Nacionalni inštitut za biologijo
29	National Institute of Public Health	Inštitut za varovanje zdravja R Slovenije
30	Novalis-seed	Novalis
31	Phytosanitary Administration of the Republic of Slovenia	Fitosanitarna uprava Republike Slovenije
32	Pioneer - seed	Pioneer
33	Semenarna-LJ - seed	Semenarna-LJ
34	Semevit -seed	Semevit
35	Slovenian Chamber of Commerce – Section for Food	Trgovinska zbornica Slovenije - Sektor za živila
36	Syngenta - seed	Syngenta
37	The Institute of the Republic of Slovenia for Nature Conservation	Zavod Republike Slovenije za varstvo narave
38	Triglav – insurance company	Triglav
39	GIZ - seed production	GIZ - semenarstvo

[19] in alphabetical order

APPENDIX 2
Replies of organizations consulted

Agricultural Chamber of Slovenia
Kmetijsko gozdarska zbornica

ANNEX
Lead questions per area and stakeholder
For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

<u>1. - Economic and social implications</u>

Upstream
1.1. Farmers
For each question, answers can be broken down by the range of relevant agricultural stakeholders farmers
- farmers cultivating GM crops;
- and/or conventional crops;
- and/or organic crops;
- beekeepers;
- seed producers producing GM seeds;
- seed producers producing conventional seeds;
- seed producers producing organic seeds;
…
Has GMO cultivation an impact regarding the following topics? If so, which one?
- farmers' revenues (output prices and agricultural yields);
- farmers' production costs;
- labour flexibility;
- quality of the harvest (e.g.mycotoxines);
- cost of alternative pest and/or weed control programmes;

GMO are not produced in our country so we can't comment this topics
- price discrimination between GM and non-GM harvest;

Price discrimination is expected but it should be based on economy of production.
- availability of seeds and seed prices;

We do not have any experience on this topic. But the regulation should enable unrestricted availability of seeds (conventional, organic or GM)
- dependence on the seed industry;

In the way this is going on in USA farmers who will grow GM crops will be strongly dependent on seed industry.
- farmers' privilege (as established by Article 14 of Regulation (EC) No 2100/94 on Community plant variety rights) to use farm-saved seeds;

This should still apply to conventional and organic seeds. The industry of GM seeds overpasses this with the contract for use of GM seeds.
- the use of agriculture inputs: plant protection products, fertilisers, water and energy resources;
- health of labour (possible changes in the use of plant protection products);

In Slovenia we do not have any experience on that, but information on the topic is diversified. Depends from which (pro or contra) part it is presented. EU regulation on use of plant protection products is relatively strict and there is low possibility of health problems in existing practices.
- farming practices, such as coexistence measures and clustering of GMO and/or non-GMO production;

In Slovenia coexistence regulation is in the procedure of adoption. There are relatively high expectations about segregation of GM and non GM crops. Clustering is taken into account in possibility of founding areas of GM free or with GM production in consensus of all farmers in concerned area.
- cost of coexistence measures;

Cost of coexistence measures should be a part of production cost for farmer producing GM plants. In Slovenia production fee is foreseen.
- conflicts between neighbouring farmers or between farmers and other neighbours

In Slovenia the probability of conflicts is very high since land ownership is highly fragmented.

- labour allocation- insurance obligations;

We have no experience on that.

- opportunities to sell the harvest due to labelling;

Labelling is more opportunity for consumers. Labelling should be obligatory. Any cultivation should be economically justified. Trading opportunities due the labelling should not be restricted.

- communication or organisation between the farmers;

GMO production will polarise our farmers. If this will be good enough reason to promote any kind of communication and organization between farmers (pro or contra) will be the question of interests and "stakes in the game".

- farmer training;

In the area of farmers training advisory service, faculties or institutes should see an opportunity.

- beekeeping industry.

Beekeeping is an old tradition in Slovenia. Beekeepers are very sceptic on possibility of coexistence of beekeeping and GM crops. The opportunity for organic beekeeping will be minimised.

Any other impacts you would like to mention:

Downstream

1.7. Insurance companies

Does the GMO cultivation have any impact regarding insurance companies (e.g. in terms of developing new products)? If so, which one?

There is no obligation of any insurance of GM crops production in our legislation. It is expected that this will not be interesting to insurance companies due to small number of GM crop producers.

Economic context

2. - Agronomic sustainability

2.2. Biodiversity, flora, fauna and landscapes (other impacts than the ones considered in the environmental risk assessment carried out under Directive 2001/18 and Regulation (EC) No 1829/2003)

Does the cultivation of EU approved GMOs have an impact regarding the number of non agriculture species/varieties?

Yes all weed species are endangered.

Does GMO cultivation have an impact on agriculture diversity (number of plant varieties available, agriculture species, etc?)

The approach of GM crops cultivation incorporates also decrease of biodiversity on field due to use of herbicides in herbicide tolerant crops. All non tolerant field crops will be excluded.

Does GMO cultivation have an impact, and if so which one, regarding:

- protected or endangered species;
- their habitats;
- ecologically sensitive areas;

Generally protected areas, habitats and ecologically sensitive areas should be strong argument for forming GMO free zones in accordance to the regulation of GM crops production.

Does GMO cultivation have an impact, and if so which one, regarding:

- migration routes;
- ecological corridors;
- buffer zones.

All these functions of the natural environment will be undoubtedly affected by monocultre of GMOs.

Does GMO cultivation have an impact, and if so which one, regarding:

- biodiversity;

Biodiversity will be threatened on field and on neighbouring areas.

- flora;

Natural and weed flora can face decrease.

- fauna;

Some kind of impact is to be expected of insect tolerant GM plants to insect, insectivore and bird fauna. The data on influence of insect tolerant MG crops on biodiversity are again diversified depending on the source of information.

- landscapes.

The impact is expected because of wider (economical justified) monoculture areas.

Any other impacts you would like to mention:

2.4. Climate

Does GMO cultivation have an impact regarding our ability to mitigate (other than by possibly reducing CO2 emissions from fuel combustion – see next section) and adapt to climate change? If so, which ones?
We don't see any real mitigation opportunity in GMO crops.

Any other impacts you would like to mention:

National Institute of Biology
Nacionalni inštitut za biologijo

ANNEX
Lead questions per area and stakeholder
For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

<u>1. - Economic and social implications</u>

Downstream

1.8. Laboratories
If GMOs would be cultivated in Slovenia it can be expected that more samples will need to be analysed to control the Coexistance, even for the country large as SLovenia we do not expect very large increase.

- feasibility of analyses;
At the National Institute of Biology we have the capacity to run more samples and to reorganize the existing staff and usage of facilities.
- employment, turn over, profits;
Maybe one additional employee will be needed. We are non-profit organization so we do not expect profit.
- *time necessary to provide the results;*
We do not expect prolongation of time needed for results.
- prices of the analyses.
More analyses is done lower can be the price.
Any other impact you would like to mention:
The main burden to the laboratories which we expect is higher number of different GMOs which will need to be tested in future (not only for cultivation, but also for testing ingredients in food and feed) and consequently constant introduction of new methods for their detection.

1.9. Innovation and research
At the moment cultivation of GMOs in EU is very limited, but possibility of more relaxed attitudes to GMOs can stimulate also the investements resulting in more patents.

In paralel it is possible that non-GM breeding techniques will develop intensively since approval of the products is less laborious.

The Institute of the Republic of Slovenia for Nature Conservation
Zavod Republike Slovenije za varstvo narave

Dne, 12.11.2009 ste na naslovni Zavod poslali vlogo z vprašalnikom Evropske komisije na temo socio-ekonomskih dejavnikov dajanja gensko spremenjenih organizmov (GSO) na trg z namenom pridelave. Kot pristojna institucija za področje ohranjanja narave vam zato v nadaljevanju posredujemo zgolj načelne (teoretične) odgovore za soobstoj GSO na naravovarstveno pomembnih območjih, saj z rezultati verodostojnih raziskav na to temo ne razpolagamo.

Varstvo ogroženih vrst in narave nasploh je ena ključnih nalog Evropske Skupnosti (ES). Rezultat teh prizadevanj je poleg številnih predpisov ES (npr. Bernska konvencija, Evropska konvencija o krajini, Barcelonska konvencija, Alpska konvencija, Aarhuška konvencija) tudi vzpostavitev omrežja evropsko pomembnih območij varstva, znanega pod imenom Natura 2000. Rečemo torej lahko, da je skrb za ohranjeno naravo pomembna in družbeno zelo zaželjena vrednota evropejcev.

Z vidika varstva narave je soobstoj gensko spremenjenih rastlin (GSR) v odprtih sistemih (na prostem) sporen zlasti iz naslednjih razlogov:

1.) Spremembe genskega potenciala
V odprtih sistemih (na prostem) je prenos genskega materiala GSR nemogoče kontrolirati, saj lahko veter pelod nosi tudi kilometre daleč. Obstaja torej realna nevarnost, da bi prišlo do »genskega onesnaženja« tradicionalnih in avtohtonih kulturnih rastlin, ki predstavljajo pomemben element pri varovanju tradicionalne kmetijske kulturne krajine. Potencialno ogrožene pa s tega vidika niso le kulturne rastline temveč tudi samonikle vrste, v kolikor bi v odprte sisteme spuščali npr. okrasne GSR iz istih oz. sorodnih rodov, ki bi se v naravi lahko križale z avtohtonimi (gensko nespremenjenimi) vrstami.

2.) Kopičenje toksinov in vpliv na herbivore
Različne študije in raziskave so pokazale, da je npr. tolerantnost GSR na insekte pravzaprav posledica kopičenja različnih toksinov v listih in steblih rastline. Pojavlja se torej vprašanje, kako ta povečana koncentracija toksinov vpliva na herbivore (rastlinojede) in hkrati tiste vrste, ki jim kulturne rastline niso primarna prehrana ampak se na njih znajdejo zgolj slučajno? Ali povečana toksičnost povzroči njihovo smrt, ali ima (in kako velik) vpliv na njihovo preživetveno in reproduktivno sposobnost?

3.) Gojenje na herbicide odporne GSO
V kolikor bi prišlo do gojenja na herbicide odporne GSO, bi za kemijsko tretiranje najverjetneje uporabili univerzalne pripravke, ki pa bi potencialno lahko ogrozili nekatere redke in ogrožene plevelne vrste (t.i. okopavinske plevele).

4.) Dolgoročni kumulativni učinki
O dolgoročnih kumulativnih učinkih gojenja GSO v odprtih sistemih ne vemo skorajda ničesar. Prehranjevalne verige v naravi so namreč zelo kompleksne in dejstvo, da GSR v prehranjevalno verigo lahko vstopajo že na stopnji herbivorov (torej skoraj na samem začetku) je lahko njihov potencialen negativen vpliv (smrtnost, slabša reprodukcijska sposobnost,…) zelo velik.

Zaključimo torej lahko, da je potrebno pred dajanjem GSO v odprte sisteme narediti temeljite študije o vseh možnih vplivih, med drugim tudi na področju ohranjanja biodiverzitete. Menimo, da je trenutno znanje o tem, kako se GSO obnašajo v okolju (na prostem) in kakšni so njihovi, zlasti dolgoročni kumulativni učinki, še premalo raziskano.

Dajanje GSO v naravo brez predhodnih znanj o morebitnih posledicah je neodgovorno in lahko resno ogrozi obstoj številnih avtohtonih (gensko nespremenjenih) vrst, s čimer bo posledično ogroženo tudi doseganje evropsko zastavljenih ciljev po ohranjanju narave in tradicionalne krajine, ki so – kot smo uvodoma že povedali, zelo visoko na družbeni lestvici vrednot.

Agricultural Institut of Slovenija
Kmetijski inštitut Slovenije

ANNEX
Lead questions per area and stakeholder
For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

1. - Economic and social implications

Downstream

1.3. Consumers
Has GMO cultivation any impact regarding the following topics? If so, which one?

- consumer choice (regarding quality and diversity of products): increased diversity and quality of products
- the price of the goods: more effective production therefore lowering of prices is envisaged
- consumer information and protection: increased due to EU wide adoption of mandatory regulations in the field of GMOs;

Any other impact you would like to mention:

1.8. Laboratories
Has GMO cultivation any impact regarding the following topics? If so, which one?

- employment, turn over, profits: Yes, increased employment, more need for analytical personnel;
- feasibility of analyses: No change;
- time necessary to provide the results: increased time, if very stringent regulation, depending on the number of samples in the flow-through;
- prices of the analyses: increased cost.

Any other impact you would like to mention:

1.9. Innovation and research
Do GMO cultivation and the technology spill over have an impact on the following topics? If so, which one?

- investment in plant research, number of patents held by European organisations (public or private bodies): Yes, increased investment;
- investment in research in minor crops: it is possible, depending on the importance of minor crops in the future;
- employment in the R&D centres in the EU: increased, if GMO continue to be regulated;
- use of non-GM modern breeding techniques (e.g. identification of molecular markers): Yes, due to low acceptance of GMO in EU, more investment is given to other techniques;
- access to genetic resources: no change;
- access to new knowledge (molecular markers, use of new varieties in breeding programmes, etc.): Yes, new methods developed.

Economic context

1.11. Internal market
Does the placing on the market of GMO seeds have an impact on the functioning of the EU internal market on seeds? If so, which one? Yes, new regulations foreseen.

Does it have an impact on the internal markets for services (if so which impact and which services), for agriculture products and on workers' mobility? If so, which one? Increased demand for agriculture inspection.

Does GMO cultivation have an impact on monopolies? If so, which ones (emergence/disappearance)? The companies developing and selling GM seeds will have advantage.

Does it provoke cross-border investment flows (including relocation of economic activity)? Probably (e.g. in seed production).

Any other impact you would like to mention:

1.12. Specific regions and sectors
Answers can be broken down on the purpose of the level (national, regional, local) and according to region.

Has GMO cultivation any regional and local impact in those regions regarding the following topics. If so, which one?

- agriculture incomes: Yes, but cannot be predicted (dependent on the farming system);
- farms' size: yes, the farms specializing in GMO – farm size is foreseen;
- the farm production practices (e.g. increase or decrease of monoculture): yes, if specialized for GMO increase of monoculture;
- the reputation regarding other commercial activities of the region/localities: yes, in case of specialization (reputation hampered in both directions, positive and negative, e.g. GMO cultivation in an organic region may lower reputation of organic farms, on the other hand, in specialized GMO region – increase reputation for GMO farming).

Any other impact you would like to mention:

2. - Agronomic sustainability

2.1 Agricultural inputs
Does the cultivation of EU approved GMOs for cultivation have an impact regarding the use of pesticides against target insect pests (i.e. corn borer)? Not in the case of corn borer (not treated by insecticides in Slovenia), but will have big impact in the case of other pests (e.g. root worm)

Does the placing on the market of GMOs have an impact, and if so which ones, regarding the use of pesticides or/and on the patterns of use of chemical herbicides? Yes. Decreased use of pesticides and herbicides, but on the other hand increased problems, if using only one herbicide.

2.2. Biodiversity, flora, fauna and landscapes (other impacts than the ones considered in the environmental risk assessment carried out under Directive 2001/18 and Regulation (EC) No 1829/2003)

Does the cultivation of EU approved GMOs have an impact regarding the number of non agriculture species/varieties? No.

Does GMO cultivation have an impact on agriculture diversity (number of plant varieties available, agriculture species, etc?) No, or increase number of plant varieties available (due to new GM varieties).

Does GMO cultivation have an impact, and if so which one, regarding:

- protected or endangered species: no negative impact is foreseen;
- their habitats: no negative impact is foreseen;
- ecologically sensitive areas: no negative impact is foreseen, positive effect in the ground water protected areas;

Does GMO cultivation have an impact, and if so which one, regarding:

- migration routes : no;
- ecological corridors : no;
- buffer zones : yes, the magnitude depending on the stringency of regulation.

Does GMO cultivation have an impact, and if so which one, regarding:

- biodiversity: no negative impact is foreseen;
- flora: no negative impact is foreseen;
- fauna: no negative impact is foreseen;
- landscapes: yes, if increased monoculture and farm size.

Any other impacts you would like to mention:

2.3. Renewable or non-renewable resources
Does the placing on the market of GMOs have an impact, if so which ones, regarding the use of renewable resources (water, soil…)? Yes, positive effect in the ground water protected areas and lower soil compaction due to less mechanical passages.

Does the placing on the market of GMOs have an impact, if so which ones, regarding the use of non-renewable resources? Yes, lower fuel consumption.

Any other impacts you would like to mention:

2.4. Climate
Does GMO cultivation have an impact regarding our ability to mitigate (other than by possibly reducing CO2 emissions from fuel combustion – see next section) and adapt to climate change? If so, which ones? Positive, e.g. when using drought tolerant varieties.

Any other impacts you would like to mention:

2.5. Transport / use of energy
Does the cultivation of EU approved GMOs have an impact regarding energy and fuel needs/consumption? If so, which ones? Yes, lower use of fossil fuels in production, and increased use of energy needed in post production (e.g. dual handling, cleaning, flushing).

Does the cultivation of EU approved GMOs have an impact regarding the demand for transport in general terms? If so, which ones? No.

Any other impacts you would like to mention:

Biotechnical faculty
Biotehniška fakulteta

ANNEX
Lead questions per area and stakeholder
For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

1. - Economic and social implications

Downstream

1.9. Innovation and research
Do GMO cultivation and the technology spill over have an impact on the following topics? If so, which one?
- investment in plant research, number of patents held by European organisations (public or private bodies);
- investment in research in minor crops;
- employment in the R&D centres in the EU;
- use of non-GM modern breeding techniques (e.g. identification of molecular markers);
- access to genetic resources;
- access to new knowledge (molecular markers, use of new varieties in breeding programmes, etc.).

Consumer Protection Office of the Republic of Slovenia
Urad za varstvo potrošnikov (UVP-MG)

1.3. Consumers

V skladu z vašim elektronskim sporočilom in dogovorom na usklajevalnem sestanku z dne 3.11.2009 vam v nadaljevanju posredujemo naš prispevek k točki **1.3. Consumers**. Kot dogovorjeno, izhajamo iz teoretične osnove, ki ni podprta s študijami ali anketami. Odgovor temelji na ocenah zaposlenih našega urada ter na osnovi vprašanj, povezanih s tematiko GSO, s katerimi se posamezni potrošniki obračajo na naš urad.

