SOCIO-ECONOMIC IMPACTS OF GMOs ON EUROPEAN AGRICULTURE

IFOAM EU GROUP

MAKING EUROPE MORE ORGANIC

FiBL

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EXECUTIVE SUMMARY

Genetically modified (GM) crops (e.g. maize, soybean, oilseed rape and cotton) have been produced commercially since 1996. In 2016, 185 million hectares of GM crops were grown globally corresponding to 3.4% of the worldwide utilised agricultural area (UAA). Compared to Canada or the US, cultivation of GM crops in the EU agriculture is limited and decreased by 4.2% from 136,338 ha UAA in 2016 to 130,571 ha UAA in 2017. Indeed, GM crops, are mainly grown in Spain and Portugal. The EU coexistence strategy seeks to ensure the choice of consumers and farmers between conventional, organic and GM crop production. As adventitious presence of GM crops in non-GM crops cannot be excluded, suitable measures are needed during cultivation, harvest, transport, storage and processing to ensure coexistence.

So far, most coexistence studies focus on costs for GM producers even though coexistence involves cost for both the GM and the non-GM producer. Furthermore, there is a lack of studies from cases where coexistence is a real issue such as in Spain. Therefore, there is the need to analyse the socio-economic impacts of GM production on the actors of organic or non-GM supply chains. This applies not only for food and feed supply chains but also for cotton.

The aim of the study is to identify strategies and the corresponding costs of European non-GM and organic supply chain actors to ensure GMO-free commodities and seeds as a consequence of GM crop production in Europe and imports from third countries.

Information from 17 interviews with actors from organic and non-organic GMO-free supply chain actors from France (6), Germany, (6), Spain (2), Switzerland (2) and India (1) were analysed (seed companies, breeders, feed processors, soy food processors, cotton processors and traders). Information received from the interviews was rather qualitative as companies interviewed considered providing economic data on coexistence to be too sensitive or too difficult to allocate and quantify.

Results from the interviews can be summarised as follows:

- Co-existence in breeding and seed production is considered to be unfeasible. A potential GM-contamination case is a tremendous risk to the companies as losing a line means that long-term investment in the breeding and the profits from the corresponding business are lost. As official testing is perceived to be insufficient, additional testing is implemented. The situation is easier in countries with a national GMO ban.
- For organic and non-organic GMO-free feed producers, the most important coexistence costs are testing and certification costs. In Spain, due to the high risk of contamination with GMOs, farmers abandon growing organic maize and thus lost a potential income opportunity. Feed processors fear that a contamination case results in quite relevant costs. The most important avoidance strategies implemented are to source commodities from well-known suppliers or safe origins and operating only organic feed or spatial segregation in specific plants.
- The soy food processing companies interviewed, highlighted that costs of coexistence are mainly due to product testing, careful cleaning at every processing stage and certification. Similar to the feed processors, soy food processors also minimise the risk of contamination with GMOs by sourcing organic or non-organic GMO-free soya from well-known suppliers or safe origins.
- Most of the coexistence costs for the cotton supply chain incur in the production country and during the first stages of cotton processing (delivery and ginning). The most relevant measures to avoidance GMO contaminations are the rejection of contaminated batches and cleaning before each lot is processed.

Since the first authorisations of GMOs and first contamination cases, companies seem to have adapted their strategies and to have learnt from past experiences and past contamination cases across Europe. Important strategies adopted by the interviewed companies consist in producing only Identity Preserved (IP) certified products, or in having totally segregated plants. This suggests that banning the cultivation of GM crops is an efficient strategy and a pre-requisite to maintain coexistence costs to a manageable level. The companies interviewed fear that problems related to GMOs and coexistence costs might increase in the future if the area under GM production grows worldwide. New genetic engineering techniques are also a growing concern amongst seed companies, and organic and conventional non-GM processors. To allow the GMO-free sector to be able to remain GMO-free, these new techniques need to be regulated within the scope of the GMO legislation and mandatory traceability and labelling is required.

The study showed, that coexistence affects the organic and conventional GMO-free sectors in terms of additional costs and in managing insecurity or the permanent prevailing risk of a contamination case respectively. As a consequence, European non-GM operators are forced to find solutions to minimise this risk by additional testing, limiting sourcing to GMO-free countries and specific suppliers or by even abandoning commodities. Thus, GMO-free business face constraints and lose options for their business. Following the polluter-pays-principle, the costs of coexistence should be borne by the companies that place GMOs on the market, and not by the organic and GMO-free sectors. On the other hand, there is an increasing demand for GMO-free seeds, feed and food and thus, providing GMO-free products is also a business opportunity for European seed companies, farmers and processors.

The adoption of efficient coexistence measures by Member States should be made mandatory at European level and mechanisms to compensate all disadvantages caused by contamination should be established. The unprecedented development of organic agriculture in the European Union is a clear message from European citizens in favour of a more sustainable agriculture, without GMOs. The Commission and the EU Member States should thus provide the regulatory framework that allows developing competitive non-GM businesses.

1. BACKGROUND

Genetically modified (GM) crops (e.g. maize, soybean, oilseed rape and cotton) have been produced commercially since 1996. In 2016, 185 million hectares of GM crops were grown globally, corresponding to 11.3% of the arable area, 3.4.% of the worldwide utilised agricultural area (UAA) with an annual growth rate of 3 – 4% (ISAAA, 2016). 91% of the global biotech crop area was in the USA, Brazil, Argentina, India and Canada which all are important exporters for agricultural commodities (ISAAA, 2016). The dominant traits are herbicide tolerance (Ht) and insect resistance (Bt)[1], whilst other traits such as virus resistance only play a marginal role so far (Finger *et al.*, 2011; Speiser *et al.*, 2013).

Compared to Canada or the US, cultivation of GM crops in the EU agriculture is limited and decreased by 4.2% from 136,338 ha UAA in 2016 to 130,571 ha UAA in 2017. Indeed, GM crops, namely maize MON810, is mainly grown in Spain (124,227 ha) and Portugal (6,344 ha) (Inf'OGM, 2017). 17 countries and four European regions opted out of GMO cultivation in 2015[2]. Low adoption of GM crops in Europe is due to concerns from the public, food industry and scientific community (Lemaire *et al.*, 2010; Myhr, 2010; Friends of the Earth Europe, 2011) on the potential environmental risks of GM crops (Heard *et al.*, 2003; Giovannetti *et al.*, 2005; Relyea, 2005; Benachour and Séralini, 2009; Graef, 2009; Lang and Otto, 2010).

The EU coexistence strategy seeks to ensure consumers and farmers can choose between conventional, organic and GM crop production, in compliance with the legal obligations for labelling defined in the EU legislation (Verrière, 2015). As adventitious presence of GM crops in non-GM crops cannot be excluded, suitable measures are needed during cultivation, harvest, transport, storage and processing to ensure coexistence. The EU subsidiarity-based approach on coexistence requires Member States to develop a national coexistence legislation (European Commission, 2009) internalising the external costs of GM production with the GM producer to bear the costs associated with coexistence measures (Areal *et al.*, 2012). After the modification of Directive 2001 / 18 in 2015[3], Member States also have the right to ban cultivation of EC approved GMOs based on other grounds than those assessed during the EU authorisation process.