Poleg vseh treh vplivov, ki so že navedeni v gradivu in jih podpiramo, predlagamo še naslednje:

- nezaupanje potrošnikov v gensko spremenjeno hrano – nevarnosti bremenijo potrošnike, dobiček pa gre gospodarstvu, strah pred neznanimi učinki uporabe na človeka
- nepovratno igranje z naravo
- označevanje gensko spremenjene hrane in izdelkov-potrošniki želijo označene izdelke
- informiranje revnih in manj izobraženih
- vpliv izobraženih in bogatih
- ali bo spoštovana pravica potrošnikov do izbire, varne hrane in preskrbljenosti z le-to?
- vedno večja naklonjenost ljudi k naravni hrani
- ali so potrošniki pripravljeni plačati več za gensko nespremenjen izdelek
- razlika v hranljivosti proizvodov, če obstaja
- nevarnost monopolov in prevlada biotehnoloških podjetij, ki proizvajajo življenjsko pomembne dobrine, kar lahko na daljši rok vpliva na cene

vpliv npr. na eko turizem v majhnih državah kot je naša - ali je zagotovljeno oz. bo v zadostni meri preprečeno samodejno razširjanje GSO po državi, da na njenih tleh dolgoročno ne bodo le GSO, s tem pa potrošnikova pravica do izbire ne bo več spoštovana?

Consumer Association of Slovenia
Zveza potrošnikov Slovenija

1.3. consumers
Slovene consumer attitude towards GMO is negative and this negative share is rising with years (see resources).
More then 75% on surveyed Slovene consumers/inhabitants throughout the last 7 years expressed their unwillingness to buy/choose GMO foods in spite of the legislation on information and labeling of GMO foods.
More then three quarters of consumers would not buy a GMO food even if it were 30% cheeper.
Slovene consumers do not see any benefits in GMO quality/safety, the majority (over 63%) are concerned with the negative impact on health and environment.
Around 40% of consumers believe that the only benefit in GMO is the profit of the corporations, only 30% of them consider smaller use of pesticides as a benefit to the quality of food products and environment.
88% (2007, 69% 2002)of the consumers do not approve of the cultivation of the GMO on the fields.
Near 50% of the consumers believe that food safety controls are good, over 60% believe that local, Slovene foods are better then imported ones.
Concerning GMO, they believe that there is not enough long term research on effects on health and environment, thus more research is needed as well as better transparency in information flow .
Nearly 40% of Slovene communities - Občine (local government), have signed the statement, that they will declare their territory GMO free(ITR 2007/ 2008).

Therefore, among Slovene inhabitants widespread disapproval of genetically modified foods exists. A great majority of Slovene people agree, that certain applications of genetically modified foods are risky and not useful for the society, they are not prepared to support them and find them morally unacceptable, minority considers lesser use of pesticides as a benefit of GMO cultivation.
The majority of Slovenian inhabitants does not agree that genetically modified foods are safe for human health and the environment.
A majority of people would not purchase food, if they knew it contained genetically modified organisms.
People who disapprove the most are middle age, university educated and young parents. People who disapprove the least are people, younger than 30 years.
The results of several statistically significant surveys show that more knowledge about biology and genetics does not lead to a higher acceptance of genetically modified food, while higher education has even an opposite effect.
The most important reasons for rejection of this GMO foods are not the lack of knowledge and lack of education but in other human concernes.
It is no suprise that throughout slovenia, communities – Občine, as a local government , have signed a statement that their territory is GMO free.

Maslow postulated that security and safety of food and shelter are the basic human needs and the above Slovene consumer/inhabitants concerns regarding GMO foods clearly reflect that. They do not perceive any benefits of GMO to the community and or themselves (economic and or healt and or environment improvement) or for the betterment of their human needs.

Resources:
Umanotera 2002
IVZ, Kirnčič/Tivadar 2004,
Eurobarometer 2005,
ITR 2007/2008

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ANNEX
Lead questions per area and stakeholder
For each question, answers should be broken down:
- by the purpose of the genetic modification if this affects the content of the responses,
- between ex ante and ex post considerations.

1. - Economic and social implications

Upstream

1.1. Farmers
For each question, answers can be broken down by the range of relevant agricultural stakeholders farmers
- *farmers cultivating GM crops;*
- *and/or conventional crops;*
- *and/or organic crops;*
- *beekeepers;*
- *seed producers producing GM seeds;*
- *seed producers producing conventional seeds;*
- *seed producers producing organic seeds;*

…

Has GMO cultivation an impact regarding the following topics? If so, which one?
- **farmers' revenues (output prices and agricultural yields);**
- **farmers' production costs;**

INPUT PRICES:
Since GM seeds are patented farmers are forced to buy the expensive GM seeds each year from the patent-owner company. Over the last years the seed industry (GM and non-GM) has undergone major consolidation allowing a handful of companies to dominate the market and inflate seed prices. A single company, Monsanto, owns over 90% of all GM seeds. According to a recently published study, in the US from 1975 to 2000 the price of soybeans rose by 63%, however between 2000 and 2010 with GM seeds taking over greater and greater share of the market the price rose an additional 230%.[20] Similar trends can be observed in the US with regards to maize and cotton seed prices.

Parallel to the inflation of the prices of seeds, the pesticide prices have also gone up. Round-up Ready prices increased significantly over the past decade.

AGRICULTURAL YIELDS:

According to a recent report based on figures obtained from the US: GM soybeans have not increased yields, and GM maize has increased yield only marginally.[21]

Insect-resistant cotton has a poor performance record in many parts of the world, particularly during extremes of temperature experienced in China and Australia.[22] In Argentina, average cotton yields were higher from 1987-96, the decade before GM cotton was introduced, than they have been since.[23]

Studies of Round-up Ready (RR1) soya, the most widely planted GM crop, suggest that it has on average 5-10% lower yield than equivalent conventional varieties.[24]

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3 Benbrook, Ch. 2009a. The magnitude and impacts of the biotech and organic seed price premium. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf

21 Gurian-Sherman, G. 2009. Failure to yield - Evaluating the Performance of Genetically Engineered Crops. Union of Concerned Scientists. http://www.ucsusa.org/assets/documents/food_and_agriculture/failure-to-yield.pdf

22 Chen, D., Ye, G., Yang, C., Chen, Y. & Wu, Y. 2005. The effect of high temperature on the insecticidal properties of Bt Cotton. Environmental and Experimental Botany 53: 333–342.
Olsen, K.M., Daly, J.C., Finnegan, E.J. & Mahonr. R.J. 2005. Changes in Cry1Ac Bt transgenic cotton in response to two environmental factors: temperature and insect damage. Journal of Economic Entomology 98: 1382-1390.

23 Based on data from FAOSTAT, ProdStat and Crops, Subject: Yields, Commodity: cotton lint; Year 1986-2006, (last accessed 2 December 2007).

Meanwhile, researchers have been trialling drought-tolerant and disease-resistant pearl millet varieties developed through marker-assisted selection.[25] Pearl millet is an important subsistence crop for millions of farmers in agriculturally marginal areas.

Scientists in the Philippines are using marker-assisted selection to develop a non-GM rice that can tolerate several days' complete submersion, for example during flash floods.[26] Scientists say the greatest hope to develop new crop varieties to meet future challenges of increased salinity, drought and other problems is expected to be through conventional plant breeding and marker-assisted selection techniques.

Looking at experience from USA it is clear that yield from GMO-crops is not higher. Even the USDA states that *"Currently available GE crops do not increase the yield potential of a hybrid variety. In fact, yield may even decrease if the varieties used to carry the herbicide-tolerant or insect-resistant genes are not the highest yielding cultivars"*[27]

Similar results are reported from South America. Speaking about soy cultivation in the state of Mato Grosso, Brazil one grower comments: *"We're seeing less and less planting of GMO soy around here. It doesn't give consistent performance," said Jeferson Bif, who grows soy and corn on a large 1,800 hectare farm in Ipiranga do Norte, near the key Mato Grosso soy town of Sorriso. He said he obtained average yields of 58 bags (60 kg) per hectare with conventional soy last season while fields planted with GMO soy in the same year yielded 10 bags less.*[28]

The International Assessment of Agricultural Science and Technology for Development (IAASTD) found that in the USA the cultivation of GM soy and maize has not resulted in improved yields; rather, the yields are slightly reduced.[29]

- **labour flexibility;**

In Argentina small holders have been driven away from their land as the GM crop monocultures advanced through the country. Many subsistence family farmers have lost their only source of income and were forced to move to the slums of the cities.

- **quality of the harvest (e.g.mycotoxines);**

There is no GMO available that improves the nutritional values of the crop. However, studies have shown that organically grown fruits and vegetables are richer in beneficial components (for example, antioxidants) and contain significantly less pesticide residues.

- **cost of alternative pest and/or weed control programmes;**

The increased use of a single pesticide (for example glyphosate or glufosinate) on herbicide tolerant GM crops have lead to the emergence of numerous weed species that are resistant to the herbicide. These uncontrollable weeds force farmers to increase the amounts and toxicity of herbicides used on the fields. A recently published study concludes based on USDA figures, that pesticide-use in the US has increased by 144 000 tons in the past 13 years due to the introduction of GM herbicide-tolerant crops.[30]

- price discrimination between GM and non-GM harvest;
- **availability of seeds and seed prices;**
- **dependence on the seed industry;**

The GM seed market is highly consolidated, with one single company, Monsanto, owning around 90% of all GM seeds. The rest is shared by only a handful of companies.[31] This makes it possible for these companies to control the market, as it has been seen in the US, where the prices of GM seeds increased disproportionally over the past years.[32]

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24 Elmore, R.W., Roeth, F. W., Nelson, L.A., Shapiro, C.A., Klein, R.N., Knezevic, S.Z. & Martin A. 2001. Glyphosate-resistant soybean cultivar yields compared with sister lines. Agronomy Journal, 93: 408-412.

25 Howarth, C.J & Yadav, R.S. 2002. Successful marker assisted selection for drought tolerance and disease resistance in pearl millet IGER Innovations http://www.iger.bbsrc.ac.uk/Publications/Innovations/In2002/ch3.pdf

26 Xu, K. et al. 2006. Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice. Nature 442, 705-708

27 The First Decade of Genetically Engineered Crops in the United States/EIB-11 Economic Research Service/USDA, p 9

28 Inae Riveras, Reuters "Biggest Brazil soy state loses taste for GMO seed", Fri Mar 13, 2009 http://www.reuters.com/article/internal_ReutersNewsRoom_BehindTheScenes_MOLT/idUSTRE52C5AB20090313

29 IAASTD Synthesis Report p 60

30 Benbrook, Ch. 2009b. Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf

31 Hubbard, K. 2009. Out of Hand: Farmers face the consequences of a consolidated seed industry. Farmer to Farmer Campaign. http://farmertofarmercampaign.com/Out%20of%20Hand.FullReport.pdf

32 Benbrook, Ch. 2009a. The magnitude and impacts of the biotech and organic seed price premium. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf

Monsanto has a history of suing farmers who have been unwillingly contaminated by neighbouring GM fields and thus were growing GM crops without being aware of that.[33]

- **farmers' privilege (as established by Article 14 of Regulation (EC) No 2100/94 on Community plant variety rights) to use farm-saved seeds;**

Cultivation of GMOs results in contamination risk for non-GM crop farmers. The contamination risk means for example that, although farmers privilege (to use farm saved seeds) is protected by legislation, farmers are in fact forced to use certified seeds, in order to reduce risk of a contaminated harvest. In many similar ways even a very small amount of GMO-cultivation will impose lost rights and extra costs on all other farmers.

- **the use of agriculture inputs: plant protection products, fertilisers, water and energy resources;**

Herbicide tolerant GM crops lead to increased use of a single pesticide (for example glyphosate or glufosinate) due to the emergence of numerous weed species that are resistant to the herbicide. These uncontrollable weeds force farmers to increase the amounts and toxicity of herbicides used on the fields. A recently published study concludes based on USDA figures, that pesticide-use in the US has increased by 144 000 tons in the past 13 years due to the introduction of GM herbicide-tolerant crops.[34]

- **health of labour (possible changes in the use of plant protection products);**

In Latin-America it is common practice to spray GM crops from helicopters, which means that the spread of the herbicide cannot be properly controlled: it lands on natural habitats, field boundaries, water streams and also neighbouring houses, sheds and villages. The health problems associated to such practice are becoming more and more evident.[35]
As resistant weed species emerge, farmers switch to more toxic herbicides, even those which have been banned in other parts of the world, such as the EU.

- **farming practices, such as coexistence measures and clustering of GMO and/or non-GMO production;**

Contamination of conventional crops is one of the major problems associated with the growing of GM plants and one of the reasons why we believe there should be no release of genetically modified organisms into the environment.
Mounting evidence shows that ‘coexistence’ between GM and conventional and organic crops is impossible. GMOs, being living organisms, once released into the environment, cannot be controlled and will lead to genetic contamination. GMOs can easily be transferred by the wind, via insects, farm and wild animals and humans. The genetic contamination undermines farmers' right to produce GM-free products as well as consumer’s right to eat GM free food.
Every year dozens of cases of genetic contamination are reported worldwide.
While 90% of GMOs are cultivated in four countries contamination spreads beyond their borders. Greenpeace's GM Contamination Register Report[36] alone has recorded 216 officially reported contamination events in 57 countries. The number of undetected and/or unreported cases is estimated to be of a greater magnitude, since most countries do not monitor GMOs after commercialisation and even detected GM contamination is often not published by food producers.
Alarming contamination cases have also been caused by experimental crops. A clear example is the global contamination accident caused by Bayer's GM rice (LL601) in 2006 and 2007 and the recent Canadian GM-linseed (flax) scandal. Both GMOs escaped from field trials and were found in the supply chain many years after the trails have been discontinued.

- **cost of coexistence measures;**

The non-GMO supply chain is suffering many extra costs to prevent GMO-contamination. The polluter pays principle is reversed, meaning that GMOs impose testing and segregation costs on GMO-free producers thereby creating an unfair price advantage for GM-produce. In a fair system the cost of protecting GMO-free products from GMO pollution throughout the entire seed, cultivation and processing chains should be borne by the polluter.

- **conflicts between neighbouring farmers or between farmers and other neighbours**
- **communication or organisation between the farmers;**

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33 See for example P. Schmeiser vs Monsanto: http://www.percyschmeiser.com/
34 Benbrook, Ch. 2009b. Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years. The Organic Center, Critical Issue Report. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf
35 See for example: http://americas.irc-online.org/am/6254
36 Greenpeace and GeneWatch UK. 2007. GM contamination register. Online: http://www.gmcontaminationregister.org

According to a peer reviewed study,[37] the small acreage of Bt corn grown in Spain has created conflicts within society. “The concept of coexistence and its proposed implementation both fail to resolve previous conflicts and actually work to generate new ones through the individualization of choice and impacts.”
“The liability scheme is perceived as transferring the problem to the organic farmers. As a result, many farmers are reluctant to publicly report cases of contamination in a context where there is a need for social cohesion, as in small villages. One organic farmer said: *“as a consequence of social pressure, when farmers suffer contamination, they do not want to say so. Last year there were 4 contamination cases and 2 made it public but 2 did not. For fear of confronting the people in the town... so they have to assume the economic cost, the environmental cost, and the cost of losing the organic certification but they do not say so”* (interview). Consequently, data on admixture cases are not systematically registered, although the organic certification is withdrawn in these cases”
“As a result [of these cases], from 2004 (when the first analyses were done) to 2007, the area devoted to organic maize was reduced by 75% in Aragon [where GE Bt maize is concentrated].”
Greenpeace has published a report[38] highlighting several testimonies of organic and conventional farmers and food processors in Spain who have been accidentally contaminated by GMOs and had to face the socio-economic damages.
In Argentina small holders have been driven away from their land as the GM crop monocultures advanced through the country. Many subsistence family farmers have lost their only source of income and were forced to move to the slums of the cities.

- **labour allocation- insurance obligations;**

Greenpeace does not have an insight into this issue.

- opportunities to sell the harvest due to labelling;
- **farmer training;**

Greenpeace does not have an insight into this issue.

- beekeeping industry.

Any other impacts you would like to mention:

- **Farmers cultivating organic or conventional crops;**

According to a peer reviewed study,[39] the small acreage of Bt corn grown in Spain has created conflicts within society. “The concept of coexistence and its proposed implementation both fail to resolve previous conflicts and actually work to generate new ones through the individualization of choice and impacts.”
“The liability scheme is perceived as transferring the problem to the organic farmers. As a result, many farmers are reluctant to publicly report cases of contamination in a context where there is a need for social cohesion, as in small villages. One organic farmer said: *“as a consequence of social pressure, when farmers suffer contamination, they do not want to say so. Last year there were 4 contamination cases and 2 made it public but 2 did not. For fear of confronting the people in the town... so they have to assume the economic cost, the environmental cost, and the cost of losing the organic certification but they do not say so”* (interview). Consequently, data on admixture cases are not systematically registered, although the organic certification is withdrawn in these cases”
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Greenpeace has published a report[40] highlighting several testimonies of organic and conventional farmers and food processors in Spain who have been accidentally contaminated by GMOs and had to face the socio-economic damages.
The non-GMO supply chain is suffering many extra costs to prevent GMO-contamination. The polluter pays principle is reversed, meaning that GMOs impose testing and segregation costs on GMO-free producers thereby creating an unfair price advantage for GM-produce. In a fair system the cost of protecting GMO-free products from GMO pollution throughout the entire seed, cultivation and processing chains should be borne by the polluter.

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37 Binimelis, R. 2008. Coexistence of plants and coexistence of farmers: is an individual choice possible? Journal of Agricultural and Environmental Ethics doi 10.1007/s10806-008-9099-4

38 Greenpeace. 2009. Testimonies of Contamination - Why co-existence of GM and non-GM crops remains impossible. http://www.greenpeace.org/raw/content/international/press/reports/testimonies-of-contamination.pdf

39 Binimelis, R. 2008. Coexistence of plants and coexistence of farmers: is an individual choice possible? Journal of Agricultural and Environmental Ethics doi 10.1007/s10806-008-9099-4

40 Greenpeace. 2009. Testimonies of Contamination - Why co-existence of GM and non-GM crops remains impossible. http://www.greenpeace.org/raw/content/international/press/reports/testimonies-of-contamination.pdf

1.2. Seed industry

For each question, answers can be broken down by the range of relevant stakeholders, including:

- *plant breeders;*
- *multiplying companies;*
- *seed producing farmers;*
- *seed distributors;*

And/or:

- *GM seeds;*
- *conventional seeds;*
- *organic seeds;*

And/or:

- *industrial / arable crops;*
- *vegetable crops…*

Has GMO cultivation an impact regarding the following topics? If so, which one?

- **employment, turn over, profits;**

Greenpeace does not have an insight into this issue.

- **the production of seeds (easiness/difficulty to find seed producers, easiness/difficulty to find areas to produce these seeds…);**

Additional measures have to be taken by the seed producers to avoid contamination.

- **marketing of seeds;**
- **the protection of plant breeders rights;**

Greenpeace does not have an insight into these issues.