The socio-economic assessment of GMO cropping is a very disputed issue, depending on the considered stakeholders, countries and crops, the study level (parcel versus farms), the duration of the studies and what is considered as incomes (freed time for other jobs or direct incomes from cropping), and the way coexistence costs are managed and by whom there are borne as well as whether negative externalities can be considered or not. Kathage *et al.* (2015) compiled a list of topics and appropriate indicators and methods which could be used for socio-economic assessments of the cultivation of GM crops.

Socio-economic impacts of GM crop cultivation have been subject of a body of scientific literature such as (Finger *et al.*, 2011; Klümper and Qaim, 2014; Fischer *et al.*, 2015; Catacora-Vargas *et al.*, 2017) as well as by the *Haut Conseil des Biotechnologies* (French High Council for biotechnologies [HCB]) for both farms and supply chains (Soler, 2013; Lemarié and Fugeray-Scarbel, 2014). The focus has mostly been on the GM producers, with the presumption that there are benefits to be expected from GM cultivation. Furthermore, published research mainly focused on a restricted set of monetary economic parameters, and is not based on empirical research. The special situation of organic producers is rarely addressed. Moreover, the HCB synthesis showed no clear improvements in terms of yield and incomes but for freeing time (Lemarié and Fugeray-Scarbel, 2014). However, Menrad *et al.* (2013) stress that every actor and supply chain level will be economically affected by a coexistence policy suggesting economic impacts on all actors of both GM and non-GM supply chains.

The aim of this study is to identify on the basis of interviews with supply chain actors strategies and the corresponding costs of European non-GM and organic supply chain actors to ensure GMO-free commodities and seeds as a consequence of GM crop production in Europe and imports from third countries.

1 Herbicide tolerance at 47% and stacked traits (Insect resistance and herbicide tolerance in one plant) occupied 41% of the global hectare.

2 https://ec.europa.eu/food/plant/gmo/authorisation/cultivation/geographical_scope_en: Austria, Bulgaria, Croatia, Cyprus, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Netherlands, Slovenia, Northern Ireland, Scotland, Wales, Wallonia.

3 Directive 2015/412 of the European Parliament and of the Council of 11 March 20154 amending Directive 2001/18/EC as regards the possibility for the Member States to restrict or prohibit the cultivation of genetically modified organisms (GMOs) in their territory.

2. OVERVIEW LITERATURE

The assessment of the socio-economic impacts of growing GM crops for European organic supply chains remains a major political and scientific challenge. Co-existence and socio-economic impacts of GM cultivation have been subject of several research projects (e.g. GMImpact, SIGMEA, Co-EXTRA, PRICE, COM 2011). In the next paragraphs, we make a general review of the scientific literature on socio-economic impacts at farm and supply chains level.

Two partial meta-analyses of socio-economic literature found economic benefits of GM crops. These economic benefits result from a potential decrease in yield losses and in pesticide application costs, whereas seed costs are usually substantially higher (Finger *et al.*, 2011; Klümper and Qaim, 2014). Generally, economic benefits are lower in developed countries than in developing countries (Qaim, 2009; Klümper and Qaim, 2014) and Park *et al.* (2011) conclude that revenue forgone and practical benefits are limited for EU farmers. Garcia-Yi *et al.* (2014) stresses however that contradictory results abound and thus suggest systematic procedure for socio-economic impact assessments.

Indeed, yield increase is quite heterogeneous over regions and time and cannot simply be extrapolated (Finger *et al.*, 2011; Franke *et al.*, 2011). Analysing data from Spanish farms between 2002 – 2004, Gomez-Barbero *et al.* (2008) found negative (-1.3%) and positive (+12.1%) yield effects for Bt maize in three Spanish regions. More recently, in 2015, the Department of Agriculture of Aragón (the area in Spain with the highest concentration of GM maize) reports that for the previous 5 years, yield of conventional maize varieties have been as high or even higher than their GM counter-parts (Dirección General de Alimentación y Fomento Agroalimentario Servicio de Recursos Agrícolas, 2015).

Depending on the region, infestation level and the effectiveness of common pest management practices, Finger *et al.* (2011) concluded for Germany that yield effects are highly heterogeneous. Similarly, cost reductions and gross margins also vary considerably (Gomez-Barbero *et al.*, 2008; Finger *et al.*, 2011; Franke *et al.*, 2011).

In contrast to the previous studies, several studies took a broader perspective by considering the economic impacts of compliance with coexistence rules and cleaning of machinery (Bullock and Desquilbet, 2002; Copeland *et al.*, 2007; Consmüller *et al.*, 2010; Vögeli *et al.*, 2010; Gryson *et al.*, 2013; Menrad *et al.*, 2013). Cleaning costs at farm level were estimated by Bullock and Desquilbet (2002). Carefully cleaning of a planter might take 15 minutes of labour for an 8-row planter or 25 minutes for a 12-row planter. To obtain a level of purity of 99.9%, 40 or 55 minutes would be necessary to clean out an 8 row or 12-row planter, respectively. But it is also possible to use two persons spending each 15 minutes of their time to clean manually the harvester and then to "flush" the harvester by harvesting a very small area of non-GM maize that will be sold as conventional. Vögeli *et al.* (2010) analysed the impacts on profitability of a hypothetical coexistence regulation in Switzerland of growing GM wheat and maize. The study showed that for the GM producer, cleaning of transport vehicles and combine harvester are the most relevant coexistence costs whereas buffer strips, second-growth control and cleaning of sowing machines generate lowest coexistence costs per hectare GM crop. The total costs of coexistence per hectare GM crop amounted to between CHF 58 and CHF 160 / ha which corresponds to 1.1 to 3.1% of the full wheat production costs. The authors concluded that despite the small-scale Swiss farm structure, the costs of the coexistence measures are therefore negligible for GM producers (Vögeli *et al.*, 2010). These results from Switzerland cannot however be generalised. They were based on a crop rotation system limiting the share of GM maize and GM wheat on the arable area to 25%. In some Spanish regions, the share of GM maize per farm exceeds 80%.

Demont *et al.* (2008) argued that flexible coexistence regulations should be preferred to fixed rules. The authors stressed that both GM and non-GM producers have an economic interest in cooperating and finding a compromise. They also advocate that rigid regulations lead to a so-called domino-effect, that is, to repetitive GM limitations and to increasing conflicts on buffer strips, which in turn increase the cost of coexistence. However, research from Spain showed that flexible coexistence regulations do not work due many technical and social restrictions (Binimelis, 2008).

Additional on-farm costs for buffer zones of €60 to €78 / ha were calculated by Messéan *et al.* (2006) depending on the field size, the share of maize in the crop rotation, the buffer zone width and the Bt maize adoption rate. Copeland *et al.* (2007) revealed that large isolation distances (rigid coexistence rules) decrease the risk of contamination and costs for non-GM producers but increase the coexistence costs of the GM producer. Small isolation distances and high GM adoption rate leads to low coexistence costs for the GM producer but high costs for the non-GM producer. Large discard zones in regions with a small structured agriculture may particularly lead to a domino effect (Demont *et al.*, 2008), meaning that non-GM production or GM production will rarely be possible in a region (Copeland *et al.*, 2007; Groeneveld *et al.*, 2013).

A study from UK (Areal and Copeland, 2005) tried to estimate the costs of farming measures implemented to allow coexistence of conventional, GM and organic winter oilseed rape (WOSR). This analysis was undertaken using different scenarios and distinguishing different plot shapes (i.e. square or rectangular) to calculate coexistence costs. It was shown that these costs are extremely sensitive to separation distances and depend on farm practices (e.g. cultivation of GM crops or not) and on both the field shape and size. Additional costs for an organic producer were estimated at between 8 and 63% of the total income contrary to 1 to 4% for conventional WOSR farmers. However, Areal and Copeland (2005) expect a low risk of contamination of organic WOSR due to the very low uptake of organic WOSR in the UK. Bock *et al.* (2002) calculated for oil seed rape seed production extra cost for changing agricultural practices, monitoring GMO content and insurance costs of €345 / ha for organic oilseed rape seed production compared to a cost of €126 / ha for conventional seed production. Tolstrup *et al.* (2003) estimated an added cost of 8 to 21% of the production cost in organic farming and between 3 and 9% for conventional.

Under flexible coexistence regimes, that do not foresee isolation distances, non-GM farmers cannot guarantee GMO-free produce in any case (Binimelis, 2008). Downstream supply chain partners who demand pure GMO-free produce may not be willing to source from non-GM farmers from regions with flexible coexistence regimes. Thus, while income foregone of non-GM farmers could be compensated by the GM farmers or through insurances, the non-GM farmers would be excluded from non-GM market channels (Copeland *et al.*, 2007).

Skevas *et al.* (2010) found, low ex-ante coexistence costs for GM farmers, based on a case study of five GM farmers from a Portuguese cooperative. Due to the clustered GM crops, liability costs were covered by the government and transaction costs (negotiation with neighbouring farmers) were almost zero. However, this is due to the fact that both the GM and the non-GM products are sold as GM products. Thus, farmers can choose whether they wish to grow GM crops or not; but they cannot market their non-GM products as non-GM. This limits non-GM farmers' freedom of choice considerably. Consmüller *et al.* (2010) raises the problem of liability for organic producers: in case of cross-pollination, organic farms may lose organic certification, the corresponding premium price and may have to pay organic area payments back. So far, no German courts dealt with such cases of liability which could result in significant additional losses for GM producers (Consmüller *et al.*, 2010).

A recent synthesis made for the *Haut Conseil des Biotechnologies* showed that in almost all the situations outlined as benefiting from GM crops, the results are unreliable, for instance in terms of crops' yield and farmers' incomes, as they are only based on a few fields experiments and on short periods for delivering any conclusion except the reduced workload for certain farmers (Lemarié and Fugeray-Scarbel, 2014). Furthermore, the synthesis was also inconclusive about a positive GMO impact on incomes for the supply chains (Soler, 2013).

Only a few studies addressed the socio-economic impacts of coexistence along entire supply chains. Gryson *et al.* (2013) and Menrad *et al.* (2013) analysed cases of a hypothetical coexistence scenario. Then and Stolze (2010) based their analysis on empirical data.

Gabriel and Menrad (2015) showed that coexistence of GM and non-GM products within food supply chains is leading to important extra costs for the non-GM food product. Depending on the segregation strategy undertaken in rapeseed oil and maize starch supply chains, they estimated that ensuring coexistence leads to increased prices for the non-GM product of between 7 and 14% (Gabriel and Menrad, 2015).

Gryson *et al.* (2013) stressed that every step of each supply chain can be considered as a critical point for potential admixture of GM and non-GM crops. From a supply chain perspective, Then and Stolze (2010) and Menrad *et al.* (2013) reveal that additional commodity costs and thus the farm level borne co-existence and additional sourcing and quality management costs are the most relevant cost factors. The most important issue, however, is to control the seed purity as impurity at the seed level will be transferred throughout the entire chain. Then and Stolze (2010) showed that supply chains dedicated to organic or non-GM markets take considerable efforts in avoiding admixture at seed level by highly integrated approaches causing considerable sourcing and quality management costs.

Several authors (Qaim, 2009; Finger *et al.*, 2011; Franke *et al.*, 2011; Fischer *et al.*, 2015; Catacora-Vargas *et al.*, 2017) stress some limitations of studies on the socio-economic impacts of GM production: limited empirical research, skewed data towards some countries, restricted set of economic parameters analysed, differences in assumptions, purposes and methodologies employed, selection bias when comparing the productivity of adopters in high pest pressure environments with that of non-adopters in low pest pressure environments and problems in disentangling the specific role of GM from other drivers of change in agriculture (Qaim, 2009; Finger *et al.*, 2011; Franke *et al.*, 2011; Fischer *et al.*, 2015; Catacora-Vargas *et al.*, 2017). Furthermore, several authors (Macarthur *et al.*, 2010; Bellocchi *et al.*, 2013a; Bellocchi *et al.*, 2013b; Bertheau, 2013; Onori *et al.*, 2013) highlight that most studies so far ignore the impact of sampling and measurement uncertainties. These sampling and measurement uncertainties obligate supply chains actors worldwide to require GMO contents between 1 / 3 and 1 / 10th of the labelling threshold. Such a situation is found for all supply chains committed to safety or quality thresholds. Moreover, the distance on which pollen is considered to disperse is crucial for socio-economic impact assessments (Brunet *et al.*, 2013; Hofmann *et al.*, 2014).

To conclude, results on socio-economic impacts of coexistence are in most cases based on partial studies, which make them generally not generalizable and subject to lobbying by the classical "bias of confirmation".

From the review of scientific literature, we identify following research gaps:

- For Europe, most studies analysed the socio-economic impacts of GM production in a hypothetical setting. Results from these studies are limited as it is difficult to assess a situation which is not real yet. Therefore, information from studies based on hypothetical GM scenarios is quite different and sometimes contradictory. Thus, there is a lack of studies from cases where coexistence is a real issue.
- Most studies primarily focus on costs for GM producers. The literature suggests that, in any case, coexistence involves cost for both the GM and the non-GM producer, which implies that there is a lack of research on analysis of economic impacts of GM production on non-GM farmers.
- So far, there are no studies available analysing the socio-economic impacts on non-GM farmers in countries which implemented a strategy of dedicated production areas.

- Markets for organic or non-GM products were generally not considered in most of the studies. Scientific studies on cross pollination increased in the last years but there is still a lack of consistent data and available information on the cost of coexistence at supply chain level (Gabriel and Menrad, 2015). Some studies like from Hirzinger *et al.* (2008) looked at critical points along supply chains but only partly address economic impacts and costs. Still, these studies utilize quite different methodologies or only apply to specific territories or enterprises. Lin (2002) made an estimation of coexistence costs for export elevators dealing with GM soybeans and high oleic oil maize in the US. Another study, analysing a few cases of organic or non-GM products markets, suggested that these supply chains are considerably affected. Therefore, there is the need for more robust research to analyse the socio-economic impacts of GM production on the actors of such dedicated organic or non-GM supply chains. This applies not only for food and feed supply chains but also for cotton. However, cotton is not regulated by the EU since it is not a feed. Cotton is regulated by private certification bodies like the Global Organic Textile Standard (GOTS).

- Negative externalities are generally not considered in the current coexistence studies. These externalities come for instance from general surveillance (e.g. losses and pesticide applications decreased on Bt cotton in China while pesticide applications increased in neighbouring fields (Lu *et al.*, 2010).