- **the protection of plant genetic resources.**

The "green revolution" has lead to a loss in crop varieties, GMOs are a continuation of industrial farming and will lead to loss of traditional varieties and knowledge.

Does the marketing of GM seeds have an impact on the seed industry and its structure in the EU (size of companies, business concentration, competition policy)? Please specify per sector.

- **for plant breeders;**
- **for seed multiplication;**
- **for seed producers;**
- **for the availability of conventional and organic seeds;**
- **creation/suppression of barriers for new suppliers;**
- **market segmentation.**

Greenpeace does not have an insight into these issues.

Any other impact you would like to mention:

Downstream

1.3. Consumers

Has GMO cultivation any impact regarding the following topics? If so, which one?

- **consumer choice (regarding quality and diversity of products);**

One of the major problems associated with GMO cultivation is the contamination of conventional and organic products, for reasons explained before. Keeping conventional and organic supply chains strictly GMO-free is impossible. This will gradually make the consumption of GMO-free products impossible and thus seriously affect consumer's freedom of choice.

The independent Belgian consumer organisation Test Achats found that 80,5 % of 113 analysed products based on maize or soy, didn't contain GMOs. In 20 % of the – unlabelled – products, traces of GMOs were found, an increase compared to the earlier tests. 10,6 % of the products – including 2 organic products – contained traces of GMOs below 0,9 % and 6,2 % contained traces of GMOs that are not allowed in the EU (less than 0,1 %). Two unlabelled products contained more than 0,9 % of GMOs and thus were violating the law.[41]

- **the price of the goods;**

The non-GMO supply chain is suffering many extra costs to prevent GMO-contamination. The polluter pays principle is reversed, meaning that GMOs impose testing and segregation costs on GMO-free producers thereby creating an unfair price advantage for GM-produce. In a fair system the cost of protecting GMO-free products

41 L. BUELENS & G. MAERTENS, "Genetisch gemodificeerde organismen. Genetische vervuiling op komst?", Test Aankoop, nr. 528, februari 2009, pp. 36-39.

from GMO pollution throughout the entire seed, cultivation and processing chains should be borne by the polluter.

- **consumer information and protection;**

The European food industry avoids using GMOs as direct ingredient, so in direct food-use consumer choice is largely unaffected. Exception is as in the current GM linseed scandal (or the GM rice scandal), where GMO-cultivation results in GMO contamination in foods. Impact on consumers is firstly, that they are exposed to untested GMOs; secondly, that products are recalled and therefore not available; and thirdly, that the cost of the clean-up in the end must be borne by the consumers. The current GMO contamination of linseed also illustrates very well that the costs are much higher than cost of replacing the linseeds. The contaminated linseeds have been used in a variety of products (breads, muesli etc.) which have a value much higher than the costs of replacing the linseeds. This is the costs of GMO contamination that must be quantified for the food chain. In addition to quantifying the cost of market closure and clean-up costs for the GMO-free farmers who unwittingly had their harvest contaminated with GMO.
99% of the GMO used in the EU is used as animal feed. However, an informed consumer choice is hindered as there is no labelling of animal products of animals fed with GM-feed. It is well established that consumer/citizen concern with GMOs goes beyond immediate impact on own health and includes concerns for environment, food security, sustainability, corporate control and irreversibility when GMOs are released in the environment. Therefore it is making a mockery of consumers interests when GMO labelling only covers the minuscule use of GMO in food, while exempting the animal products produced from millions of tons of GMO feed (99% of the GMO used in EU) unlabelled.
A direct result of the misleading labelling law is distortion of the market in favour of producers who use GMO-feed. Producers who are responsive to consumer demands and therefore use GMO-free feeds are not rewarded by the market place for their GMO-free status. This creates a market distortion favouring the producers who use GMO-feed.

Any other impact you would like to mention:

1.4. Cooperatives and grain handling companies
Has GMO cultivation any impact regarding the following topics? If so, which one?

- **work organisation;**
- **handling and storage;**
- **transport;**
- **administrative requirements on business or administrative complexity.**

Greenpeace does not have an insight into these issues.

Any other impact you would like to mention:

1.5. Food and feed industry
Has GMO cultivation any impact regarding the following topics? If so, which one?

- range of products on offer;
- employment, turn over, profits;
- work organisation;
- crop handling (drying, storage, transport, processing, etc...);
- administrative requirements on business or administrative complexity;

Any other impact you would like to mention:

- **lack of GM-free labelling in the EU**

Lack of GMO-labelling of animal products distort the feed market. The application of the polluter pays principle is reversed, meaning that GMO impose segregation costs on GMO-free producers thereby creating an unfair price advantage for GMO-feed. In a fair system the cost of protecting GMO-free products from GMO-pollution throughout the entire food chain should be borne by the polluter.
A survey from the independent Danish consumer council found that nearly half of the consumers in Denmark wrongly believe that EU law requires that animal products are labelled if the animals have been fed with GMOs. So, the current labelling scheme is misleading. It is well established that consumer/citizen concern with GMOs goes beyond immediate impact on own health and includes concerns for environment, food security, sustainability, corporate control and irreversibility when GMOs are released in the environment. Therefore it is making a mockery of consumers interests when GMO labelling only covers the minuscule use of GMO in food, while exempting the animal products produced from millions of tons of GMO feed (99% of the GMO used in EU) unlabelled.

A direct result of the misleading labelling law is distortion of the market in favour of producers who use GMO-feed. Producers who are responsive to consumer demands and therefore use GMO-free feeds are not rewarded by the market place for their GMO-free status. This creates a market distortion favouring the producers who use GMO-feed.
If GMO-labelling of animal products was introduced it would enable consumers to reward the producers who are responsive to consumer demands. This means that GMO-free producers would be able to recover any extra costs for GMO-free feed. But fair labelling would also entice many more producers to be GMO-free. When more GMO-free feed is demanded the extra costs per feed unit would also be drastically reduced: firstly when scale increase to allow dedicated GMO-free feed plants, secondly when scale increase so much that GMO-free feed can be ordered as full ships of GMO-free feed (30-50,000 tons) as opposed to ordering only GMO-free feed by the hull (3-8000 tons).
Introducing GMO-labelling of animal products would be fairly cost-free, provided the industry is given approximately 6-12 month to adjust, so the producers who want to be GMO-free have reasonable time to secure GMO-free feed supplies. It is assumed that branded products would be first to shift to non-GMO feed. This would be enough to reach economies of scale and thus result in lowering the GMO-free premium, enticing even more producers to be GMO-free. If a significant share of EU producers gives signals to be willing to go GMO-free, growers in Brazil and Argentina will immediately increase the availability of GMO-free soy.

1.6. Transport companies
Has GMO cultivation any impact regarding carriers (insurance, cleaning, separate lines...)? If so, which one?
Greenpeace does not have an insight into these issues.

1.7. Insurance companies
Does the GMO cultivation have any impact regarding insurance companies (e.g. in terms of developing new products)? If so, which one?
Greenpeace does not have an insight into these issues.

1.8. Laboratories
Has GMO cultivation any impact regarding the following topics? If so, which one?

- **employment, turn over, profits;**
- **feasibility of analyses;**
- **time necessary to provide the results;**
- **prices of the analyses.**

Greenpeace does not have an insight into these issues.

Any other impact you would like to mention:

1.10. Public administration
Has GMO cultivation any impact regarding the actions of the national public administrations and the necessary budget (national and local level) for example policing and enforcement costs

Greenpeace does not have an insight into these issues.

Any other impact you would like to mention:

1.12. Specific regions and sectors

Answers can be broken down on the purpose of the level (national, regional, local) and according to region.

Has GMO cultivation any regional and local impact in those regions regarding the following topics. If so, which one?

- agriculture incomes;
- **farms' size;**
- **the farm production practices (e.g. increase or decrease of monoculture);**

In South America GM cultivation has lead to a massive increase in the size of farms and decrease in the number of farmers. Local communities have been destroyed, subsistence farmers driven away from their lands as the GM monocultures advanced in the country.
The biotech industry claims that majority of GM farmers are small-scale farmers, however globally most of the farmers are small holders. In fact less than 1% of all farmers globally grow GM crops!

- the reputation regarding other commercial activities of the region/localities.

The EU's GMO-legislation that allows the import of massive quantities of GM products un-sustainably produced in monoculture systems in Latin America has clearly a huge responsibility in causing the serious health, ecological social and economic problems these countries are facing. Thousands of families have been displaced from their lands in countries like Argentina and now live in slums beside cities, chemical pollution on crop fields has increased massively (due to weed resistance to herbicides), biodiversity as well as agriculture diversity have been lost, with direct consequences for these countries' food security.

Any other impact you would like to mention:

<u>2. - Agronomic sustainability</u>

2.1 Agricultural inputs

Does the cultivation of EU approved GMOs for cultivation have an impact regarding the use of pesticides against target insect pests (i.e. corn borer)?

Does the placing on the market of GMOs have an impact, and if so which ones, regarding the use of pesticides or/and on the patterns of use of chemical herbicides?

A study based on data from the US agricultural authorities USDA concludes that the use of Roundup-resistant GM crops in the US in the last 13 years has resulted in 318 million pounds (144 000 tons) more pesticide than if they had grown non-GM plants in conventional farming.[42]

2.2. Biodiversity, flora, fauna and landscapes (other impacts than the ones considered in the environmental risk assessment carried out under Directive 2001/18 and Regulation (EC) No 1829/2003)

Does the cultivation of EU approved GMOs have an impact regarding the number of non agriculture species/varieties?

Does GMO cultivation have an impact on agriculture diversity (number of plant varieties available, agriculture species, etc?)

Does GMO cultivation have an impact, and if so which one, regarding:

- **protected or endangered species;**
- **their habitats;**
- **ecologically sensitive areas;**

Does GMO cultivation have an impact, and if so which one, regarding:

- **migration routes;**
- **ecological corridors;**
- **buffer zones.**

Does GMO cultivation have an impact, and if so which one, regarding:

- **biodiversity;**
- **flora;**
- **fauna;**
- **landscapes.**

In the past years, new peer reviewed scientific studies have demonstrated that the effects of Bt maize varieties are far from predictable and their potential to cause negative effects is even greater than previously thought.
In February 2008, 37 scientists from 11 countries wrote an open letter to Environment Commissioner Stavros Dimas supporting his proposal to reject the authorisation for cultivation of two GM Bt maize varieties (1507 and Bt11). They highlighted the "*lack of scientific consensus on the safety assessment of GM crops*", stressed that "*data quality on available studies is highly variable*" and argued for a "*temporary suspension of cultivation until a more rigorous risk assessment has been done*".[43]
Target insects develop resistance to the pesticides produced by the Bt GM crops.[44] Farmers will then be forced to apply both greater quantities and additional varieties of insecticide to fight these resistant pests, to the benefit of pesticides manufacturers, which are often the same companies that make GMOs.
The European Commission, in its submission to the WTO case, criticised the EU environmental risk assessment on GMOs, and on Bt crops in particular, by stating that "*the current state of Bt environmental risk assessment in*

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42 Benbrook C. 2009b.

43 The letter can be found on the internet at: http://www.vdw-ev.de/Scientists%20letter%20to%20Dimas.pdf

44 Tabashnik, B.E., Gassmann, A.J., CrowdeDr, .W. &C arrière, Y. 2008 . Insect resistance to Bt crops: evidence versus theory. Nature Biotechnology 26: 199-202.

Europe shows that there were and still are considerable grounds for concern about the toxin Bt, especially non-target effects,..."[45]

Bt maize results in swapping one pest for another. Catangui et al. (2006)[46] showed that in the US new insects (Western bean cutworm) fill the niche of the pest organism killed by Bt maize (European corn borer).

Bt maize (including Bt11 and MON810) is unexpectedly susceptible to aphid infestation. Faria et al. (2007)[47] detected differences in amino acid concentrations not described in any of the applications for marketing of Bt maize. This demonstrates that Bt maize is subject to unexpected and unpredictable effects and that plant-insect interactions are too complex to be assessed by the current EU risk assessment.

The Bt toxin from GM Bt maize may affect headwater stream ecosystems. Rosi-Marshall et al. (2007)[48] demonstrated that GM crops producing Bt toxins can affect ecosystems via unexpected pathways, because interactions in the natural environment are complex and not fully understood. Thus, the current risk assessment does not consider all toxicity pathways and therefore all risks of GM plants.

The level of Bt toxin produced by MON810 varies. Nguyen, H. T. & J. A. Jehle (2007)[49] showed that the level of Bt toxin produced by MON810 varies strongly between different locations and even between plants on the same field. The reasons for these differences are not known. This raises serious questions about the current capacity to assess the impact of Bt toxins on the environment.

Bt toxin affects behaviour of monarch butterfly larvae. Prasifka et al. (2007)[50] showed that monarch butterfly's larvae exposed to Bt maize anthers (the part of the flower that carries the pollen) behave in a surprisingly different way, compared to other larvae exposed to non-Bt crops.

Environmental testing invalidated by unknown toxin. Rosati et al. (2008)[51] showed that the Bt toxin actually produced by MON810 is likely to be different from the Bt toxin used in the crop's environmental testing. This invalidates most, if not all, MON810 environmental 'safety' tests.

Leaves or grain from Bt maize could be toxic to aquatic life in streams. Bøhn et al. (2008)[52] showed that GM Bt maize could be toxic to aquatic life (insects). This underlines the conclusions of Rosi-Marshall et al. (2007, above) that this unexpected pathway is important and has not been considered in the risk assessment of Bt crops.

Herbicide-tolerant GMOs: The introduction of GM crops tolerant to herbicides such as glyphosate (the active ingredient of Monsanto's 'Roundup') have caused an increase in weed resistance. This lead to significant changes in agricultural practices, namely increased quantities of more toxic herbicides being sprayed on the crops.

The use of Glyphosate dramatically increased with the introduction of Roundup-Ready GM crops, since their introduction a decade ago[53, 54.] Now, glyphosate-resistant weeds are occurring in direct association with Roundup-Ready GM crop cultivation in many parts of the US. 34 cases of glyphosate resistance in nine species have been documented in the US since 2000[.55, 56, 57, 58]

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45 European Communities – Measures affecting the approval and marketing of biotech products (DS291, DS292, DS293). Comments by the European Communities on the Scientific and Technical Advice to the WTO Panel, para 128

46 Catangui M.A. et al. 2006.Western bean cutworm, Striacosta albicosta (Smith) (Lepidoptera : Noctuidae), as a potential pest of transgenic Cry1Ab Bacillus thuringiensis corn hybrids in South Dakota Environmental Entomology 35 1439-1452.

47 Faria, C.A., Wäckers, F.L., Pritchard, J., Barrett, D.A. & Turlings, T.C.J. 2007. High susceptibility of Bt maize to aphids enhances the performance of parasitoids of lepidopteran pests. PLoS ONE 2: e600. doi:10.1371/journal.pone.0000600.

48 Rosi-Marshall, E.J., Tank, J.L., Royer, T.V., Whiles, M.R., Evans-White, M., Chambers, C., Griffiths, N.A., Pokelsek, J. & Stephen, M.L. 2007. Toxins in transgenic crop byproducts may affect headwater stream ecosystems. Proceedings National Academy of Sciences of the USA 41: 16204–16208.

49 Nguyen, H. T. & J. A. Jehle 2007.Quantitative analysis of the seasonal and tissue-specific expression of Cry1Ab in transgenic maize Mon810. Journal of Plant Diseases and Protection.

50 Prasifka, P.L., Hellmich, R.L., Prasifka, J.R. & Lewis, L.C. 2007. Effects of Cry1Ab-expressing corn anthers on the movement of monarch butterfly larvae. Environmental Entomology 36:228-33

51 Rosati, A., Bogani, P., Santarlasci, A. Buiatti, M. 2008. Characterisation of 3´ transgene insertion site and derived mRNAs in MON810 YieldGard maize. Plant Molecular Biology DOI 10.1007/s11103-008-9315-7.

52 Bøhn, T., Primicerio, R., Hessen, D.O. & Traavik, T. 2008. Reduced fitness of Daphnia magna fed a Bt-transgenic maize variety. Archives of Environmental Contamination and Toxicology DOI 10.1007/s00244-008-9150-5

53 Benbrook, C. 2009a.

54 Nandula, V.K., Reddy, K.N., Duke, S.O. & Poston, D.H. 2005. Glyphosate-resistant weeds: current status and future outlook. Outlooks on Pest Management August 2005: 183-187.

55 Baucom, R.S. & Mauricio, R. 2004. Fitness costs and benefits of novel herbicide tolerance in a noxious weed, Proceedings of the National Academy 101: 13386–13390.

56 van Gessel, M.J. (2001) Glyphosate-resistant horseweed from Delaware. Weed Science, 49, 703-705.

57 http://www.weedscience.org/Summary/Uspecies MOA.asp?lstMOAID=12&FmHRACGroup=Go

58 Zelaya, I.A., Owen, M.D.K. (2000). Differential response of common water hemp *Amaranthus rudis* Sauer) to glyphosate in Iowa. Proc. North Cent. Weed Sci. Soc., 55, 68. and Patzoldt, W.L., Tranel, P.J., & Hager, A.G. (2002) Variable herbicide responses among Illinois waterhemp (*Amaranthus rudis* and *A. tuberculatus*) populations Crop Protection, 21, 707-712. http://www.weedscience.org/Case/Case.asp?ResistID=5269

In Argentina, new weeds, resistant to glyphosate, are replacing the usual weeds found in the fields as a result of cultivating GM herbicide tolerant soya.[59] Now farmers are recommended to spray stronger formulas, mixtures and other more notorious of herbicides to control glyphosate resistant weeds.[60, 61]

Any other impacts you would like to mention:

2.4. Climate

Does GMO cultivation have an impact regarding our ability to mitigate (other than by possibly reducing CO2 emissions from fuel combustion – see next section) and adapt to climate change? If so, which ones?
In the context of changing climate, climate change mitigation, food security, soil and water restoration, improved crop stress tolerance etc. the solution is multifunctional agriculture as outlined by the UN panel on agriculture, IAASTD and not chemical intensive GM monocultures. Some of the IAASTD's points are summarised below. For an EU context it is worth looking also at the reports from the EU-funded Policy Incentives for Climate Change Mitigation Agricultural Techniques (PICCMAT) Working group.
Reduce N2O: An important step in agriculture climate mitigation is to reduce use of N-fertiliser, in order to reduce N2O (ca 300 times worse GHG than CO2). Beans and legumes that capture nitrogen from the air need to replace the use of artificial fertilisers. In this regard it is a major concern that GMO-soy beans reportedly require artificial N-fertilisation, as opposed to conventional soy-beans growing in healthy soils.
Increase SOC: Increasing soil organic carbon (SOC) serves many purposes of improving soils, improving water management, improving yields, improving adaptability to erratic weather etc. Most importantly agricultural lands has the potential to off-set the total direct GHG-emissions from agriculture. Also research shows that in soils rich in SOC excess nitrogen tends to form N2, rather than N2O. Whereas N2O is a very serious GHG, N2 is not. In regard to SOC GMO has nothing to offer. Soil needs to be managed using organic methods in order to increase SOC, and feed crops should be perennial (grass) rather than single year monocultures (soy and maize).
Low input farming. Soy and maize (the big feed crops = the big GMO crops) are primarily grown in huge monocultures, highly dependent on fossil energy and pesticides. This is the type of farming that GMO-crops were developed for. The type of agriculture that according to IAASTD will be needed to meet future food supply is multifunctional farming methods that rely on IPM rather than chemical warfare. In contrast to IPM, GMO, whether it is Bt or HT GMO-crops, both require more and more toxins to combat pests. As pests (weeds and insects) develop resistance to Round-up and Bt-toxin farmers apply higher and higher dosages Round-up (and biotech industry develop plants that express more and more Bt toxins)

Any other impacts you would like to mention:

2.5. Transport / use of energy
Does the cultivation of EU approved GMOs have an impact regarding energy and fuel needs/consumption? If so, which ones?
Does the cultivation of EU approved GMOs have an impact regarding the demand for transport in general terms? If so, which ones?

Any other impacts you would like to mention:

3 - Other Implications
Socio-economic impact is important in addition to proper risk assessment. Socio-economic impacts should not be considered as an alternative of bringing the quality of the risk assessment up to the level agreed in Directive 2001/18. The Norwegian GMO-legislation[62] provides example of the proper way to include socio-economic and sustainability criteria. The deliberate release of genetically modified organisms may only be approved when there is no risk of adverse effects on health or the environment. In deciding whether or not to grant an application, considerable weight shall also be given to whether the deliberate release will be of benefit to society and is likely to promote sustainable development..."

59 Vitta, J.I., Tuesca, D. & Puricelli, E. 2004. Widespread use of glyphosate tolerant soybean and weed community richness in Argentina. Agriculture, Ecosystems and Environment, 103, 621-624.
60 See, e.g. http://farmindustrynews.com/mag/farming_saving_ glyphosate/index.html
61 Brooks, R.J. 2003. Saving glyphosate. Farming Industry News http://farmindustrynews.com/mag/farming_saving_glyphosate/index.html. Monsanto 2008b. Roundup PowerMAX™ is advertised as "proven on hard-to-control weeds". http://www.monsanto.com
62 http://www.regjeringen.no/en/doc/Laws/Acts/Gene-Technology-Act.html?id=173031

Economic and social implications

1.1 Farmers

a) Impact on revenue, yields and profitability
The information provided below summarises the main ‘first round’ socio-economic global impacts of genetically modified (GM) crop technology since it was first adopted on a broad commercial scale in 1996. As such, the data presented is ex post analysis. The material presented largely draws on the findings presented in the latest (4^{th}) annual update report on the global socio-economic and environmental impacts of biotech crops by Brookes G & Barfoot P (2009)[63]. This information follows the same methodology used for the previous three annual reports, all of which have been published in the peer review scientific journal AgBioforum[64]. This latest report (4^{th} edition) has also recently received acceptance for publication in the next edition of AgBioforum. It should also be noted that the Brookes & Barfoot analysis is based on an extensive review of existing farm level impact data for biotech crops (over 50 references on direct/first round socio-economic impacts, many of which are in peer reviewed journals).

Insect resistant (IR) corn/maize
Two biotech insect resistant traits have been commercially used targeting the common corn boring pests (*Ostrinia nubilalis* (European corn borer or ECB) and *Sesamia nonagroides* (Mediterranean stem borer or MSB) and Corn Rootworm pests – *Diabrotica).* These are major pests of corn crops in many parts of the world and significantly reduce yield and crop quality, unless crop protection practices are employed.

The two biotech IR corn traits have delivered positive yield impacts in all user countries when compared to average yields derived from crops using conventional technology (mostly application of insecticides and seed treatments) for control of corn boring and rootworm pests.

The positive yield impact varies from an average of about +5% in North America to +24% in the Philippines (

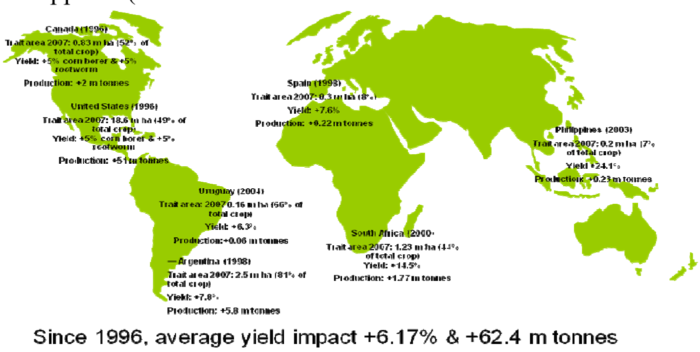
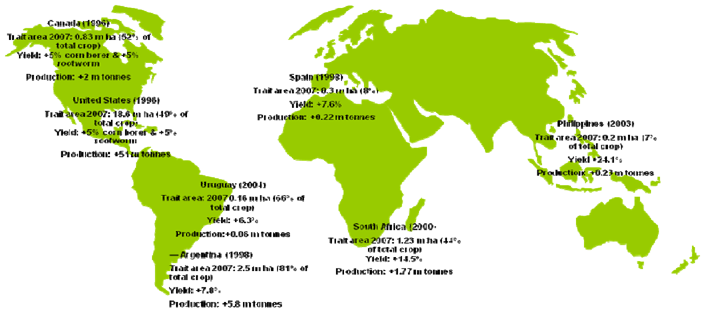


Figure 1). In terms of additional production, on an area basis, this is in a range of +0.25 tonnes/ha to +0.88 tonnes/ha.

Average positive yield and production impact across the total area planted to biotech IR corn traits over the cumulative time period of adoption (a maximum of twelve years) has been + 6.17%. This has added 62.4 million tonnes to total corn production in the countries using the technology. In 2007, the technology delivered an extra 15 million tonnes of corn production (Table 1).
In the EU, in maize growing regions affected by corn boring pests, the primary impact of the adoption of GM IR maize has been higher yields compared to conventional maize. Average yield benefits have often been +10% and sometimes higher, although impacts vary by region and year according to pest pressure (Table 1).

[63] Available at www.pgeconomics.co.uk
[64] AgbioForum 8 (2&3) 187-196, 9 (3) 1-13 and 11 (1), 21-38. www.agbioforum.org



Since 1996, average yield impact +6.17% & +62.4 m tonnes

Figure 1: Corn: yield and production impact of biotechnology 1996-2007 by country

Table 1: Corn: yield and production impact of biotechnology 1996-2007

	Year of first adoption	**GM trait area 2007**	**% of crop to trait[65]**	**Average trait impact on yield %[66]**	**Average yield impact (tonnes/ha)**	**Additional production from trait (tonnes): 2007**	**Additional production from trait (tonnes): cumulative**
US Corn borer resistant	1996	18,560,907	49	5	0.43	8,584,419	44,662,867
US Corn Rootworm resistant	2003	8,417,645	22	5	0.43	3,893,161	7,023,290
Canada Corn borer resistant	1996	831,000	52	5	0.38	344,450	1,972,525
Canada Corn Rootworm resistant	2004	39,255	2.5	5	0.38	16,271	30,591
Argentina corn borer resistant	1997	2,509,000	81	7.8	0.48	938,366	5,801,153
Philippines corn borer resistant	2003	193,890	7	24.15	0.52	117,998	233,281
S Africa Corn borer resistant	2000	1,234,000	44	15.3	0.46	740,400	1,775,135
Uruguay Corn borer resistant	2004	105,000	62	6.3	0.32	32,398	62,957
Spain Corn borer resistant	1998	75,148	21	7.4	0.7	70,188	288,320
France Corn borer resistant	2005	22,135	1.5	10	0.88	20,807	25,540
Germany Corn borer resistant	2005	2,685	0.7	4	0.35	976	1,374
Portugal corn borer resistant	2005	4,263	3.6	12.5	0.65	2,936	4,203
Czech Republic Corn borer resistant	2005	5,000	4.7	10	0.66	2,875	3,939
Slovakia Corn borer resistant	2005	948	0.6	12.3	0.68	499	519
Poland Corn borer resistant	2006	327	0.1	12.5	0.59	216	231
Romania Corn borer resistant	2007	360	0.02	7.1	0.25	89	89
Cumulative totals		**32,001,563**				**14,766,049**	**61,886,014**

Insect resistant (IR) cotton

Insect resistant traits have been commercially used targeting various *Heliothis* pests (eg, budworm and bollworm). These are major pests of cotton crops in all cotton growing regions of the world and can devastate crops, causing substantial reductions in yield, unless crop protection practices are employed.

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[65] From year of first commercial planting to 2006

[66] Average of impact over years of use, as estimated by Brookes & Barfoot (2009)

The biotech IR cotton traits used have delivered positive yield impacts in all user countries (except Australia[67]) when compared to average yields derived from crops using conventional technology (mainly the intensive use of insecticides) for control of *heliothis* pests.

The positive yield impact varies from an average of about +6% in South America to +54% in India (Figure 2). In terms of additional production, on an area basis, this is in a range of +0.05 tonnes/ha to +0.17 tonnes/ha (of cotton lint).

The average positive yield and production impact across the area planted to insect resistant cotton over the eleven year period has been + 13.3%. This has added 6.85 million tonnes to total cotton lint production in the countries using the technology. In 2007, the technology delivered an extra 2.01 million tonnes of cotton lint production (Table 2).

Figure 2: Cotton: yield and production impact of biotechnology 1996-2007 by country

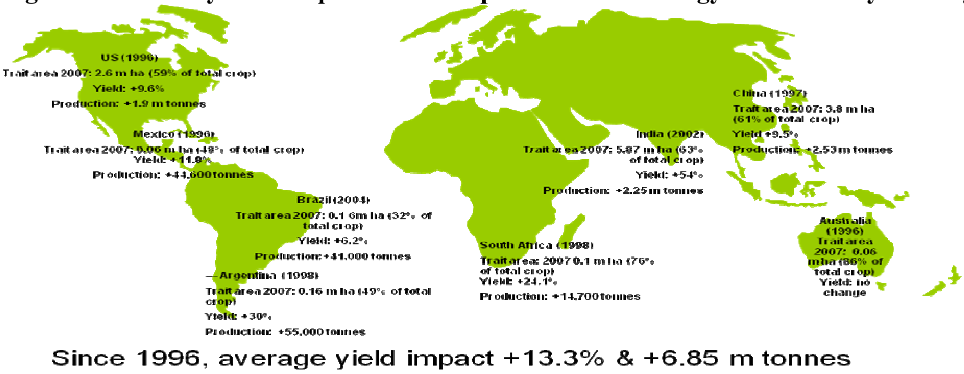


Table 2: Cotton: yield and production impact of biotechnology 1996-2007

	Year of first adoption	GM trait area 2007	% of crop to trait[68]	Average trait impact on yield %[69]	Average yield impact (tonnes/ha)	Additional production from trait (tonnes): 2007	Additional production from trait (tonnes): cumulative
US	1996	2,585,160	59	9.6	0.07	240,420	1,900,796
China	1997	3,800,000	61	9.5	0.1	449,920	2,533,336
South Africa	1998	9,900	76	24.3	0.11	1,644	14,734
Australia	1996	55,328	86	Nil	-	-	-
Mexico	1996	60,000	48	11.8	0.12	6,570	44,628
Argentina	1998	162,300	49	30	0.12	20,352	55,349
India	2002	5,868,000	63	54.8	0.17	1,261,620	2,255,826
Columbia	2002	20,000	43	8.1	0.06	1,763	5,360
Brazil	2006	358,000	32	6.2	0.08	29,440	40,627
Cumulative totals		**12,918,688**				**2,011,730**	**6,850,656**

Herbicide tolerant soybeans

Weeds have traditionally been a significant problem for soybean farmers, causing important yield losses (from weed competition for light, nutrients and water). Most weeds in soybean crops have been reasonably controlled, based on application of a mix of herbicides.

[67] This reflects the levels of *Heliothis* pest control previously obtained with intensive insecticide use. The main benefit and reason for adoption of this technology in Australia has arisen from significant cost savings (on insecticides) and the associated environmental gains from reduced insecticide use

[68] From year of first commercial planting to 2006

[69] Average of impact over years of use, as estimated by Brookes & Barfoot (2009)

Although the primary impact of biotech herbicide tolerant (HT) technology has been to *provide more cost effective* (less expensive) and *easier* weed control versus improving yields from *better* weed control (relative to weed control obtained from conventional technology), improved weed control has, nevertheless occurred - delivering higher yields. Specifically, the main country in which HT soybeans has delivered higher yields has been in Romania, where the average yield increased by over 30 per cent (Figure 3)[70].

Biotech HT soybeans have also facilitated the adoption of no tillage production systems, shortening the production cycle. This advantage enables many farmers in South America to plant a crop of soybeans immediately after a wheat crop in the same growing season. This second crop, additional to traditional soybean production, has added 67.6 million tonnes to soybean production in Argentina and Paraguay between 1996 and 2007. In 2007, the second crop soybean production in these countries was 14.5 million tonnes (Table 3).

Table 3: Second crop soybean production facilitated by biotech HT technology in South America 1996-2007 (million tonnes)

Country	Year first commercial use of HT soybean technology	Second crop soybean production 2007	Second crop soybean production cumulative
Argentina	1996	13,987,114	64,870,614
Paraguay	1999	472,358	2,689,280
Total		**14,459,472**	**67,559,894**

Herbicide tolerant canola

Weeds represent a significant problem for canola growers contributing to reduced yield and impairing quality by contamination (eg, with wild mustard seeds). Conventional canola weed control is based on a mix of herbicides which has provided reasonable levels of control although some resistant weeds have developed (eg, to the herbicide trifluralin). Canola is also sensitive to herbicide carryover from (herbicide) treatments in preceding crops which can affect yield.

The main impact of biotech HT canola technology, used widely by canola farmers in Canada and the US, has been to provide more cost effective (less expensive) and easier weed control, coupled with higher yields. The higher yields have arisen mainly from more effective levels of weed control than was previously possible using conventional technology. Some farmers have also obtained yield gains from biotech derived improvements in the yield potential of some HT canola seed.

The average annual yield gains (average over all years of adoption) have been about +3.5% in the US and +9% in Canada (Figure 3).

Over the 1996-2007 period, the additional North American canola production arising from the use of biotech HT technology was +4.44 million tonnes (Figure 3).

Herbicide tolerant corn & cotton

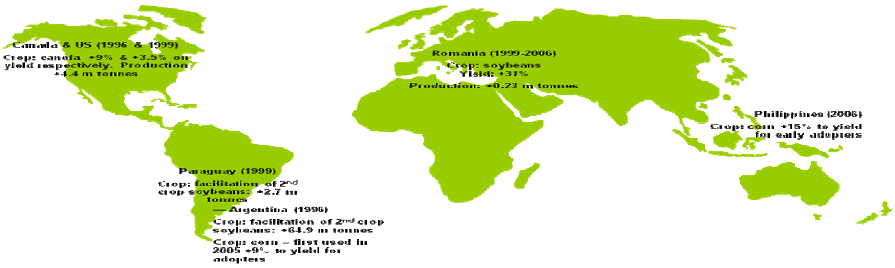
Weeds have also been a significant problem for corn and cotton farmers, causing important yield losses. Most weeds in these crops have been reasonably controlled based on application of a mix of herbicides.

The HT technology used in these crops has mainly provided more cost effective (less expensive) and easier weed control rather than improving yields from better weed control (relative to weed control levels obtained from conventional technology).

Improved weed control from use of the HT technology has, nevertheless, delivered higher yields in some regions and crops (Figure 3). For example, in Argentina, where HT corn was first used commercially in 2005, the average yield effect has been +9%, adding +0.45 million tonnes to national production (2005-2007). Similarly in the Philippines, (first used commercially in 2006), early adopters are finding an average of +15% to yields (this has delivered an extra 83,000 tonnes on the small area using the technology in the first two years of adoption).

Figure 3: Herbicide tolerant crops: yield and production impact of biotechnology 1996-2007 by country

[70] Weed infestation levels, particularly of difficult to control weeds such as Johnson grass have been very high in Romania. This is largely a legacy of the economic transition during the 1990s which resulted in very low levels of farm income, abandonment of land and very low levels of weed control. As a result, the weed bank developed substantially and has been subsequently very difficult to control, until the GM HT soybean system became available (glyphosate has been the key to controlling difficult weeds like Johnson grass)



Production impacts: summary

Drawing on the impacts presented above, Table 4 summaries the impact that adoption of biotech traits has had on production levels of the four main crops in which the technology has been used (soybeans, corn, cotton and canola) over the 1996-2007 period. Key points to note are:

- The biotech IR traits, used in the corn and cotton sectors, have accounted for 99% of the additional corn/maize production and all of the additional cotton production;
- In 2007, at the global level, world production levels of soybeans, corn, cotton lint and canola were respectively +6.5%, +1.9%, +7.7% and +1.1% higher than levels would have otherwise been if biotech traits had not been used by farmers;
- In area equivalent terms, if the biotech traits used by farmers in 2007 had not been available, maintaining global production levels at the 2007 levels would have required additional (conventional crop) plantings of 5.89 million ha of soybeans, 3 million ha of corn, 2.54 million ha of cotton and 0.32 million ha of canola. This total area requirement is equivalent to about 6% of the arable land in the US, or 23% of the arable land in Brazil.