- Economic studies on coexistence should also take into account the effect of GM cultivation on legal actions by non-GM farmers and their redress for adventitious presence (unless strict liability regime is in place and the organic certification is not suppressed) and the necessary distance between GM crops and bee hives, considering that honey bees look for nectar in ca 13 km around the hives.

3. APPROACH

The aim of this study is to contribute to closing some of the research gaps identified above. More specifically, the study will aim at identifying coexistence strategies of non-GM and organic supply chain actors to ensure GMO-free products and estimate the co-existence costs involved.

For the case study approach conducted, a questionnaire was developed which addressed handling of commodities sensitive to contamination with GM organisms and segregation and testing strategies implemented. A particular focus was placed on measures implemented to avoid contamination and the corresponding additional costs. Most of the interviews were conducted by telephone or face-to-face, but some actors responded in writing to the questionnaire. Anonymity was assured to all participants.

41 companies where contacted and asked to complete to the questionnaire. However, 22 companies either did not reply or did not agree in providing the requested information. Furthermore, two companies sent back the questionnaire but the information provided was too poor and thus could not be used for analysis. Furthermore, companies who participated in the survey only provided limited economic data due to its sensitivity and some were not able to quantify and allocate the costs involved in ensuring GMO-free products. As a consequence, the information analysed was rather qualitative.

In total, information from interviews with 17 supply chain actors were analysed (see Table 1). These were seed companies, breeders, feed processors, food processors, cotton processors and traders. GMO-sensitive commodities were mainly soy, maize and cotton; however, some actors also considered wheat, beetroot, radish, brassica rape, chard, rapeseed as GMO-sensitive operated products. The analysed questionnaires were received from France (6), Germany, (6), Spain (2), Switzerland (2) and India (1). Twelve actors only operated organic seed or products. Five processors operated both organic and non-organic GMO-free products (Identity Preservation – IP). One cotton processor operated organic and conventional cotton seeds. Two feed processors in Spain were located in a region where GMO maize is cropped. Furthermore, one seed company operates in a region where GMO-crops were produced until 2008. Thus, in these cases, coexistence is a real issue.

Table 1: Overview of interviewed actors from which data was analysed

GMO-sensitive commodities	Type
Soy	Food
Soy, concentrated tomato	Food
Soy, various products	Food
Soy, maize	Feed
Soy, maize	Feed
Soy, maize	Feed
Soy, maize	Feed
Soy, maize	Feed
Maize	Feed
Cotton	Textile
Cotton	Textile
Various seeds	Seed
Sweet corn, beetroot, radish, brassica rape	Seed
Soy, maize	Seed
Maize, wheat	Seed
Maize, beetroot, chard, rapeseed	Seed
Beetroot, chard, sugar & fodder beet, maize, brassica rape	Seed

Supply chain level	Country	Organic volume share	Non-organic GMO-free (IP) volume share	Conventional volume share	Segregation
Processor	FR	45%	55%		sequential
Processor	FR	60%	40%		no information
Processor / wholesaler	DE	100%			n.a.
Processor	DE	x	x		spatial; specific plant
Processor	FR	100%			n.a.
Processor	ES	85%	15%		spatial; specific plant
Processor	FR	100%			n.a.
Processor	FR	100%			n.a.
Processor	ES	100%			n.a.
Trade / networking	India				n.a.
Processor	DE	80%		20%	no information
Seed company	CH	100%			n.a.
Seed company	DE	100%			n.a.
Seed company	FR	100%			n.a.
Breeder	CH	100%			n.a.
Breeder	DE	100%			n.a.
Seed producer	DE	100%			n.a.

n.a.: not available *IP: Identity Perservation*

4. STRATEGIES OF VALUE CHAIN ACTORS TO ENSURE GMO-FREE PRODUCTION AND PROCESSING

4.1 SEED PRODUCTION

INTRODUCTION: SITUATION AND PROBLEMS

For on-farm coexistence, the EU delegates technical and details required in the EU legislation to the Member States. In the national or regional co-existence legislations, e.g. registration of GMO crop production, training for GMO crop producers, isolation distances between GMO and conventional or organic crops and monitoring, are addressed, but in very different ways[4]. However, the existing national coexistence laws in the EU Member States does not address seed production for the organic or non-GMO sector. Hence seed selection, and multiplication, seed cleaning and packaging are mentioned by only a few of the Member States[5]. Furthermore, Spain, the country in the EU with the highest commercial GM cultivation area does not have any coexistence regulation.

In their coexistence legislations, most Member States refer to non-GM seed production as follows: *In the case of non-GM seed production the seed producers are responsible for implementation of appropriate additional measures.* It seems as if there are no appropriate legal measures to protect breeding and seed production for organic farming against GMO contamination.

While the protection of seed production in coexistence legislation is inadequate, the EU law does not tolerate GMO contamination in seeds. This means that seed lots containing unauthorised GMOs are not permitted for marketing. In addition, labelling is mandatory for seed lots containing GMOs that are authorised for cultivation in the EU.

Despite this clear legal requirement, the *"gmcontamination-register.org"* reports 37 cases of seed contaminations from Austria, Croatia, France, Germany, Greece, Hungary, Ireland, Italy, Romania, Serbia, Slovenia, Sweden, Switzerland, the Netherlands and UK, from 1999 to 2015. The contamination was detected most often in maize and oil seed rape, sugar beet, potato, soya, cotton, and zucchini.

Some recent examples of seed contamination detected in the EU (www.gmcontaminationregister.org):

- On 28 October 2015, the British Department for Environment, Food and Rural Affairs (DEFRA) announced that unauthorised GM seed had contaminated seed that had been planted for variety testing. The French company informed DEFRA following their own testing. The DEFRA press release states that all the trials containing seed from that batch have been destroyed. Contamination with the same GM event was found in 8 EU Member States.
- In August 2011, it was reported that the Hungarian Rural Development Ministry state secretary Gyorgy Czervan said 8,500 – 9,000 hectares of maize were being destroyed because of maize tainted with genetically modified (GM) seeds. This total included 4,500 ha of GM contaminated maize and 4,000 ha of a buffer zone. It was reported that the 225 producers affected by the contamination would be compensated with a total of about €4,800 (HUF 360,000).
- On 3 June 2010, the Irish Department of Agriculture, Fisheries and Food informed the Irish Environmental Protection Agency that it had discovered GM contamination at some of its trial sites. Conventional maize variety PR39T83, provided by Pioneer Hybrid, was found to contain 0.3% of the GM line NK603. The variety which was developed by Pioneer Hybrid is authorised to be used as food and animal feed in the EU but not for cultivation. Pioneer Hybrid had previously provided certificates claiming the seed to be completely free of any GMO.
- On 12 September 2008, the Scottish Executive announced that trial sowings of a new variety of conventional oilseed rape in Scotland were found to contain small amounts of unauthorised GM material. On 19th December 2008, the Department for Environment Food and Rural Affairs (DEFRA) announced that "Conventional oilseed rape seed that contained a low level of unapproved GM seed was sown at a trial site in Somerset, England". The GM event was identified as GT73 which is authorised for food and animal feed use in the EU, but not for unrestricted cultivation.