Table 4: Additional crop production arising from positive yield effects of biotech crops

	1996-2007 additional production (million tonnes)	2007 additional production (million tonnes)
Soybeans	67.80	14.46
Corn	62.42	15.08
Cotton	6.85	2.01
Canola	4.44	0.54

Farm income and cost of production effects

Over the twelve year period 1996-2007, biotechnology has had a significant positive impact on global farm income derived from a combination of enhanced productivity and efficiency gains (Table 5):

- In 2007, the direct global farm income benefit from biotech crops was $10.1 billion. This is equivalent to having added 4.4% to the value of global production of the four main crops of soybeans, maize, canola and cotton;
- Since 1996, farm incomes have increased by $44.1 billion;
- The largest gains in farm income have arisen in the soybean sector, largely from cost savings. The $3.9 billion additional income generated by GM herbicide tolerant (GM HT) soybeans in 2007 has been equivalent to adding 7.2% to the value of the crop in the biotech growing countries, or adding the equivalent of 6.4% to the $60 billion value of the global soybean crop in 2007. These economic benefits should, however be placed within the context of a significant increase in the level of soybean production in the main biotech adopting countries. Since 1996, the soybean area in the leading soybean producing countries of the US, Brazil and Argentina increased by 58%. Of the total cumulative income gains from biotech HT soybeans ($21.81 billion 1996-2007), 78.5% has been due to cost savings and the balance due to yield increases (from improved weed control mainly in Romania and Mexico) and facilitation of 2nd crop soybeans in South America (by shortening the production cycle for soybeans, the technology has enabled many South American farmers to plant a crops of soybeans immediately after a wheat crop ‘in the same season’). The average farm income gain over the 1996-2007 period across the total biotech HT soybean area was $42/ha and for 2nd crop soybeans the average gain was $167/ha;
- Substantial gains have also arisen in the cotton sector through a combination of higher yields and lower costs associated with the use of GM IR technology. In 2007, cotton farm income levels in the biotech adopting countries increased by $3.2 billion and since 1996, the sector has benefited from an additional $12.6 billion. Within this, 65% of the farm income gain has derived from yield gains (less pest damage) and the balance (35%) from reduced expenditure on crop protection (spraying of insecticides). The 2007 income gains are equivalent to adding 16.5% to the value of the cotton crop in these countries, or 10.2% to the $27.5

billion value of total global cotton production. Biotech IR cotton has provided the largest gains per hectare, with an average farm income gain across the total biotech IR cotton area, over the 1996-2007 period, of $150/ha. Income gains have been largest in developing countries, notably China and India, where the average income gain has respectively been +$286/ha and +$275/ha;

- Significant increases to farm incomes have also resulted in the maize and canola sectors. The combination of GM insect resistant (GM IR) and GM HT technology in maize has boosted farm incomes by $7.2 billion since 1996. In the North American canola sector an additional $1.44 billion has been generated;
- Of the total cumulative farm income benefit, $20.5 billion (46.5%) has been due to yield gains (and second crop facilitation), with the balance arising from reductions in the cost of production. Within this yield gain component, 68% derives from the GM IR technology and the balance to GM HT crops.

Table 5: Global farm income benefits from growing biotech crops 1996-2007: million US $

Trait	Increase in farm income 2007	Increase in farm income 1996-2007	Farm income benefit in 2007 as % of total value of production of these crops in biotech adopting countries	Farm income benefit in 2007 as % of total value of global production of crop
GM herbicide tolerant soybeans	3,935	21,814	7.2	6.4
GM herbicide tolerant maize	442	1,508	0.7	0.4
GM herbicide tolerant cotton	25	848	0.1	0.1
GM herbicide tolerant canola	346	1,439	7.65	1.4
GM insect resistant maize	2,075	5,674	3.2	1.9
GM insect resistant cotton	3,204	12,576	16.5	10.2
Others	54	209	Not applicable	Not applicable
Totals	**10,081**	**44,068**	**6.9**	**4.4**

Notes: All values are nominal. Others = Virus resistant papaya and squash. Totals for the value shares exclude 'other crops' (ie, relate to the 4 main crops of soybeans, maize, canola and cotton). Farm income calculations are net farm income changes after inclusion of impacts on yield, crop quality and key variable costs of production (eg, payment of seed premia, impact on crop protection expenditure)

Table 6 summarises farm income impacts in key biotech adopting countries. This highlights the important farm income benefit arising from GM HT soybeans in South America (Argentina, Brazil, Paraguay and Uruguay), GM IR cotton in China and India and a range of GM cultivars in the US. It also illustrates the growing level of farm income benefits being obtained in South Africa, the Philippines and Mexico.

Table 6: GM crop farm income benefits 1996-2007 selected countries: million US $

	GM HT soybeans	GM HT maize	GM HT cotton	GM HT canola	GM IR maize	GM IR cotton	Total
US	10,422	1,402.9	804	149.2	4,778.8	2,232.7	***19,789.6***
Argentina	7,815	46	28.6	N/a	226.8	67.9	***8,184.3***
Brazil	2,868	N/a	N/a	N/a	N/a	65.5	***2,933.5***
Paraguay	459	N/a	N/a	N/a	N/a	N/a	***459***
Canada	103.5	42	N/a	1,289	208.5	N/a	***1,643***
South Africa	3.8	5.2	0.2	N/a	354.9	19.3	***383.4***
China	N/a	N/a	N/a	N/a	N/a	6,740.8	***6,740.8***
India	N/a	N/a	N/a	N/a	N/a	3,181	***3,181***
Australia	N/a	N/a	5.2	N/a	N/a	190.6	***195.8***
Mexico	8.8	N/a	10.3	N/a	N/a	65.9	***85***
Philippines	N/a	11.4	N/a	N/a	33.2	N/a	***44.6***
Romania	92.7	N/a	N/a	N/a	N/a	N/a	***92.7***
Uruguay	42.4	N/a	N/a	N/a	2.7	N/a	***45.1***
Spain	N/a	N/a	N/a	N/a	60.0	N/a	***60***
Other EU	N/a	N/a	N/a	N/a	12.6	N/a	***12.6***
Columbia	N/a	N/a	N/a	N/a	N/a	10.4	***10.4***

Notes: All values are nominal. Farm income calculations are net farm income changes after inclusion of impacts on yield, crop quality and key variable costs of production (eg, payment of seed premia, impact on crop protection expenditure). N/a = not applicable

In terms of the division of the economic benefits obtained by farmers in developing countries relative to farmers in developed countries. Table 7 shows that in 2007, 58% of the farm income benefits have been earned by developing country farmers. The vast majority of these income gains for developing country farmers have been from GM IR cotton and GM HT soybeans[71]. Over the twelve years, 1996-2007, the cumulative farm income gain derived by developing country farmers was $22.1 billion (50.1% of the total).

Table 7: GM crop farm income benefits 2007: developing versus developed countries: million US $

	Developed	Developing
GM HT soybeans	1,375	2,560
GM IR maize	1,773	302
GM HT maize	402	41
GM IR cotton	286	2,918
GM HT cotton	16	8
GM HT canola	346	0
GM virus resistant papaya and squash	54	0
Total	**4,252**	**5,829**

Developing countries = all countries in South America, Mexico, India, China, the Philippines and South Africa

It is important to recognise that the analysis presented above is largely based on estimates of average impact in all years. Recognising that pest and weed pressure varies by region and year, additional sensitivity analysis is presented below for the crop/trait combinations where yield impacts were identified in the literature. This sensitivity analysis was undertaken for two levels of impact assumption; one in which all yield effects in all years were assumed to be 'lower than average' (levels of impact that reflected yield impacts in years of low pest/weed pressure) and one in which all yield effects in all years were assumed to be 'higher than average' (levels of impact that reflected yield impacts in years of high pest/weed pressure). The results of this analysis suggests a range of positive direct farm income gains in 2007 of +$8.5 billion to +$12.9 billion and over the 1996-2007 period, a range of +$38.2 billion to +$52.2 billion (Table 8). This range is broadly within 85% to 120% of the main estimates of farm income presented above.

Table 8: Direct farm income benefits 1996-2007 under different impact assumptions (million $)

Crop	Consistent below average pest/weed pressure	Average pest/weed pressure (main study analysis)	Consistent above average pest/weed pressure
Soybeans	21.796.0	21,814.1	21,829.0
Corn	4,571.0	7,181.2	12,152.0
Cotton	10,920	13,424.4	15,962.0
Canola	818.7	1,438.6	2.013.0
Others	101.4	208.8	224.3
Total	**38,207.1**	**44,067.1**	**52,180.3**

Note: No significant change to soybean production under all three scenarios as almost all gains due to cost savings and second crop facilitation

EU focus

GM HT soybeans: Romania

After joining the EU at the beginning of 2007, Romania was no longer officially permitted to plant GM HT soybeans. The impact data presented below therefore covers the period 1999-2006.

The growing of GM HT soybeans in Romania had resulted in substantially greater net farm income gains per hectare than any of the other countries using the technology:

- Yield gains of an average of 31%[72] have been recorded;
- The cost of the technology to farmers in Romania tended to be higher than other countries, with seed being sold in conjunction with the herbicide. For example, in the 2002-2006 period, the average cost of seed and herbicide per hectare was $120/ha to $130/ha. This relatively high cost however, did not deter adoption of the technology because of the major yield gains, improvements in the quality of soybeans produced (less weed material in the beans sold to crushers which resulted in price premia being obtained[73]) and cost savings derived;

[71] The classification of different countries into developing or developed country status affects the distribution of benefits between these two categories of country. The definition used is consistent with the definition used by James (2007)

[72] Source: Brookes (2005)

[73] Industry sources report that price premia for cleaner crops were no longer payable from 2005 by crushers and hence this element has been discontinued in the subsequent analysis

- The average net increase in gross margin in 2006 was $220/ha (an average of $175/ha over the eight years of commercial use: Table 9);
- At the national level, the increase in farm income amounted to $28.6 million in 2006. Cumulatively in the period1999-2006 the increase in farm income was $92.7 million (in nominal terms);
- The yield gains in 2006 were equivalent to an 21% increase in national production[74] (the annual average increase in production over the eight years was equal to 14.9%);
- In added value terms, the combined effect of higher yields, improved quality of beans and reduced cost of production on farm income in 2006 was equivalent to an annual increase in production of 33% (124,000 tonnes).

Table 9: Farm level income impact of using herbicide tolerant soybeans in Romania 1999-2006

Year	Cost saving ($/ha)	Cost savings net of cost of technology ($/ha)	Net increase in gross margin ($/ha)	Impact on farm income at a national level ($ millions)	Increase in national farm income as % of farm level value of national production
1999	162.08	2.08	105.18	1.63	4.0
2000	140.30	-19.7	89.14	3.21	8.2
2001	147.33	-0.67	107.17	1.93	10.3
2002	167.80	32.8	157.41	5.19	14.6
2003	206.70	76.7	219.01	8.76	12.7
2004	260.25	130.25	285.57	19.99	27.4
2005	277.76	156.76	266.68	23.33	38.6
2006	239.07	113.6	220.55	28.67	33.2

Sources and notes:

1. Impact data (source: Brookes 2005). Average yield increase 31% applied to all years, average improvement in price premia from high quality 2% applied to years 1999-2004
2. All values for prices and costs denominated in Romanian Lei have been converted to US dollars at the annual average exchange rate in each year
3. Technology cost includes cost of herbicides
4. The technology was not permitted to be planted in 2007 – due to Romania joining the EU

GM IR maize: Spain

Spain has been commercially growing GM IR maize since 1998 and in 2007, 21% (75,150 ha) of the country's maize crop was planted to varieties containing a GM IR trait.

As in the other countries planting GM IR maize, the main impact on farm profitability has been increased yields (an average increase in yield of 6.3% across farms using the technology in the early years of adoption). With the availability and widespread adoption of the Mon 810 trait from 2003, the reported average positive yield impact is about +10%[75]. There has also been a net annual average saving on cost of production (from lower insecticide use) of between $37/ha and $57/ha[76] (Table 10). At the national level, these yield gains and cost savings have resulted in farm income being boosted, in 2007 by $20.6 million and cumulatively since 1998 the increase in farm income (in nominal terms) has been $60 million.

Relative to national maize production, the yield increases derived from GM IR maize were equivalent to a 2% increase in national production (2007). The value of the additional income generated from Bt maize was also equivalent to an annual increase in production of 1.94%.

Table 10: Farm level income impact of using GM IR maize in Spain 1998-2007

Year	Cost savings ($/ha)	Net cost savings inclusive of cost of technology ($/ha)	Net increase in gross margin ($/ha)	Impact on farm income at a national level ($ millions)
1998	37.40	3.71	95.16	2.14
1999	44.81	12.80	102.20	2.56
2000	38.81	12.94	89.47	2.24
2001	37.63	21.05	95.63	1.10
2002	39.64	22.18	100.65	2.10
2003	47.50	26.58	121.68	3.93

[74] Derived by calculating the yield gains made on the GM HT area and comparing this increase in production relative to total soybean production

[75] The cost of using this trait has been higher than the pre 2003 trait (Bt 176) – rising from about €20/ha to €35/ha

[76] Source: Brookes (2002) and Alcade (1999)

2004	51.45	28.79	111.93	6.52
2005	52.33	8.72	144.74	7.70
2006	52.70	8.78	204.5	10.97
2007	57.30	9.55	274.59	20.63

Sources and notes:

1. Impact data (based on Brookes (2002 & Brookes (2008)). Yield impact +6.3% to 2004 and 10% used thereafter (originally Bt 176, latterly Mon 810). Cost of technology based on €18.5/ha to 2004 and €35/ha from 2005
2. All values for prices and costs denominated in Euros have been converted to US dollars at the annual average exchange rate in each year

GM IR maize: Other EU countries

A summary of the impact of GM IR technology in other countries of the EU is presented in Table 11. This shows that in 2007, the additional farm income derived from using GM IR technology in these seven countries was +$7.4 million. Cumulatively over the 2005-2007 period, the total income gain was $8.6 million.

Table 11: Farm level income impact of using GM IR maize in other EU countries 2005-2007

	Year first planted GM IR maize	**Area 2007 (hectares)**	**Yield impact (%)**	**Cost of technology 2007 ($/ha)**	**Cost savings 2007 (before deduction of cost of technology: $/ha)**	**Net increase in gross margin 2007 ($/ha)**	**Impact on farm income at a national level 2007 (million $)**
France	2005	22,135	+10	54.57	68.21	254.73	5.64
Germany	2005	2,685	+4	54.57	68.21	117.32	0.32
Portugal	2005	4,263	+12.5	47.75	0	143.94	0.61
Czech Republic	2005	5,000	+10	47.75	24.56	146.25	0.73
Slovakia	2005	948	+12.3	47.75	0	102.35	0.09
Poland	2006	327	+12.5	47.75	0	123.33	0.04
Romania	2007	360	+7.1	43.66	0	34.66	0.01
Total other EU (excluding Spain)		**35,670**					**7.44**

Source and notes:

1. Source: based on Brookes (2008)
2. All values for prices and costs denominated in Euros have been converted to US dollars at the annual average exchange rate in each year

b) Labour flexibility

GM herbicide tolerant crops have been shown in a number of ex-post studies to have increased management flexibility. This comes from a combination of the ease of use associated with broad-spectrum, post-emergent herbicides like glyphosate and the increased/longer time window for spraying (see for example Brookes & Barfoot (2009), American Soybean Association (2001), Carpenter & Gianessi (1999) and Fernandez-Cornejo J & McBride W (2002)).

GM insect resistant crops have also provided a convenience/flexibility benefit from less time being spent on crop walking and/or applying insecticides (see for example, Brookes (2002)).

Relevant references in full

American Soybean Association Conservation Tillage Study (2001). http://www.soygrowers.com/ctstudy/ctstudy_files/frame.htm

Brookes G (2002) The farm level impact of using Bt maize in Spain, ICABR conference paper 2003, Ravello, Italy. Also on www.pgeconomics.co.uk

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk Also Global impact of biotech crops: income and production effects 1996-2007, Agbioforum (2009) forthcoming

Carpenter J & Gianessi L (1999) Herbicide tolerant soybeans: Why growers are adopting Roundup Ready varieties, Ag Bioforum, Vol 2 1999, 65-72

Fernandez-Cornejo J & McBride W (2002) Adoption of bio-engineered crops, USDA, ERS Agricultural Economics Report No 810

c) Quality of the harvest

There is a growing body of ex-post analysis evidence to show that the adoption of GM IR maize has delivered important improvements in grain quality from significant reductions in the levels of mycotoxins found in the grain. Several papers quantifying and measuring this, in the EU, are summarised in Brookes G (2008). In terms of revenue from sales of corn, however, no premia for delivering product with lower levels of mycotoxins have, to date, been reported although where the adoption of the technology has resulted in reduced frequency of crops failing to meet maximum permissible fumonisin levels in grain maize (eg, in Spain), this delivers an important economic gain to farmers if they sell their grain to the food using sector. GM IR corn farmers in the Philippines have also obtained price premia of 10% (see Yorobe J (2004) relative to conventional corn because of better quality, less damage to cobs and lower levels of impurities.

Improved weed control arising from the adoption of GM HT crops has also reduced harvesting costs for many farmers. Cleaner crops have resulted in reduced times for harvesting. It has also improved harvest quality and led to higher levels of quality price bonuses in some regions. Examples where this arisen include in Romania (GM HT soybeans: see Brookes (2005)), in Canada (GM HT canola: see Canola Council (2001) and in Argentina (GM HT soybeans: see Qaim & Traxler (2002)).

Relevant references in full

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Qaim M & Traxler G (2002) Roundup Ready soybeans in Argentina: farm level, environmental and welfare effects, 6th ICABR conference, Ravello, Italy

Yorobe J (2004) Economics impact of Bt corn in the Philippines. Paper presented to the 45th PAEDA Convention, Querzon City

d) Seed prices

Brookes G & Barfoot P (2009) examined this issue in terms of the cost farmers pay for accessing GM technology relative to the total trait benefit (measured in terms of the farm income gain plus the cost of accessing the technology at the farm level). Table 12 summarises their ex-post analysis across the four main biotech crops for 2007, and identified that the total cost was equal to 24% of the total technology gains (inclusive of farm income gains plus cost of the technology payable to the seed supply chain[77]).

For farmers in developing countries the total cost was equal to 14% of total technology gains, whilst for farmers in developed countries the cost was 34% of the total technology gains. Whilst circumstances vary between countries, the higher share of total technology gains accounted for by farm income gains in developing countries relative to the farm income share in developed countries reflects factors such as weaker provision and enforcement of intellectual property rights in developing countries and the higher average level of farm income gain on a per hectare basis derived by developing country farmers relative to developed country farmers.

Table 12: Cost of accessing GM technology (million $) relative to the total farm income benefits 2007

	Cost of technology: all farmers	Farm income gain: all farmers	Total benefit of technology to farmers and seed supply chain	Cost of technology: developing countries	Farm income gain: developing countries	Total benefit of technology to farmers and seed supply chain: developing countries
GM HT soybeans	931	3,935	4,866	326	2,560	2,886
GM IR maize	714	2,075	2,789	79	302	381
GM HT maize	531	442	973	20	41	61
GM IR cotton	670	3,204	3,874	535	2,918	3,453
GM HT cotton	226	25	251	8	8	16
GM HT canola	102	346	448	N/a	N/a	N/a
Total	**3,174**	**10,081**	**13,255**	**968**	**5,829**	**6,797**

[77] The cost of the technology accrues to the seed supply chain including sellers of seed to farmers, seed multipliers, plant breeders, distributors and the GM technology providers

1. N/a = not applicable. Cost of accessing the technology is based on the seed premia paid by farmers for using GM technology relative to its conventional equivalents. Total farm income gain excludes £26 million associated with virus resistant crops in the US

Qaim & Traxler (2005) identified that, in terms of aggregate welfare, the economic surplus associated with GM HT soybeans in Argentina in 2001 was $335 million, of which farmers were able to capture 90% of the benefit. In contrast, they estimated that in the US, the share of the total trait benefit (of GM HT soybeans) was, the supply chain and farmers captured 57% and 43% respectively of the benefit. This greater share of the supply chain in the US relative to Argentina reflected the more effective Intellectual Property Rights (IPR) protection available in the US.

Pray et al (2002) examined these issues relating to the adoption of GM IR cotton in China but extended their analysis to consider consumer level impacts. They concluded that because the Chinese government bought all of the cotton at a fixed price, no benefits were passed on down the supply chain to consumers. Also because of weak intellectual property rights the major share of benefits was retained by farmers, with little accruing to the technology providers (public and private sector).

Traxler et al (2001) and Traxler and Godoy-Avila (2004) similarly found in Mexico (adoption of GM IR cotton) that 85% of the total benefits from adoption went to farmers with only 15% earned by the seed suppliers and technology providers.

Trigo and CAP (2006) estimated the distribution of accumulated benefits generated by GM HT soybeans in Argentina in the period 1996 to 2005, to be farmers 78%, the supply chain 9% and the government (from export taxes), 13%.

Demont M et al (2007) estimated the annual (ex-post) share split of global benefits from the first generation of GM crops to have been two-thirds 'downstream' (farmers and consumers) to one third 'upstream' (the input suppliers including biotechnology companies, plant breeders, seed suppliers, seed producers and wholesalers). This analysis also examined the potential (ex ante) share of these benefits if first generation GM crops were widely used in the EU (Insect resistant maize and herbicide tolerant maize, sugar beet and oilseed rape). This part of the analysis suggested a similar likely breakdown of benefits with 62% going to farmers/consumers and 38% to the supply chain (based on a total estimated annual benefit of €668 million).

Overall, all of the papers that have examined this issue have consistent findings, namely that a significant majority of the benefit has accrued to farmers (relative to the supply chain, including the providers of the technology).

Relevant references in full

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Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, The Plant Journal 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, World Development 29 (5), 813-825

Qaim M & Traxler G (2005) Roundup Ready soybeans in Argentina: farm level & aggregate welfare effects, Agricultural Economics 32 (1) 73-86

Traxler G et al (2001) Transgenic cotton in Mexico: economic and environmental impacts, ICABR conference, Ravello, Italy

Traxler and Godoy-Avila (2004): Transgenic cotton in Mexico, Agbioforum 7, (1-2), 57-62, www.agbioforum.org

Trigo E & Cap E (2006) Ten years of GM crops in Argentine agriculture, ArgenBio, Argentina

e) Impact on seed variety availability/biodiversity

This issue has been examined in a limited number of ex-post studies. Zilberman et al (2007) examined whether the introduction of biotech traits may lead to a loss of seed (bio) diversity and a reduction in the number of varieties grown. They identified that the introduction of biotech traits may actually increase the number of distinct varieties when the technological, economic and regulatory conditions facilitate the adoption of biotech traits in a large number of local varieties. However, limited capacity to modify local varieties may adversely affect seed (bio)diversity, as it may result in a small number of varieties containing biotech traits (sometimes imported) being planted on land where a larger number of local varieties had formerly grown. In the seed markets of most countries, the decisions about adoption of different varieties by farmers and the availability of different seed varieties containing various traits/attributes by the local seed sector are made on economic grounds. It is therefore in the interests of biotech trait 'holders' to facilitate access to their traits by companies that breed and supply local varieties, best suited to local conditions, if they wish to maximise uptake of their technology at the farm level. However, when there are a large number of local varieties grown with small shares of the total market, supplied by a large number of seed companies, it may prove unattractive (from an economic perspective) to licence biotech traits to many (small) local seed companies. Therefore, if it is considered to be desirable from a public policy perspective to maintain/preserve local varieties, Zilberman et al argue it may be appropriate for the public sector to address this 'market failure' through a) operating policies and regulations that provide favourable conditions to introduce biotech traits into local varieties (ie, an efficient, transparent and low cost regulatory approval process so as to maximise the market incentives for trait availability in local seed), and b) providing incentives for farmers to continue to use local varieties without a biotech trait. In this way, partial adoption of biotech traits will occur, allowing farmers to gain access to new technology and helping to preserve seed (bio)diversity.

Pehu F & Ragasa C (2007) concluded that the quick and extensive adoption of GM IR cotton in China owed much to publicly developed GM IR cotton varieties and to a decentralised breeding system, which transferred quickly the GM trait to local varieties that could then be sold at relatively low prices. Similarly, in Mexico good availability of seed and credit facilitated a high adoption rate for GM IR cotton. In contrast, lack of credit and access to credit in South Africa was considered as an important factor hindered adoption.

Relevant references in full

Pehu F & Ragusa C (2007) Agricultural Biotechnology: transgenics in agriculture and their implications for developing countries, World Bank, Background Paper for the World Development Report of 2008

Zilberman D et al (2007) The impact of agricultural biotechnology on yields, risks and biodiversity in low income countries, Journal of Development Studies, vol 43, 1, 63-78, Jan 2007

f) Health of labour

Improved health and safety for farmers and farm workers (from reduced handling and use of insecticides) is also a feature highlighted in several papers examining the ex-post impact of GM IR cotton in developing countries. Huang et al (2002 & 2003) and Pray et al (2001 & 2002) identified benefits from reduced exposure to insecticides and associated incidences of pesticide poisonings being reported in China as a result of the adoption of GM IR cotton.

Bennett, Morse and Ismael (2006) suggested that the number of accidental pesticide poisonings cases associated with growing cotton in South Africa had fallen following the adoption of GM IR cotton.

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Huang J et al (2002) Transgenic varieties and productivity of smallholder cotton farmers in China, Australian Journal of Agricultural and Resource Economics 46 (3): 367-387

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Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, The Plant Journal 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, World Development 29 (5), 813-825

g) Use of inputs

See 2. Agronomic sustainability.

h) Impact on labour use

Ex-post analysis by Qaim M et al (2006) identified in India, associated with the adoption of GM IR cotton, that reduced insecticide sprayings resulted in a lower requirement for labour to undertake pest scouting and spraying (this mostly affected male family members) but this was counterbalanced by additional labour requirements for harvesting (higher yields), with the latter labour change mainly affecting casual, usually female labour. Overall, they concluded that the net effect on labour use was neither, positive or negative.

These impacts were also identified by Dev S & Rao N (2007), albeit in an ex-post study focusing on the Andra Pradesh region of India only. Their work identified that the net impact on labour use of using GM IR cotton was positive (ie, the extra harvest labour requirement was greater than the loss of pest scouting and spraying labour requirement).

Subramanian A & Qaim M (2008) looked at this issue further through research into a small cotton growing community in India, via monitoring of household expenditure patterns and activities. Whilst this was only a small piece of research it provided a useful insight into wider economic impacts and was representative of semi arid tropical regions in central and southern India. Its key findings were that GM IR cotton had delivered a net creation of rural employment, with the additional harvest labour requirements being greater than the reductions associated with pest scouting and spraying. This did have gender implications given that it has been mostly females who gained, relative to males who lost out. Their analysis, however shows that on average, the saved male family labour has been/can be re-employed efficiently in alternative agricultural and non agricultural activities so that, the overall returns to male labour increase.

The returns to management time saved for famers/farm workers and their re-deployment also tended to be greater for larger farmers than smaller ones. This was largely explained by the fact that large farmers are often better educated and have better access to financial resources which help them gain alternative employment or set up self employment activities.

Fernanez-Cornejo J & Caswell M (2006) showed that the adoption of GM HT soybeans in the US, by reducing management time associated with the crop, allowed additional time for off-farm income earning opportunities.

Gouse M et al (2006) found that the use of GM IR technology in maize (in the Kwazulu-Natal region of South Africa, in 2003/04 was neutral in respect of labour use (a year of low pest pressure). They perceive that in years of higher pest pressure the labour requirement would likely fall, as less insecticide granules would be applied by farmers/workers.

Trigo E & Cap E (2006), looking at the social changes associated with the expansion of soybean production, using GM HT technology and its facilitation of no tillage production practices, cite statistics on farm employment trends between 1993 and 2005, which show that the total number of jobs in the sector has been consistent (1.2-1.3 million) during a period in which the country's unemployment rate reached its highest historic level.

Relevant references in full

Dev S & Rao N (2007) Socio economic impact of Bt cotton, Centre for Economic and Social Studies, Hyderabad, Monograph, Nov 2007

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i) Co-existence and GM IR maize production in Europe

Research

The possibility of GM adventitious presence occurring in a non GM crop because of cross-pollination in maize crops is well researched. It draws on practical (commercial) ex-post experience of growing specialty maize crops (eg, waxy maize), GM crops, and specific research studies. Maize pollination essentially relies on wind dispersal of pollen. As such, levels of cross-pollination are generally closely related to distance of a receptor plant from a pollen donating plant, with the level of cross-pollination falling rapidly the further away the recipient plant is from the pollen source (as maize pollen is fairly heavy, the vast majority is deposited within a short distance of any emitter plant). On average, almost all maize pollen travels no further than 100 metres and nearly all potential cross-pollination between fields of non GM maize occurs within 18-20 metres of an emitter crop. In respect of GM maize containing a single trait such as insect (Bt) resistance, the presence of the GM trait in only 50% of pollen means that almost all cross pollination (of pollen with the GM trait) will occur at a reduced distance from the GM emitter crop.

Not surprisingly, it is possible to find examples of research that identified rates of cross-pollination (and hence levels of adventitious presence) at variance with these rates, because of the influence of a number of other factors. These include:

- *Timing of planting (and flowering) of different maize crops*: the greater the difference between planting times of crops of the same variety, the lower the levels of cross-pollination;
- *Varietal differences*: recommendations for planting times and the time each variety takes to flower (and produce/be receptive to pollen) usually varies by variety. Consequently, varietal differences can contribute differences in the timing of flowering and hence to the chances of cross-pollination occurring (see above);
- *Buffer crops*: the planting of (non GM) buffer crops affects cross-pollination levels. This is because a non GM buffer crop (of maize) can act as a interceptor to a large proportion of GM pollen and can provide additional non GM pollen that 'crowds out' the GM pollen (further reducing the chances of the GM pollen introgressing with the non GM crop in which adventitious presence is to be minimised). One row of buffer crop is considered to be roughly equal to 10 metres equivalent of separation distance;
- *Temperature and humidity levels*: the drier and hotter conditions are at time of flowering the lower the levels of cross-pollination and vice versa;
- *The strength and direction of wind:* levels of cross-pollination are highest in receptor crops that are typically downwind of donor crops. Not surprisingly, the stronger the wind at time of pollen dispersal, the greater the likelihood of cross-pollination being recorded at greater distances;
- *Barriers*: objects such as hedges and woods, as well as topography can affect levels of cross-pollination by interrupting and diverting airborne pollen flow. These barriers can cause pollen to be diverted

upwards (and hence could travel further than otherwise would be the case) and sometimes this can result in pollen being deposited in 'hot spots';

- *Length of border/shape of fields*: the longer the border between a GM and non GM crop, the greater the chances of cross-pollination occurring and vice versa;
- *Volunteers*. The presence of volunteer maize plants from an earlier crop may increase the level of adventitious presence in a crop. Whilst this possible source of adventitious presence is potentially highest in regions which do not have low enough average winter temperatures to kill volunteer plants, farm level experience (eg, in Spain) shows that this is a very minor source of adventitious presence.

In terms of achieving the EU labelling threshold of 0.9% for grain maize, research findings in Spain, France, Portugal, Italy, Switzerland, Germany and the UK have produced consistent results; this threshold is achievable through the application of measures such as isolation distances and the use of buffer rows. For (non GM or organic) plots/fields with a size of over 5 ha, no isolation distance is required. Where the non GM/organic plot is within 1-5 ha in size an isolation distance of 20 metres will be sufficient to ensure purity levels within the 0.9% labelling threshold (or if an isolation distance is not possible, the application of four buffer rows of non GM maize between a GM crop (on the GM growing farm) and a non GM crop as a single measure will deliver effective co-existence). For non GM plots under 1 ha in size an isolation distance of up to 50 metres may be required, for example if a non GM plot is located downwind of GM emitter crops.

Commercial experience

These factors of influence are known to growers of specialty maize crops (eg, waxy maize) and to the organisations that typically supply seed to farmers and/or buy (specialty) maize from farmers. As a result, the application of a variety of measures (such as separation distances, the use of buffer crops, varying the time of planting or varieties used), and taking into consideration the dilution effect on adventitious presence levels of normal harvesting practices[78], usually delivers required levels of purity. More recently, the same principles and practices have been successfully applied in respect of commercial GM maize crops where a non GM maize market has developed in a number of countries including Spain. Adventitious presence levels in excess of required purity levels (eg, set at the EU labelling threshold and in some cases to more stringent, market-driven thresholds) are rare[79]. This is because the measures taken are based on years of experience and usually operate to 'worst case' scenarios. Also in commercial crops, the rate of GM adventitious presence from cross pollination tends to be less than observed in research tests/trials due to factors such as differences in flowering time of crops and the dilution effect.

Overall, evidence from both commercial practice, and research shows that GM, conventional and organic growers[80] of maize have co-existed, and can co-exist and maintain the integrity of their crops without problems through the application of good farming and co-existence practices. Where GM maize growers are located near non GM maize growers who sell their crops into markets with a requirement for certified non GM maize, a separation distance of up to 25 metres (possibly extended to 50 metres in some, limited circumstances[81]) or the planting of 4-6 buffer rows should be sufficient to allow effective co-existence.

The summary provided above draws on the following references:

APROSE (2004) Evaluation of cross pollination between commercial GM (Mon 810) maize and neighbouring conventional maize fields. Analytical survey of 14 commercial Bt fields in 2003 by Monsanto, Nickersons and Pioneer Hi-Bred International, presented to the Spanish Bio-Vigilance Commission, unpublished

Bénétrix F & Bloc D (2003) Mais OGM et non OGM possible coexistence. Perspectives Agricoles No 294

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78 The key point being that it is normal practice to test crops for adventitious presence of all unwanted material (eg, the presence of GM material in non GM crops that are required to be certified as non GM, weed material, dirt, seed off types etc) after harvest. As a result, levels of adventitious presence of any unwanted material tend to be lower in harvested crops than might be the case if testing was undertaken in the field before harvest

79 Instances of GM adventitious presence in non GM/organic maize crops have occasionally been reported. These have been rare and usually caused by failure to apply good farming and co-existence practices rather than any failure of co-existence measures per se

80 In respect of organic growers this assumes application of the EU legal (labelling) threshold of 0.9%. It does not consider the threshold applied by some organic certifying bodies of zero detectible presence because it is not possible to meet such a threshold in any form of agricultural production system

81 For example, if the non GM crop is in a plot size under 1 ha and located downwind of a GM crop

Brookes G and Barfoot P (2003) Co-existence of GM and non GM crops: case study of maize grown in Spain, paper presented to the 1st European conference on the coexistence of GM crops with conventional and organic crops, GMCC-O3, Denmark, November 2003
Brookes G et al (2004) GM maize: pollen movement and crop co-existence. www.pgeconomics.co.uk/pdf/maizepollennov2004final.pdf
Devos Y et al (2005) The co-existence between transgenic and non-transgenic maize in the European Union: a focus on pollen flow and cross-fertilisation, Environ. Biosafety Res. 4 71-87
Foueilassar X & Fabie A (2003) Waxy maize production, an experiment evaluating coexistence of GM and conventional maize, ARVALIS, France
Joint Research Centre (2006) New case studies on the coexistence of GM and non GM crops in European agriculture, Eur 22102, JRC, IPTS Technical Report Series. www.
Loubet, B and Foueillassar, X. et al., (2003) INRA Thiverval-Grignon Etude mécaniste du transport et du dépôt de pollen de maïs dans un paysage hétérogène.Rapport de fin de projet Convention INSU N° 01 CV 081
Ma B et al (2004) Crop ecology, management & quality: extent of cross-fertilisation in maize by pollen from neighbouring transgenic hybrids, Crop Science 44, 1273-1284, Crop Science Society of America, USA
Melé E et al (2004) First results of co-existence study: European Biotechnology Science & Industry News No 4, vol 3
Meir-Bethke & Schiemann J (2003) Effect of varying distances and intervening maize fields on outcrossing rates of transgenic maize, Proceedings of the 1st European conference on the co-existence of GM crops with conventional and organic crops, Denmark, November 2003
Ortega Molina J (2006) The Spanish experience with co-existence after 8 years of cultivation of GM maize, paper presented to the Co-existence of GM, conventional and organic crops, Freedom of Choice Conference, Vienna, April 2006
Porta G et al (2006) Indagine sulle dinamiche di diffusione del polline tra coltivazioni contigue di mais nel contesto padano, CRA-Instituao Sperimentale per la Cerealicoltura
Rodriguez-Cerezo E (2006). Segregation up to the farmgate: agronomic measures to ensure co-existence. JRC IPTS paper presented to the Co-existence of GM, conventional and organic crops, Freedom of Choice Conference, Vienna, April 2006
Sears, M. K. & Stanley-Horn, D. (2000) Impact of Bt corn pollen on monarch butterfly populations. In: Fairbairn, C., Scoles, G. & McHughen, A. (Eds.) Proceedings of the 6th International Symposium on The Biosafety of Genetically Modified Organisms. University Extension Press, Canada.
Weber W et al (2005) Koexistenz von gentechnisch verandertem und konventionellem mais. Mais ½, 1-6

1.2 Seed industry
For analysis of the shares of total benefits derived by the seed sector from GM crops, see section 1.1 d) above.

1.3 Consumers
Impact on prices
Assessing the impact of the biotech agronomic, cost saving technology such as herbicide tolerance and insect resistance on the prices of soybeans, maize, cotton and canola (and derivatives) is difficult. Current and past prices reflect a multitude of factors of which the introduction and adoption of new, cost saving technologies is one. This means that disaggregating the effect of different variables on prices is far from easy.
In general terms, it is also important to recognise that the real price of food and feed products has fallen consistently over the last 50 years. This has not come about 'out of the blue' but from enormous improvements in productivity by producers. These productivity improvements have arisen from the adoption of new technologies and techniques.
Against this background, Brookes & Barfoot (2009) point out the extent of use of biotech adoption globally shows that:

- For soybeans the majority of both global production and trade is accounted for by biotech production;
- For maize, cotton and canola, whilst the majority of global production is still conventional, the majority of globally traded produce contains materials derived from biotech production.