[4] On 2 April 2009, the Commission published a report about the implementation of national coexistence measures: REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT on the coexistence of genetically modified crops with conventional and organic farming (SEC (2009) 408)

[5] The Grand Duchy of Luxembourg: Segregation is based on isolation distances only. The following isolation distances apply: maize: 600 m; potato: 50 m; beet: 100 m towards non-GM crop fields and 2000 m towards non-GM seed production fields.
Latvia: maize: 200 m; beet: 200 m to non-GM crop fields and 1000 m to non-GM seed production fields;

DESCRIPTION OF STRATEGIES IMPLEMENTED TO ENSURE GMO-FREE PRODUCTION

The three countries where the six seeds companies operate (France, Germany and Switzerland) all have a national ban on GMOs cultivation (Table 2). The companies are all organic and therefore not involved in breeding and trading GM seeds. Therefore, no additional measures for segregation are installed to avoid contamination within the companies.

Table 2: Description of the six seed companies who provided information for this report

Country and region	Switzerland (2), Germany (3), France (1). In one case, selection and propagation takes place in countries outside Europe
Main products:	Seeds of cereals, vegetables, herbs, flowers
Number of employees:	2–70
Annual turnover:	€1–€7 million
Share organic turnover:	100%
Share organic production (per volume):	100%
Experiences with GM contamination	None

The main focus lays on measures to avoid contamination from seed accessions (collecting seed from multiple points, combining them into a single lot, storing, planting) and to make sure that seeds remain free from contamination. The strategies mentioned in the survey are:

- Use of breeding material that stems from regions without risk of GMO contamination
- Talk to their neighbours about risky crops
- Removal of wild cross-fertile plants
- Sowing delayed in time
- Production in a GMO-free region
- Certificates, contracts, reserve samples, quick tests
- Own machinery, storage, transport and distribution under own control and in closed bags / bins
- Reduced exchange with conventional companies, own conservation, multiplication
- QM document regarding GMO contamination to inform the network, covering:
- Awareness of what neighbours do: *"In one case we had to destroy a complete production on the field because of GMO-maize production in the neighbourhood"*
- Management during harvest (e.g. when machines of other enterprises are ordered to do the harvesting) and transport
- Taking and keeping retention samples

One company produced seeds in a region where GMO production took place until 2008. At that time, official data on GMO fields were not available. So the company had to gather information from their neighbours, and GM tests were conducted.

ECONOMIC IMPACTS OF THE IMPLEMENTED STRATEGIES

All of the companies interviewed work exclusively for the organic sector. They feel a high responsibility to supply the organic market with non-GM seeds. In the context of this responsibility, it was found that the most important concern for the interviewed persons is that co-existence of GMOs and GMO-free breeding and seed production is not possible.

"Coexistence is not possible. This is the main problem. In particular regarding cross pollinators like beetroot, maize or rapeseed, coexistence is definitely not feasible. As soon as GMOs of such crops are on the fields, it will no longer be possible to keep the GM-free crops free from contamination. Many examples illustrating that impossibility exist, e.g. from Canada, the US, Spain and other regions."

"Even now, when no GM crops are officially cultivated in Central Europe, many field trials with cultivation of GMOs have taken place in this region. Furthermore, seed is traded worldwide, and seed is imported from regions where GMOs are grown (cultivation or trials). Hence, we cannot be sure that there are no undetected, hidden GMO contaminations in seed lots and plants growing in Central Europe…"

New accessions, that the interviewed organic companies want to use for further breeding, are tested for GMO contaminants. Often, they have the impression that official GMO testing strategies are not sufficient, as governments do tests randomly on a small amount of all the seed lots at the market. Also this illustrates the high responsibility the interviewed companies feel for the organic sector. Due to the documented cases of seed contamination (see list above), companies are also concerned about possible undetected or undetectable contamination.

"But even now, where in our region there is no official GM crop production, we do not have 100% security because of undetected contaminations of planted seed lots and no complete official controls (only about 7 – 10% of all lots of at-risk crops have been tested in the past)".

The uncertainty leads to testing for GMOs, mainly when new breeding programmes start. New accessions have to be tested, and the testing causes additional costs (Table 3). One breeder stated:

"Also, organic breeding is generally confronted with the problem of financing: Breeding is time and labour intensive and it is a constant challenge to find the financial means. Testing costs make this situation even more difficult".

The costs for testing is one aspect mentioned in the survey. Testing costs amount to around 0.4 to 0.6% of the annual turnover. For the breeders, the costs of losing breeding material and seeds through contaminations and the damage to reputation is even more severe. The breeding undertaken over many years could be lost. Not only the contaminated lot would need to be destroyed, but also the gene pools need to be checked for contaminations. One of the surveyed experts mentioned that a contamination of seeds, which was not discovered immediately, could destroy the work of one or several years.

"If we only look at the work that would be destroyed in a year's time, we could incur costs of around CHF 100,000. I assume that we have not yet passed on the seeds to third parties. Otherwise the costs would be several times higher."

Furthermore, the point of contamination would need to be identified to know whether own maintenance of that variety (or the variety as a whole, if nobody else has a maintenance) could be saved by using older basic seed. If not, a variety could be lost and the financial damage would be even worse. The potential costs are difficult to estimate based on the data received from the companies, however, losing a breeding line means that long-term investment in the breeding and the business investment are lost.

Table 3: Additional costs to exclude GMO from breeding programs

Seed testing	€1,000 – €2,500 / year; up to €40,000 / year (mainly when new breeding material is introduced in breeding programs)
	€180 / seed lot
	€100 / test
	€100 for taking sample

The lists of contaminations (www.gmcontaminationregister.org) also shows how far undetected contamination could spread and how long they potentially remain undetected. Here more details about the most recent example from 2015:

In October 2015, it became known that rape seed with GMO contamination was cultivated on experimental plots in England and Scotland. The level of contamination was about 0.3%. Tests brought to light that experimental sites in Germany (8 sites), France, Hungary, Poland, Romania, Denmark and the Czech Republic were also affected. It is assumed that the contamination is due to GMO field tests conducted in France in 1995 / 1996! The contaminated breeding line was grown in the same area as the GMO rapeseed and the contamination was not detected until 2015 (GeN 2016).

As organic breeders supply organic farmers across Europe and beyond, a contamination could spread into several regions and cause additional costs for the farmers, but potentially also for the processing industries. One company points to the lack of implementation of the polluter pays principle:

"In our eyes, it is not correct that those companies and farmers who do not use GM crops must pay the costs to avoid contamination."

CONCLUSIONS AND PERSPECTIVES

Organic crop production, which is GMO-free by definition, needs to begin with GMO-free organic seeds. The interviews with seed producers and breeders showed that according to their practical experience, the co-existence of the deliberate release and cultivation of GMOs with GM-free seed production and breeding is judged to be unfeasible. A potential GM-contamination case is a tremendous risk to the companies as losing a line means that long-term investment in the breeding and the profits from the corresponding business are lost and the damage to reputation is considered to be severe. In addition, they do not feel protected by governments, and consider in particular that the official seed controls carried out only at a random basis would not provide sufficient protection against contamination.

"Hence, we cannot be sure that there are no undetected, hidden GMO contaminations in seed lots and plants growing in Central Europe, especially as the official controls of seed for presence of GMOs are carried out only at a random basis and not all seed lots of at-risk crops are checked for presence of GMOs."

"…This is shown by cases of contamination in different crops (rapeseed, maize, petunia…). These cases also show that the present practice of control does not work reliably and that measures must be taken to improve control mechanisms. The best solution for us would be a total ban of GM crops in Europe".

"It can be reality that we lose all areas of seed production of certain crops. Then we have to withdraw these crops. We would no longer be able to supply our customers with them, when GM-contamination would not possible to avoid 100% (e.g. sweet corn)."

"In summary GMO contamination is able to destroy our total work and existence of the company".

The breeding undertaken over many years could be lost. Not only the contaminated lot would need to be destroyed, but also the gene pools need to be checked for contaminations. One of the surveyed experts mentioned that a contamination of seeds, which was not discovered immediately, could destroy the work of one or several years.

The strategy to avoid contamination leads to a situation where exchange with others is limited. Uncertainty causes costs for testing. Some breeders think that their capacity to protect themselves against GMO contamination, even though they are fully committed to protecting themselves, is limited, due to the volume of seed available for testing and, in parallel, due to limited financial means. One breeder explained it as follows:

"The sheer volume of seed available for breeding (e.g. from gene banks) is far too little to allow testing in a lab: Nothing would be left to grow and breed with. "

"I do not know, if we really do enough"

All of the 6 companies interviewed differ in size, turnover and crops they breed. All are working for the organic sector exclusively (see Table 1). In the interviews, the concern about GMO contamination was clearly expressed and the responsibility they have for the whole sector:

"… As breeders often use breeding material from external sources, such as gene banks or private breeding initiatives, the risk of taking in contaminated material is always present. In this context, breeding material (varieties, accessions…) from risky regions (e.g. regions with deliberate releases and cultivation of GM crops of species t hat can cross-breed with the concerned crop) cannot be used without systematic testing for organic breeding projects as there is a high risk of unnoticed contamination."

"It is not possible to consider abandoning some of our varieties but we would like to find a way to protect our varieties from GMO contamination. We would like to set up seed conservation (each variety would be stored, dehydrated seeds = 15 years of conservation), in case of problem, it would be possible to use these seeds. Such conservation is quite cheap."

The companies feel that the current situation in Germany, France and Switzerland makes it easier to avoid GMO contamination.

"As long there are no GM crops in fields in our regions of seed production, it may seem there is no problem to keep our seeds GMO- free."

"At the moment, we have no direct problems with GM and with coexistence… But we also produce other crops in other countries, and there is a certain element of risk. In general, for us it is quite clear, that coexistence is not possible in practice. There are too many possibilities of contamination on the field, during harvest (used machinery), seed cleaning and transport."

"For the moment, our situation is quite secure thanks to the national ban on GMOs. If the French government decided to drop it, then the situation would be very difficult for us, and we would have an important increase in our costs (a lot of tests, possibility to be contaminated with huge consequences)."

But breeding is about exchange and diversity of the genetic material. Hence, the strategies selected mean in parallel a limitation of breeding activity and of the available gene pool. In the long run, this means a limitation of agrobiodiversity for organic breeders.

"Consequences are not so much financial, but rather qualitative: Breeding material from regions with risk of GMO contamination cannot be used. This means a severe limitation to freely participate in the development of breeding".

All of the companies are worried about future developments, mainly linked to the use of new genetic engineering techniques (e.g. genome editing techniques such as CRISPR-Cas) in plant breeding and the question whether these will be legally regulated under the EU Directive 2001/18/EC on the deliberate release of GMOs into the environment and Regulation (EC) No 1829/2003 on GM food & feed. The organic sector excludes the use of these technologies. If they were not regulated as GMOs, these new GM plants would neither be tested for their environmental effects nor labelled, and no segregation or obligation for companies to submit detection methods would be needed.

"The main problem will be new genetic modification techniques, especially if they will not be regulated as GMOs under EU law and if no detection methods would be available."

"The debate about new genetic engineering techniques is of high importance for the future of organic breeding. (….) the use of these techniques in conventional breeding would reduce the breeding material available, and, if not labelled, make a GMO -free breeding process practically impossible."

"If these techniques were not regulated as GMOs and hence not labelled as GMOs, their widespread use in conventional breeding would be likely. Then, however, the whole conventional gene pool would become a no-go for organic breeding, and this again would mean a severe deterioration of breeding quality. As the new genetic engineering techniques are not compatible with organic agriculture (as declared by IFOAM EU, IFOAM Organics International and several national organic federations) it is critically important that these methods are regulated as GMOs and labelled, if not banned."

Another concern is that the EU's zero tolerance policy and labelling obligation for GMOs in seed are under pressure and that allegedly "technical" thresholds could be introduced. Breeders and seed producers are worried about increasing contamination risks due to such developments:

"If we would lose ensuring 0.0% threshold in our seeds, we would lose the trust of our customers (the farmers and gardeners) – and in consequence they would lose the trust of their own customers (consumers of organic products) too."

"If an allegedly "technical" threshold was established, this would mean no less than the end of safe GM-free seed production. Testing would become necessary in a dimension that, for us, would not be affordable. The breeding process would be endangered due to a significantly reduced gene pool. "

The survey was focussed on additional cost for breeders. Worries about costs and risks due to a non-protective co-existence legislation are often mentioned. However, the interviewed seed producers considered it very important to not only focus on costs. Other aspects such as loss of seed exchange, loss of seed diversity and seed sovereignty for breeding are seen as similarly important.

Co-existence in breeding and seed production is considered to be unfeasible. A potential GM-contamination case is a tremendous risk to the companies as losing a line means that long-term investment in the breeding and the profits from the corresponding business are lost. These costs however can hardly be estimated. Aspects such as loss of seed exchange, seed diversity and seed sovereignty are considered as a serious threat. As official testing is perceived to be insufficient, additional testing is implemented. The situation is easier in countries with a national GMO ban.

4.2 FEED (MAIZE AND SOY)

INTRODUCTION: SITUATION AND PROBLEMS

Six feed processors which operate with maize and soy were interviewed (Table 4) from France (3), Spain (2) and Germany (1). The two Spanish feed processors are located in a region where GM-maize is produced. These feed processors and one from France apply an internal GMO threshold of <0.9%. The remaining feed processors run an internal GMO threshold of <0.1%. One company had a contamination case which required reviewing their entire supply chain. The other interviewed feed processors did not have any serious contamination problems so far. Generally, the companies stress that GM contamination above the 0.1% threshold is exceptional. The German feed processor faced within the last 14 years one GM-contaminated soy shipload corresponding to 0.5% of the soy shiploads. One Spanish company stressed they did not experience problems with GM contamination apart from one specific case where a batch delivered from one farmer appeared to be contaminated. This required a processing stoppage and testing of samples from the suspicious batch. But no contamination above the 0.9% threshold was found. As the production of GM crops is allowed in Spain but not in France and Germany, the risk of contamination with GMOs for the six interviewed feed processors is quite different. The higher risk of GM contamination in the Spanish case studies could explain why they run a 0.9% threshold.

The companies highlight that an important potential source of contamination is the spreading of GM genes in the environment, and dust. Furthermore, they stress that the absence of legal protection in case of unexpected contamination is seen as an important issue since it is almost impossible to investigate the origin of the contamination, which would however be required for a liability case.

The German and one Spanish feed processor operate organic and non-organic identity preserved qualities (IP) which are processed in a specific plant (spatial segregation). All the other feed processors only operate organically produced commodities.