This means for a crop such as soybeans, that biotech production now effectively influences and sets the baseline price for commodity traded soybeans and derivatives on a global basis. Given that biotech soybean varieties have provided significant cost savings and farm income gains (eg, $2.76 billion in 2007) to growers, it is likely that some of the benefits of the cost saving will have been passed on down the supply chain in the form of lower real prices for commodity traded soybeans. Thus, the current baseline price for all soybeans, including conventional soy is probably at a lower real level than it would otherwise (in the absence of adoption of the technology) have been. A similar process of 'transfer' of some of the farm income benefits of using biotechnology in the other three crops has also probably occurred, although to a lesser extent because of the lower biotech penetration of global production and trade in these crops.

Building on this theme, some (limited) economic analysis has been undertaken to estimate the impact of biotechnology on global prices of soybeans.

Moschini et al (2000) estimated that by 2000 the influence of biotech soybean technology on world prices of soybeans had been between -0.5% and -1%, and that as adoption levels increased this could increase up to -6% (if all global production was biotech).

Qaim & Traxler (2002 & 2005) estimated the impact of GM HT soybean technology adoption on global soybean prices to have been -1.9% by 2001. Based on this analysis, they estimated that by 2005 it was likely that the world price of soybeans may have been lower by between 2% and 6% than it might otherwise have been in the absence of biotechnology. This benefit will have been dissipated through the post farm gate supply chain, with some of the gains having been passed onto consumers in the form of lower real prices.

In relation to the global cotton market, analysis by Frisvold G et al (2007) estimated that as a result of higher yields and production of cotton associated with the use of GM IR cotton in the US and China (in 2001), the world price of cotton lint was 0.014$/pound lower (-3.4%) than it would have otherwise have been (based on an indicative world farm level price in 2001 for cotton lint of about $900/tonne, this is equal to a $30.87/tonne of lint). Important impacts arising from this (and which are equally applicable to the impact of all GM and other (non GM) cost reducing/productivity enhancing technology) are:

- Purchasers of cotton on global markets benefit from the lower prices, as do end consumers;
- Non adopting cotton farmers, both in the countries where the new (GM IR) technology is used, and in other countries where the technology is not available, lose out because they experience the lower world prices, yet get no cost savings/productivity gains that might be derived from using the new technology.

Anderson K et al (2006) examined the impact of the adoption of GM IR cotton up to 2001 (also simulated impacts of adoption/non adoption of the technology in a number of (then) non adopting countries) on the international cotton market. At that time (2001) they estimated that global cotton production had not been significantly affected, although the world price of cotton was estimated to be about 2.5% lower than it would otherwise have been if the technology had not been adopted in the US, China, Australia and South Africa.

Relevant references in full

Anderson K et al (2006) Recent and prospective adoption of GM cotton: a global CGE analysis of economic impacts, World Bank Policy Research Working Paper 3917, World Bank, http://econ.worldbank.org

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk Also Global impact of biotech crops: income and production effects 1996-2007, Agbioforum (2009) forthcoming

Frisvold G et al (2007) Bt cotton adoption in the US and China: international trade and welfare effects, Agbioforum, vol 9, 2, 1-17

Moshini G et al (2000) Roundup Ready soybeans and welfare effects in the soybean complex, Agribusiness 16, (1): 33-55

Qaim M & Traxler G (2002) Roundup Ready soybeans in Argentina: farm level, environmental and welfare effects, 6th ICABR conference, Ravello, Italy

Qaim M & Traxler G (2005) Roundup Ready soybeans in Argentina: farm level & aggregate welfare effects, Agricultural Economics 32 (1) 73-86

1.4 Co-operatives and grain handling companies

1.5 Food and feed industry

1.6 Transport companies

1.7 Insurance companies

Various studies (summarised, for example in Brookes & Barfoot (2009)) highlight the importance of GM IR technology in improving production risk management. Essentially, the technology takes away much of the worry of significant pest damage occurring and is, therefore, highly valued by farmers who use the technology. This 'insurance' benefit of the technology has also recently been recognised by the insurance sector in the US, which began in 2008 to offer US maize farmers insurance discounts (for crop losses) if they used stacked maize traits (containing insect resistance and herbicide tolerant traits). The level of discount on crop insurance premiums is equal to about $7.41/hectare (about €5.3/ha).

1.8 Laboratories
1.9 Innovation and research
1.10 Public administration
1.11 Internal market
1.12 Specific regions and sectors

Adoption of biotech traits and size of farm

In relation to the nature and size of biotech crop adopters, there is fairly clear ex-post analysis evidence that size of farm has not been a factor affecting use of the technology. Technology adoption has been by both large and small farmers, with size of operation not having been a barrier to adoption. In 2007, 12 million farmers were using the technology globally, 90% plus of which were resource-poor farmers in developing countries. Specific examples of research that have examined this issue include:

- Fernandez-Cornejo & McBride (2000) examined the effect of size on adoption of biotech crops in the US (using 1998 data). The a priori hypothesis used for the analysis was that the nature of the technology embodied in a variable input like seed (which is completely divisible and not a 'lumpy' input like machinery) should show that adoption of biotech crops is not related to size. The analysis found that mean adoption rates appeared to increase with size of operation for herbicide tolerant crops (soybeans and maize) up to 50 hectares in size and then were fairly stable, whilst for GM IR maize adoption appeared to increase with size. This analysis did, however not take into account other factors affecting adoption such as education, awareness of new technology and willingness to adopt, income, access to credit and whether a farm was full or part time – all these are considered to affect adoption yet are also often correlated to size of farm. Overall, the study suggested that farm size has not been an important factor influencing adoption of biotech crops;
- Brookes (2003) identified in Spain that the average size of farmer adopting GM IR maize was 50 hectares and that many were much smaller than this (under 20 hectares). Size was not therefore considered to be an important factor affecting adoption, with many small farmers (small in the context of average farm size in Spain) using the technology;
- Brookes (2005) also identified in Romania that the size of farm was not an important factor in the adoption of HT soybeans. Both large and smaller farms (within the context of the structure of production in Romania), within a range of 30 hectares to 20,000 hectares in size using the technology;
- Pray et al (2002) and Huang et al (2002). This research into GM IR cotton adoption in China illustrated that adoption has been by mostly small farmers (the average cotton grower in China plants between 0.3 and 0.5 ha of cotton). They also identified that the smallest farmers experienced the largest yield gains;
- Adopters of insect resistant cotton and maize in South Africa have been drawn from both large and small farmers (see Morse et al 2004, Ismael et al 2002, Gouse (2006));
- In 2007, there were 3.8 million farmers growing GM IR cotton in India, with an average size of about 1.6 hectares (Manjunath T (2008);
- GM IR technology (in cotton) is scale neutral, in that both small and larger farms adopt (Qaim et al 2006);
- Penna J & Lema D (2001) indicate that farm size has not affected the adoption of GM HT soybeans in Argentina. In fact, these analysts perceive that the availability of GM HT technology and its facilitating role in the adoption of no tillage production systems has helped small and medium sized in Argentina to improve their competitiveness. Previously these farmers used rotation and mixed farming to maintain/restore soil nutrient levels, soil structure and levels of organic matter (necessary to maintain crop yields), but the option of using GM HT soybeans in no tillage production systems had allowed these farmers to implement crop after crop production systems (eg, continuous soybeans or a corn-soybean rotation) and allow the wider implementation of second crop soybeans (after a wheat crop in the same season). These options greatly improved profitability levels, keeping them in farming rather than leaving the sector. Bindraban P et al (2009) also concur with this view – in their analysis of the increasing scale of soybean production systems in Brazil and Argentina over the last ten years, they conclude that this trend (of increasing size of farm) was largely driven by the need to benefit from economies of scale required to export in bulk at competitive prices and that the availability of large areas of land, suitable machinery and appropriate farm management techniques facilitated the expansion of large scale soy production systems and farms. GM HT soybean production based on no tillage, fitted with this enlargement in the scale of production but was considered to have not been a major contributor to the changes in the scale/size of soy producing farms (ie, the changes in scale/size would have probably occurred without the availability of GM HT soybeans).

Nevertheless some studies (eg, Thirtle et al (2003) relating to GM IR cotton in South Africa) and Qaim & De Janvry (2003) relating to GM IR cotton in Argentina) have identified cases where small farmers have not adopted biotech traits (notably relating to GM IR cotton in South Africa) and this has been mostly attributed to lack of access to credit to buy (the more expensive) seed. In such cases, this reflects a failure in the credit market, which needs to be addressed through policy mechanisms. This is an issue of relevance for accessing all new (more expensive) technology in agriculture and is not, therefore, a GM trait-specific issue.

Relevant references in full

Brookes G (2003) The farm level impact of using Bt maize in Spain, ICABR conference paper 2003, Ravello, Italy. Also on www.pgeconomics.co.uk

Brookes G (2005) The farm level impact of using Roundup Ready soybeans in Romania. Agbioforum Vol 8, No 4. www.agbioforum.org

Bundrabin P et al (2009) GM-related sustainability: agro-ecological impact, risks and opportunities of soy production in Argentina and Brazil, Plant Research International BV, Wageningen, Netherlands.

Fernandez-Cornejo J & McBride W (2000) Genetically engineered crops for pest management in US agriculture: farm level benefits, USDA, ERS Agricultural Economics Report No 786

Gouse M et al (2006) Output & labour effect of GM maize and minimum tillage in a communal area of Kwazulu-Natal, Journal of Development Perspectives 2:2

Huang et al (2002) Transgenic varieties and productivity of smallholder cotton farmers in China, Australian Journal of Agricultural and Resource Economics 46 (3): 367-387

Ismael Y et al (2002) A case study of smallholder farmers in the Makhathini flats, South Africa, ICABR conference, Ravello Italy 2002

Manjunath T (2008) Bt cotton in India: remarkable adoption and benefits, Foundation for Biotech Awareness and Education, India. www.fbae.org

Morse S et al (2004) Why Bt cotton pays for small-scale producers in South Africa, Nature Biotechnology 22 (4) 379-380

Penna J & Lema D (2001) Adoption of herbicide resistant soybeans in Argentina: an economic analysis, INTA, Argentina

Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, The Plant Journal 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, World Development 29 (5), 813-825

Qaim M et al (2006) Adoption of Bt cotton and impact variability: insights from India, Review of Agricultural Economics, vol 28, No 1, 48-58

Qaim M & De Janvry A (2003) GM crops, corporate pricing strategies and farmers adoption: the case of Bt cotton in Argentina, American Journal of Agricultural Economics, 85 (4): 814-828

Thirtle C et al (2003) Can GM technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal, World Development 31 (4): 717-732

Impact on household incomes & food security

These impacts have been examined in few papers to date. Gouse et al (2005 & 2006) examining the impact of the adoption of GM IR maize in South Africa (ex-post analysis) found that the poorest farmers gained most from the higher yields associated with GM IR (white) maize adoption because the extra production replaced maize meal that had previously been bought in to meet family food requirements. In other words, home grinding and consumption of the additional production substituted for more expensive bought-in maize meal.

Gonzales (2006) examined in relation to the adoption of GM IR maize in the Philippines, the concept of the subsistence carrying capacity, which is defined as the minimum net farm income/profit required to cover the costs of providing a nutritional calorie intake of 2,000 kilocalories per person, per day. Based on analysis of data from farm level surveys conducted in 2003 and 2004, he found that the adoption of GM IR maize significantly improved the subsistence level carrying capacity of adopters (an average of a 66% improvement, within a range of +399% for low yielding farms and +47% for high yielding farms).

Wang G et al (2008) examined the impact of the adoption of GM IR cotton on farmers livelihoods in the Hebei Province of China in 2002 and 2003, and concluded that as a result of the increases in farm income, arising from higher yields, household incomes rose significantly (the income from cotton in one season was estimated to be twice the combined value of wheat and corn crops for two seasons). This higher income then played an important role in additional investment in family education, leisure and healthcare.

Relevant references in full

Gonzales D (2005) Harnessing the benefits of biotechnology: the case of Bt corn in the Philippines. .ISBN 971-91904-6-9. Strive Foundation, Laguna, Philippines

Gouse M et al (2005) A GM subsistence crop in Africa: the case of Bt white maize in S Africa, International Journal Biotechnology, Vol 7, No1/2/3 2005

Gouse M et al (2006) Three seasons of subsistence insect-resistant maize in South Africa: have smallholders benefited?, Agbioforum 9, 1, 1-8

Wang G et al (2008) Impact of cotton on farmer livelihood system in China, ISSCRI conference 'Rationales and evolutions of cotton policies', Montpelier, France

Impact on income distribution

Critics of GM crops sometimes contend that the introduction of GM technology contributes to wider income disparity between richer and poorer farmers because richer farmers are better able to afford the more expensive seed (as well as other inputs such as fertiliser and irrigation) and hence benefit more from the technology than their poorer counterparts. Whilst this issue applies equally to any new (more expensive) technology used in agriculture, it has been specifically examined in very few papers relating to the adoption of GM technology. Morse et al (2007) examined this issue (ex-post analysis) in relation to the adoption of GM IR cotton in India (Maharastra State in 2002 and 2003). Their findings were that income disparities between adopters and non adopters did increase (because of the income benefits from using the technology), however, income disparities between adopters narrowed. Hence, the adoption of the technology both widened some disparities, yet narrowed others. The possible reasons cited for the narrowing of this disparity between adopters include a possible greater uniformity of skills between adopting farmers, and the role of the technology in simplifying pest control management – farmers no longer needed to scout their crops so much for pest levels and were having to, therefore, make fewer decisions on which insecticides to spray, when to apply, how much to use and how to apply. In effect, the GM IR technology contributed to reducing risks of pest damage uniformly for farmers where previously the pest damage levels were more affected by farmer skills in managing pests through the use of insecticides.

Relevant references in full

Morse S et al (2007) Inequality and GM crops: a case study of Bt cotton in India: Agbioforum Vol 10, 1,

Wider economy impacts

In Argentina, agricultural exports contribute to government tax revenues (since 2002). Trigo and Cap (2006) estimated, that export taxes on soybean exports between 2002 and 2005 amounted to $6.1 billion, of which $2.6 billion can be attributed to the increase in production linked to the release of GM HT soybean varieties.

Relevant references in full

Trigo E & Cap E (2006) Ten years of GM crops in Argentine agriculture, ArgenBio, Argentina

2 Agricultural sustainability

2.1 Agricultural inputs

Use of pesticides and associated environmental impact: worldwide

To examine this impact, the Brookes & Barfoot (2009) analysis analysed both active ingredient use and utilised the indicator known as the Environmental Impact Quotient (EIQ) to assess the broader impact on the environment (plus impact on animal and human health). The EIQ distils the various environmental and health impacts of individual pesticides in different GM and conventional production systems into a single ‘field value per hectare’ and draws on all of the key toxicity and environmental exposure data related to individual products. It therefore provides a consistent and fairly comprehensive measure to contrast and compare the impact of various pesticides on the environment and human health. In the analysis of GM HT technology it uses the (reasonable) assumption that the conventional alternative delivers the same level of weed control as occurs in the GM HT production system.

Table 13 summarises the environmental impact over the 1996-2007 period identified by Brookes & Barfoot and shows that there have been important environmental gains associated with adoption of biotechnology. More specifically:

- Since 1996, the use of pesticides on the biotech crop area was reduced by 359 million kg of active ingredient (8.8% reduction), and the overall environmental impact associated with herbicide and insecticide use on these crops was reduced by 17.2%;
- In absolute terms, the largest environmental gain has been associated with the adoption of GM HT soybeans and reflects the large share of global soybean plantings accounted for by biotech soybeans. The volume of herbicides used in biotech soybean crops decreased by 73 million kg (1996-2007), a 4.6% reduction, and, the overall environmental impact associated with herbicide use on these crops decreased by 20.9% (relative to the volume that would have probably been used if this cropping area had been planted to conventional soybeans). It should be noted that in some countries, such as in South America, the adoption of GM HT soybeans coincided with increases in the volume of herbicides used relative to historic levels. This largely reflects the facilitating role of the GM HT technology in accelerating and maintaining the switch away from conventional tillage to no/low tillage production systems with their inherent other environmental benefits (notably reductions in greenhouse gas emissions: see below and reduced soil erosion). Despite this net increase in the volume of herbicides used in some countries, the associated environmental impact (as measured by the EIQ methodology) still fell, as farmers switched to herbicides with a more environmentally benign profile;
- Major environmental gains have also been derived from the adoption of GM IR cotton. These gains were the largest of any crop on a per hectare basis. Since 1996, farmers have used 147.6 million kg less

insecticide in GM IR cotton crops (a 23% reduction), and this has reduced the associated environmental impact of insecticide use on this crop area by 27.8%;

- Important environmental gains have also arisen in the maize and canola sectors. In the maize sector, herbicide & insecticide use decreased by 92 million kg and the associated environmental impact of pesticide use on this crop area decreased, due to a combination of reduced insecticide use (5.9%) and a switch to more environmentally benign herbicides (6%). In the canola sector, farmers reduced herbicide use by 9.7 million kg (a 13.9% reduction) and the associated environmental impact of herbicide use on this crop area fell by 25.8% (due to a switch to more environmentally benign herbicides).

Table 13: Impact of changes in the use of herbicides and insecticides from growing biotech crops globally 1996-2007

Trait	Change in volume of active ingredient used (million kg)	Change in field EIQ impact (in terms of million field EIQ/ha units)	% change in ai use on biotech crops	% change in environmental impact associated with herbicide & insecticide use on biotech crops
GM herbicide tolerant soybeans	-73.0	-6,283	-4.6	-20.9
GM herbicide tolerant maize	-81.8	-1,934	-6.0	-6.8
GM herbicide tolerant cotton	-37.0	-748	-15.1	-16.0
GM herbicide tolerant canola	-9.7	-443	-13.9	-25.8
GM insect resistant maize	-10.2	-528	-5.9	-6.0
GM insect resistant cotton	-147.6	-7,133	-23.0	-27.8
Totals	**-359.3**	**-17,069**	**-8.8**	**-17.2**

The impact of changes in insecticide and herbicide use at the country level (for the main biotech adopting countries) is summarised in Table 14.

Table 14: Changes in the 'environmental impact' from changes in pesticide use associated with biotech crop adoption 1996-2007 selected countries: % reduction in field EIQ values

	GM HT soybeans	GM HT maize	GM HT cotton	GM HT canola	GM IR maize	GM IR cotton
US	-29	-7	-16	-42	-6	-33
Argentina	-21	-1	-20	N/a	0	-7
Brazil	-9	N/a	N/a	N/a	N/a	-14
Paraguay	-16	N/a	N/a	N/a	N/a	N/a
Canada	-11	-9	N/a	-25	-61	N/a
South Africa	-9	-3	-8	N/a	-33	NDA
China	N/a	N/a	N/a	N/a	N/a	-35
India	N/a	N/a	N/a	N/a	N/a	-10
Australia	N/a	N/a	-5	N/a	N/a	-24
Mexico	N/a	N/a	N/a	N/a	N/a	-7
Spain	N/a	N/a	N/a	N/a	-37	N/a

Note: N/a = not applicable, NDA = No data available. Zero impact for GM IR maize in Argentina is due to the negligible (historic) use of insecticides on the Argentine maize crop

In terms of the division of the environmental benefits associated with less insecticide and herbicide use for farmers in developing countries relative to farmers in developed countries, Table 15 shows 52% of the environmental benefits (1996-2007) associated with lower insecticide and herbicide use have been in developing countries. The vast majority of these environmental gains have been from the use of GM IR cotton and GM HT soybeans.