In Spain, the government and autonomous communities provide statistics on GM production. However, the information from these sources are sometimes different and thus, the information provision needs to be improved. French feed processors interviewed stressed a lack information from official authorities about GM production and that non-official information are better than official sources. They rely mostly on information derived from sources like the *Confédération Paysanne*, a farmers union which actively works on GMOs issues. One French feed company proactively acquires information about GM production from different sources.

Table 4: Description of the six feed companies who provided information for this report

Country and region	Germany, France, Spain
Main products	Feed
Number of employees	5 – 110
Annual turnover	€7 – €39 million
Internal threshold for GM	0,1% – 0,9%
GM crops produced in the region	In Spanish case studies

DESCRIPTION OF STRATEGIES IMPLEMENTED TO ENSURE GMO-FREE PRODUCTION

Several strategies are undertaken by actors from organic supply chains in order to reduce risks of contamination of feed.

- Operating only GMO-free commodities (organic or non-organic IP): Feed processors from Spain, France and Germany operate only GMO-free products from organic and / or IP production. The reason for this is to minimise the risk of contamination and avoid costs for cleaning and additional storage facilities as the entire feed processing processes are kept GMO-free. One French and the German company highlighted that as the contamination risk is high, processing GMO-free and conventional feed is one plant is not possible.

- Spatial segregation in specific plants and / or control of the whole process: One Spanish and the German company process organic feed in spatially separated plants. One French company invested in their own oil mill plant for organic processing to ensure full control over the entire organic production process. On the one hand, this is to avoid any contamination. On the other hand, this makes it easier to fulfil and document all the requirements associated to organic farming.

- Training of staff and proactive information gathering on GM production: One French company organises trainings on contamination issues for GMOs and pesticides. Due to the lack of information on GM production from public sources, another French company proactively searches for information (approx. 2 days per year).

- Sourcing from reliable suppliers to ensure GMO-free products:

  - Sourcing from EU regions where no GM crops are produced: One French and the German feed processing company source around one third of their soy from farmers in Germany and France. They work directly with farmers and thus know the way they produce. Sourcing from countries such as France and Germany is considered to be a contamination risk minimising strategy. However, e.g. the French organic maize supply does not cover all the demand.

  - Careful selection of suppliers: One French and the German feed company highlighted the need to carefully choose their suppliers and only source from suppliers they entirely trust. The German company e.g. imports GM-free soy from Brazil in collaboration with a Swiss company which has a lot of experiences in GMO-free sourcing. The French company collaborates with a Chinese organic supplier which is certified by a French certification body and audits the supplier regularly, they visited themselves the supplier before working with them to make sure they fulfil their requirements. The Chinese supplier takes place in a region dedicated to organic production. One Spanish company sources organic maize in collaboration with the Catalan Organic Certification Body (public entity). Trust is of high importance, thus companies aim at building strong relationships.

- Testing: Testing for GMO contamination is one of the most relevant strategies to ensure GMO-free products. Some companies report increasing testing costs as new GMOs are authorised for feed.

  - When arriving at the plant, a quick test or quantitative tests are required to prove GMO-free products at two French plants. The trucks are not unloaded before negative testing results are available and the certificates are provided. This could lead to the situation that trucks could not be unloaded for up to 48 hours until the testing results are available.

  - Random tests and retention samples (sample of a batch stored for identification purposes) of the raw products: Several companies conduct random tests at the arrival of trucks and / or random tests in the storage facilities. Retention samples are taken from the silo or during drying.

  - Only one company randomly tests the final feed product. This company operates on organic products and considers the contamination risk through raw material to be low.

  - Sampling is done by own staff or by external bodies. Generally, testing is done by external laboratories. Organic control and certification bodies in Spain and France test samples 1 – 3 times per year. The Spanish ministry of industry also tests once a year at one Spanish company interviewed.

  - One French company is "Oqualim" (quality control) certified.

- Substitution of risky products: After having a contaminated batch in 2008 which required stopping the entire production for three days to identify the source of contamination, one Spanish company decided to substitute maize by wheat which is less problematic for GM contamination. Additionally, some organic additives are bought to make the colour of the egg yolk similar to that which is obtained when feeding hens with maize.

- Transport and cleaning certificates: Three French and the German company require cleaning certificates of the truck before unloading. The German feed processor requires certificates on wet cleaning plus no GM crops in the last three batches of the truck. One French company does not accept trucks with 'moving floors' as this type of transport is very difficult to clean completely. One French company decided to import soya only in jumbo bags to avoid GMO contamination through the container walls.

Even though the companies interviewed implemented several strategies, the factor of 'trust' is actually the most important factor to ensure GMO-free products.

ECONOMIC IMPACTS AND COSTS OF THE IMPLEMENTED STRATEGIES

Due to the fact that the interviewed Spanish feed processors are in region where GM-maize is produced, we found very different economic impacts in France and Germany compared to Spain.

France and Germany

Company 1 (FR): estimated extra cost related to potential GMO contamination to be around €40,000 / per year at least which correspond to extra costs of €7.6 / t soy and maize or 0.3% of the annual turnover. 50% of these costs are testing costs (€20,000/year) and 13 – 15% (€5,000 – €6,000/year) of the total GMO related costs are audit cost at suppliers (supplier visits). Other costs:

- Information costs: 2 days per year
- Training costs: around €2,000 per year (the mobilization of 8 employees from production, reception, quality).
- Investment in a new plant: around €4 million. However, this cost is not to be associated only to GMO issues but to all requirements in relation to organic production, according to the interviewed company.

Company 2 (FR): The company could not provide information about the total coexistence cost, but on testing and certification costs.

- Total testing costs: €21.3 – €21.5 / t maize and soy:
  - 3 random tests per year (€750 for 4000t): €0.19 / t
  - Testing of truck (€250 per truck): €8 / t
  - costs of immobilisation of trucks for 48 hours while waiting for the results of the tested samples: €13 / h
- Certification costs
  - Organic certification including randomly testing of final product: €1,400 / year
  - Oqualim certification: €250 / year

Company 3 (DE): The company could not provide information about the total coexistence cost, but costs on testing and sourcing costs.

- Total testing costs: €50,000 / year
- Quantitative test: €170 / test
- Additional sourcing costs: Price premium for GMO free soy: 3.5 – 4.5%

Testing costs amount between (quantitative GMO test) which is about half the costs for pesticide residue testing (€390 / test).

Potential costs in case of contamination: Two companies estimated the costs in cases of contaminations with GMOs. They estimated the cost for declassification of the organic product to amount to around €25,000 (recall of contaminated products). Communicating with the certifier and testing of raw materials to trace back the contamination pathway was estimated around €15,000. More severe is the loss of trust with clients which could lead to huge economic damages. However, costs depend very much on the travel distance and the number of contaminated lots.

Costs of spatial segregation strategies: Spatial segregation in specific plants for GM and non-GM production could lead to an increasing transport costs of between 695 and 790%. This cost is mostly due to the fact that batches cannot be delivered from silos to the closest dryers. This strategy also leads to an increase in drying costs from 17 to 34% if the share of non-GM equals less than 50% of the collected products. That is because in this case the dryer allocated to non-GM is not used at its full capacity (Coléno, 2008). However, spatial segregation is not only required to avoid contamination with GMOs. Even in absence of any GM crops, processors which operate organic and conventional products, may prefer spatial segregation to temporal or sequential segregation.