Table 15: Biotech crop environmental benefits from lower insecticide and herbicide use 1996-2007: developing versus developed countries

	Change in field EIQ impact (in terms of million field EIQ/ha units): developed countries	Change in field EIQ impact (in terms of million field EIQ/ha units): developing countries
GM HT soybeans	-3,559	-2,724
GM IR maize	-516	-12
GM HT maize	-1,910	-24

GM IR cotton	-1,053	-6,080
GM HT cotton	-726	-22
GM HT canola	-444	Not applicable
Total	**-8,208**	**-8,862**

Use of pesticides and associated environmental impact: the EU

GM HT soybeans in Romania

Brookes & Barfoot (2009) examined the impact of changes in herbicide use associated with the adoption of GM HT soybeans in Romania. As Romania joined the EU at the beginning of 2007 and therefore was no longer officially permitted to grow GM HT soybeans, the analysis refers to the period 1999-2006. It draws on herbicide usage data for the years 2000-2003 from Brookes (2005), and identified that the adoption of GM HT soybeans in Romania resulted in a small net increase in the volume of herbicide active ingredient applied, but a net reduction in the EIQ load (Table 16). More specifically:

- The average volume of herbicide ai applied has increased by 0.09 kg/ha from 1.26 kg/ha to 1.35 kg/ha);
- The average field EIQ/ha has decreased from 23/ha for conventional soybeans to 21/ha for GM HT soybeans;
- The total volume of herbicide ai use[82] is 4% higher (equal to about 42,000 kg) than the level of use if the crop had been all non GM since 1999 (in 2006 usage was 5.25% higher);
- The field EIQ load has fallen by 5% (equal to 943,000 field EIQ/ha units) since 1999 (in 2006 the EIQ load was 6.5% lower).

Table 16: National level changes in herbicide ai use and field EIQ values for GM HT soybeans in Romania 1999-2006

Year	Ai use (negative sign denotes an increase in use: kg)	eiq saving (units)	% decrease in ai (- = increase)	% saving eiq
1999	-1,502	34,016	-1.22	1.52
2000	-3,489	79,005	-3.06	3.81
2001	-1,744	39,502	-3.2	3.97
2002	-3,198	72,421	-3.55	4.41
2003	-3,876	87,783	-2.53	3.14
2004	-6,783	153,620	-4.48	5.57
2005	-8,479	192,025	-5.59	6.45
2006	-12,597	285,295	-5.25	6.53

With the banning of planting of GM HT soybeans in 2007, there will have been a net negative environmental impact associated with herbicide use on the Romanian soybean crop, as farmers will have had to resort to conventional chemistry to control weeds. On a per hectare basis, the EIQ load/ha will have probably increased by over 9%.

GM IR maize in the EU

Brookes (2009) examined the impact of the use of GM IR maize in the EU on both actual insecticide use (ex-post analysis) and extrapolated (ex-ante analysis) these impacts to the range of potential adoption areas, if the technology was made available to all EU maize farmers who suffer damage to their maize crops from corn boring pests. Table 17 summarises the environmental benefits associated with reduced insecticide use that might reasonably be derived from wider adoption of this GM IR technology in the EU maize sector. This suggests that:

- Annual savings of between about 0.41 million kg and 0.7 million kg of insecticide active ingredient could be realised;
- In 2007, only between 14% and 25% of the total annual savings in insecticide active ingredient use and associated environmental impact were realised;
- Most of the potential annual environmental benefits associated with reduced insecticide use have possibly been achieved in Spain. In the Czech Republic, up to about a quarter of the potential savings may have been realised;

[82] Savings calculated by comparing the ai use and EIQ load if all of the crop was planted to a conventional (non GM) crop relative to the ai and EIQ levels based on the actual areas of GM and non GM crops in each year

- Limited environmental benefits from reduced insecticide use were possibly being achieved in France (7%-11% of potential) and Germany (2%-3% of potential) in 2007. However, with the introduction of the ban on planting of GM IR maize from 2008 in France and 2009 in Germany, these environmental benefits are now no longer being achieved;

- The countries currently foregoing the largest environmental benefits that might reasonably be realised from use of GM IR maize are Italy, France and Germany. This contrasts with Spain, where the potential environmental benefits associated with reduced insecticide use (targeted at corn boring pests) have mostly been achieved.

Table 17: Potential annual EU environmental benefit associated with using less insecticides (for controlling corn boring pests) if GM IR maize technology used

Country	Area typically treated annually with insecticides for corn boring pests ('000 ha)	Potential saving in active ingredient usage ('000 kg)	Potential saving in associated environmental impact ('000 EIQ load units)	Estimated % of potential achieved in 2007
Spain	75-98	72 to 94.1	3,133 to 4,093	77-100
France	200-300	192 to 288	8,354 to 12,531	7-11 (Note zero from 2008)
Germany	80-120	76.8 to 115.2	3,342 to 5,012	2-3 (Note: zero from 2009)
Italy	50-175	48 to 168	2,088 to 7,310	Zero
Czech Republic	20-40	19.2 to 38.4	835 to 1,671	13-25
Others	1-5	1 to 4.8	42 to 209	0
Total	**426-738**	**409 to 708.5**	**17,794 to 30,826**	**14-25**

Notes:

1. Area treated with insecticides: for Spain based on usage in early years of GM IR maize adoption, before widespread use of the technology. For other countries based on a combination of unpublished market research data (source: Kleffmann) and industry estimates

2. Potential (and actual) savings in terms of insecticide active ingredient use and associated environmental load based 0.96 kg/ha and an EIQ load/ha of 41.77/ha – based on Spanish data (Brookes 2003)

Relevant references in full

Brookes G (2003) The farm level impact of using Bt maize in Spain, ICABR conference paper 2003, Ravello, Italy. Also on www.pgeconomics.co.uk

Brookes G (2005) The farm level impact of using Roundup Ready soybeans in Romania. Agbioforum Vol 8, No 4. www.agbioforum.org

Brookes G (2008) The benefits of adopting GM insect resistant (Bt) maize in the EU: first results from 1998-2006,International Journal of Biotechnology (2008) vol 10, 2/3, pages 148-166

Brookes (2009) The existing and potential impact of using GM Insect Resistant (GM IR) maize in the European Union, PG Economics, Dorchester, UK. www.pgeconomics.co.uk

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk Also, short version in Outlooks on Pest Management, October 2009 (forthcoming)

2.2 Biodiversity, flora, fauna and landscapes

A number of studies have been undertaken examining the impact of biotech traits on various ecological issues. One of the most comprehensive of these is the review conducted by Sanvido O et al (2006). This paper reviewed a considerable body of evidence and literature on issues relating to the environmental impact of GM crops. In its conclusions it says *'The data available so far provides no scientific evidence that the commercial cultivation of GM crops has caused environmental harm'*.

Key points from this report are:

- the environmental impact of GM crops should be considered relative to the environmental impact of the cultivation practices prevailing in modern agricultural systems. These modern production systems have had a profound impact on all environmental resources, including negative impacts on biodiversity;
- *impact of Bt crops on non target organisms*: published long term studies reveal only subtle shifts in the arthropod community. No adverse impacts on non target natural enemies have been observed, in fact there are fewer side effects on non target organisms than under conventional production systems;
- *impact of bt crops on soil organisms:* no accumulation of bt toxins have been observed after several years of cultivation. There is no evidence of lethal or sub-lethal effects of bt toxins on non target soil

organisms like earthworms, collembolan, mites, woodlice or nematodes. Some studies identify differences in numbers of microorganisms but the ecological significance is not clear, given that the natural variation in numbers in production systems has not been measured and, as such, it is not possible to assess whether differences in the bt versus non Bt crops exceed this natural variation. The study reports that the only research that has looked at this issue points to the variation being within the boundaries of this variation (ie, the differences between conventional cultivars is greater than the observed differences of bt crops);

- there is general scientific agreement that gene flow from GM crops to compatible wild relatives will occur. However, rates of spontaneous mating with wild relatives are at rates in the order of what is expected for non transgenic crops. GM HT oilseed rape can form FI hybrids with wild turnip at low frequency under natural conditions. There is a low probability that increased weediness due to gene flow could occur, and where this arises, it is unlikely that GM HT weeds would create greater agricultural problems than conventional weeds – farmers have plenty of options for control of these weeds using other herbicides, through rotation or other means of weed control;
- in natural habitat, no long term introgression of transgenes into wild plant populations leading to the extinction of any wild taxa has been observed to date. Trangenes conferring herbicide tolerance are unlikely to confer a benefit in natural habitats because these genes are selectively neutral in natural environments, whereas insect resistant genes could increase fitness if pests contribute to the control of natural plant populations;
- there is no evidence that the extensive cultivation of GM HT canola in Canada has resulted in a widespread dispersal of volunteer oilseed rape carrying herbicide tolerant traits. Two studies have identified the existence of triple and double HT resistant volunteers, but the general lack of reported multiple-resistant volunteers suggests that these volunteers are being controlled by chemical and other management strategies. This is not an agronomic issue for farmers (as also reported by a survey of canola growers by the Canola Council in 2005). There is also no evidence that GM HT oilseed rape has become feral and invaded natural habitats;
- the impact of GM crops on pest and weed management practices and their potential ecological consequences are usually difficult to assess. They are influenced by many interacting factors and show up only after an extended period of time. Numerous weed species have evolved resistance to herbicides long before the introduction of GM HT traits. The experience of large scale GM HT crop usage confirm that the development of HT resistance in weeds is not primarily a question of genetic modification, but one of crop and herbicide management applied by farmers;
- there is no evidence of weed species having so far developed tolerance to the herbicides glufosinate or glyphosate where the widespread growing of GM HT canola has occurred in Canada;
- in regions where GM HT soybeans and cotton are widely grown, some weeds are showing signs of developing resistance to glyphosate. However, this is managed by farmers using the numerous other herbicides available for weed and volunteer canola control. The net effect of applying small amounts of other herbicides in order to deal with these instances of weed resistance is still delivering a net environmental gain relative to the environmental impact associated with herbicides used on conventional (alternative) crops;
- the results of the UK farm scale evaluations (FSEs) showed that weed biomass and numbers of invertebrate groups were reduced under GMHT management in sugar beet and oilseed rape and increased in maize compared with conventional treatments. These differences were related to the weed management of both conventional and GM HT systems – highly effective weed control practices, as used in GM and non-GM HT crops in the FSEs lead to low numbers of weed seeds and insects; these might reduce bird numbers that depend on insects and seeds as a food source. The FSEs did, however, assume no other changes in field management, eg, the possible scope for facilitating conservation tillage which results in greater availability of crop residues and weed seeds, and in consequence, improving food supplies for insects, birds and small mammals.

Full reference

Sanvido O et al (2006) Ecological impacts of GM crops: experiences from 10 years of experimental field research and commercial cultivation, ART, Zurich

Impact on number of plant varieties available

An argument sometimes cited relating to seed availability and GMO issues is that farmers may be faced with limited choice and hence ‘have limited alternatives to using GM technology’. The argument is based on the view that the main biotechnology companies dominate plant breeding and seed multiplication and therefore have a vested interest in only making new varieties available that contain GM traits and accordingly neglect the provision of non GM seed (and/or non GM seed is only available in older, inferior performing germplasm). In examining this argument, the following points should be noted (taken from Brookes & Barfoot (2003)):

- A trend towards greater concentration into fewer, larger players in agriculture and allied industries is not unique to the plant breeding and seed production sectors. It is a trend that has occurred in most parts of the agricultural and allied sectors. A major driver of this trend has been the increasing costs and financial resources required to develop new products that only ever larger players can afford to stay in the marketplace. This concentration does, however not necessarily mean that farmers are faced with reduced choice of products like seed. For example, in the US, in 2003, there were about 2,000 different soybean varieties available to US growers of which about 1,200 contained GM traits. This means that, even though 75% of the US crop was herbicide tolerant (GM), about 40% of all varieties available were non GM. There were also 122 seed suppliers in the US of which 12 were owned by companies with interests in biotechnology. Also the leading five non GM varieties available had the same yield potential as the leading five GM varieties[83]. This suggests that there is little evidence to suggest that there has been a lack of seed choice for US soybean farmers;
- The leading biotechnology companies do not own all plant breeding and seed production. In most countries, there are a number of plant breeders and seed producers, which are not owned by the biotechnology companies. These companies decide whether to include GM traits in their germplasm according to whether they perceive there may be a reasonable demand for them and hence sufficient scope for earning a return on investments, relative to the level of licence fees or royalties they would have to pay the biotechnology companies. It is likely that some of these companies may choose not to insert GM traits in some varieties, to offer both conventional and GM alternatives or to offer only GM alternatives. The choice will be made on commercial criteria and often without influence from biotechnology companies. In addition, it should not be assumed that the different plant breeders, even if owned by biotechnology companies will necessarily only offer GM traits, especially if a trait available is offered by a rival biotechnology provider;
- In any market economy, where there is reasonable demand for a product (eg, non GM seed), the market usually provides the requirement. The fact that there may be a reasonable demand for non GM seed, this is likely to remain an attractive market for some plant breeders and seed suppliers. If a situation were to arrive where limited new seed became available to serve a particular market, this might suggest some form of market failure that governments might wish to address. Also if governments perceive that farmers were being provided with limited choice because of the structure of the supply industry and high barriers to entry, this problem is not related to the technology, but to a lack of effective competition policy – here any failure of farmers to benefit from new technology (including non GM) should be laid at the door of policy makers, not the suppliers of the new technology.

In addition, the impact on seed variety availability has been the subject a limited number of specific country studies. These are summarised in section 1.1 e).

Reference in full

Brookes & Barfoot (2003) Consultancy support for the analysis of the impact of GM crops on UK farm profitability, report for The Strategy Unit of the Cabinet Office of the UK government, PG Economics. www.pgeconomics.co.uk

2.3 Renewable and non renewable resources

2.4 Climate

Impact on greenhouse gas (GHG) emissions

Brookes & Barfoot (2009) identify that the scope for biotech crops contributing to lower levels of GHG emissions comes from two principle sources:

- Reduced fuel use from less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. The fuel savings associated with making fewer spray runs (relative to conventional crops) and the switch to conservation, reduced and no-till farming systems, have resulted in permanent savings in carbon dioxide emissions. In 2007, this amounted to about 1,144 million kg (arising from reduced fuel use of 416 million litres). Over the period 1996 to 2007 the cumulative permanent reduction in fuel use is estimated at 7,090 million kg of carbon dioxide (arising from reduced fuel use of 2,578 million litres);

[83] If the leading performing varieties were only GM, this would suggest that impact studies should be showing consistent signs of GM varieties out yielding their non GM counterparts. The evidence to date does not show this – there respective yields are broadly the same

- the use of 'no-till' and 'reduced-till'[84] farming systems. These production systems have increased significantly with the adoption of GM HT crops because the GM HT technology has improved growers ability to control competing weeds, reducing the need to rely on soil cultivation and seed-bed preparation as means to getting good levels of weed control. As a result, tractor fuel use for tillage is reduced, soil quality is enhanced and levels of soil erosion cut. In turn more carbon remains in the soil and this leads to lower GHG emissions. Based on savings arising from the rapid adoption of no till/reduced tillage farming systems in North and South America, an extra 3,570 million kg of soil carbon is estimated to have been sequestered in 2007 (equivalent to 13,103 million tonnes of carbon dioxide that has not been released into the global atmosphere). Cumulatively the amount of carbon sequestered may be higher due to year-on-year benefits to soil quality. However, with only an estimated 15%-25% of the crop area in continuous no-till systems it is currently not possible to confidently estimate cumulative soil sequestration gains.

Placing these carbon sequestration benefits within the context of the carbon emissions from cars, Table 18, shows that:

- In 2007, the permanent carbon dioxide savings from reduced fuel use were the equivalent of removing nearly 0.495 million cars from the road;
- The additional probable soil carbon sequestration gains in 2007 were equivalent to removing nearly 5,823 million cars from the roads;
- In total, the combined biotech crop-related carbon dioxide emission savings from reduced fuel use and additional soil carbon sequestration in 2007 were equal to the removal from the roads of nearly 6.3 million cars, equivalent to about 24% of all registered cars in the UK;
- It is not possible to confidently estimate the soil carbon sequestration gains since 1996 (see above). If the entire biotech crop in reduced or no tillage agriculture during the last eleven years had remained in permanent reduced/no tillage then this would have resulted in a carbon dioxide saving of 83.18 million kg, equivalent to taking 36.97 million cars off the road. This is, however a maximum possibility and the actual levels of carbon dioxide reduction are likely to be lower.

Table 18: Context of carbon sequestration impact 2007: car equivalents

Crop/trait/country	Permanent carbon dioxide savings arising from reduced fuel use (million kg of carbon dioxide)	Average family car equivalents removed from the road for a year from the permanent fuel savings ('000s)	Potential additional soil carbon sequestration savings (million kg of carbon dioxide)	Average family car equivalents removed from the road for a year from the potential additional soil carbon sequestration ('000s)
US: GM HT soybeans	247	110	3,999	1,777
Argentina: GM HT soybeans	609	271	6,136	2,727
Other countries: GM HT soybeans	91	40	1,341	596
Canada: GM HT canola	131	58	1,627	723
Global GM IR cotton	37	16	0	0
Total	**1,115**	**495**	**13,103**	**5,823**

Notes: Assumption: an average family car produces 150 grams of carbon dioxide of km. A car does an average of 15,000 km/year and therefore produces 2,250 kg of carbon dioxide/year

Full reference

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. www.pgeconomics.co.uk Also, short version in Outlooks on Pest Management, October 2009 (forthcoming)

[84] No-till farming means that the ground is not ploughed at all, while reduced tillage means that the ground is disturbed less than it would be with traditional tillage systems. For example, under a no-till farming system, soybean seeds are planted through the organic material that is left over from a previous crop such as corn, cotton or wheat

2.5 Transport/use of energy
Use of energy (fuel) impacts (decreased use) associated with the adoption of biotech crops globally are summarised in section 2.4 above – derived from Brookes & Barfoot (2009).

3. Other implications