Strategies to assure the absence of GMOs in food products application process in a confectionery firm (Scipioni *et al.*, 2005)

The paper stresses that elaborating and applying control plans in food firms with e.g. the HACCP method (similar to the Oqualim certification, taking the example of one French company we interviewed in this study), can be seen as one of the most important external measures. The modalities can be as follows:

- To certify particular avoidance measures implemented upstream in the supply chains, that is, at farm level (planting and harvesting of maize and soya). To verify the origin of the seeds appears to be one of the most important measure.
- To consider products are contaminated when a PCR analysis shows a contamination level of 0.1% or higher.
- To control 50% of the supplied batches, which was considered as a safe frequency in the study.
- To require from suppliers to sign a binding agreement on specific preventive and eventual curative measures to be adopted.

Spain

Costs associated with potential GM contamination in organic supply chains in Spain are of a different nature because GM production in Spain leads to the situation that Spanish organic farmers abandon or do not start cultivating organic maize to avoid contamination problems. Indeed, according to the CAAE (Comité Aragonés de Agricultura Ecológica – organic certification body in Aragon), between 2003 and 2007 the organic maize area decreased in Aragon by 75% (Herrero *et al.*, 2017). This was a consequence of some contamination cases in Spain, where organic farmers were economically affected. It was found that "100 per cent of the analysed samples were positive (for GMOs) in 2004; 40 per cent in 2005; 50 percent in 2006; 60 per cent in 2007; and 37 per cent in 2008" (Martinez, 2009).

Organic farmers are therefore now reluctant to take the risk of GMO contamination and adjust their production. In economic terms, they face opportunity costs which are the costs resulting from the need for organic farmers to produce conventional maize or alternative organic crops instead of organic maize.

Assuming a conventional maize yield of 10t/ha and a 2 – 5 t/ha lower organic grain maize yield (Table 5), the gross margin of organic grain maize is 31% to 218% or €125 – €875/ha respectively higher than the gross margin of conventional grain maize[6]. Thus, organic farmers have opportunity costs of €125 – 875ha. Azadi *et al.* (2017) estimated that for a contamination case in 2005 in Aragon with organic maize by bt176 and MON 810, that there was a cost of €4,000 due to decertification of organic maize.

Table 5: Balance between organic and conventional grain maize gross margin (gross margin organic minus gross margin conventional) in Spain depending of organic maize yield per hectare

Organic grain maize yield	Balance between organic – conventional grain maize gross margin	
in t/ha	in €/ha	in %
8	€875/ha	+219%
6	€375/ha	+94%
5	€125/ha	+31%

Source: own calculation

Similarly, opportunity costs incur when a farmer decides to abandon organic farming or not to convert to organic production and thus loses production opportunity.

In Spain, due to the expansion of GM-maize production, the area under organic maize decreased drastically and is now very small e.g. only 89 ha in 2015 in Catalonia (Herrero *et al.*, 2017). The supply gap is closed by imports. Importing organic maize e.g. from Ukraine, results in additional transport costs. This feed processor pays the same price for imported organic maize as from Spanish organic farmers.

Finally, with respect to the Spanish case of GM contamination, the following cost categories were mentioned by the interviewed company: (1) decertification, declassification cost (opportunity costs), (2) looking for a substitute to maize that is less sensitive to GM contamination, (3) additional cleaning, (4) stopping the whole production process in case of contamination, (5) stopping processing of all of the feed produced until the cause of the contamination was discovered, and (6) impacts on clients that all had to be contacted and informed about the contamination case. That said, they considered in 2008 (when the contamination happened) that this cost was too high to continue with organic maize processing and they replaced maize with wheat. Substitution, however, leads to additional sourcing (finding new suppliers) and information costs. In fact, the main challenge was that poultry feed usually includes maize and customers needed to be convinced that feeding hens or chickens without maize is possible. Meanwhile, customers accept wheat instead of maize in the poultry feed.

CONCLUSIONS AND PERSPECTIVES

Most important coexistence costs of the interviewed feed processors are the testing and certification costs, which equal between €7 and €21/t of maize and soya. In the Spanish case, the main important costs appear to be the opportunity costs of not producing organic maize or organic production, as well as the additional import costs to replace the decreasing domestic supply of organic maize in Spain. In both the French and Spanish cases, it was reported that incurred costs in case of a potential contamination might be quite important mainly because of the decertification of a certain volume of products, as well as the interruption of the business for a certain period and negative impacts on B2B and B2C relationships (trust, credibility…).

[6] We hypothesized a selling price of €250/t for organic maize and €120/t in conventional. Operational production costs were derived from FADN data (2013). We hypothesised pesticides costs of €75/ha in conventional.

One of the most important avoidance strategies implemented is to source organic maize and soya from well-known suppliers or safe origins. Other important strategies adopted by the interviewed companies were operating only organic feed or spatial segregation in specific plants. Finally, an important strategy followed by one company was the replacement of maize by wheat. At the same time, another company said that they have to provide a very well-balanced feed, and that they therefore need to ensure, especially for organic, that animals are as healthy as possible to avoid using medicines. For this reason this company considers that they cannot avoid using soy and maize.

It appears that the interviewed companies have adapted their practices to the situation and that contamination and related costs are currently not very high. This is mainly due to national bans on GMO cultivation, and to the very limited cultivation of GM crops in Europe. It was however reported by the interviewed companies that if more GMOs would be grown in the future, risks and associated costs for GM contamination would be become more important again. One company raised concerns that countries currently banning GM production, and from which they import their input products, could decide to allow cultivation of GM crops in the future. This could lead to tremendous or insurmountable problems for them, especially as the substitution of products is very difficult due to a) animal nutrition requirements, b) farmers' acceptance, and c) the fact that the GM-free quantities produced in the EU are not sufficient.

For organic and non-organic GMO-free feed producers, the most important coexistence costs are testing and certification costs. In Spain, due to the high risk of contamination with GMOs, farmers abandon growing organic maize and thus lost a potential income opportunity. Feed processors fear that a contamination case results in quite relevant costs due to decertification (loss of price premium), interruption of the business and loss in trust and credibility. The most important avoidance strategies implemented are to source commodities from well-known suppliers or safe origins and operating only organic feed or spatial segregation in specific plants.

4.3 SOY FOR FOOD

INTRODUCTION: SITUATION AND PROBLEMS

Three processors of soy for food were interviewed in France (2) and Germany (1). All companies implement a 0.1% threshold for GM contamination; one company stresses that for seed a 0.01% threshold is required (Table 6). Focusing on seeds is very important to avoid contamination problems at the harvesting stage. The German processor only processes organic products whereas the two French food processors operate organic and non-organic IP qualities. One of these runs a sequential / temporal segregation strategy.

Table 6: Description of the three soy processing companies (food) who provided information for this report

Country and region	Germany, France
Main products	Soy based food
Number of employees	220 – 977
Annual turnover	€55 – €274 million
Internal threshold for GM	0,1%; 0,01% for seeds
GM crops produced in the region	No

STRATEGIES IMPLEMENTED TO ENSURE GMO-FREE PRODUCTION

Several strategies are undertaken by actors from organic supply chains in order to reduce risks of contamination in processing soy based food products.

- Spatial / temporal segregation: separating organic from non-organic production is however not due in first instance to potential GM contamination issues. The company has different plants that are each dedicated to a specific production such as soya milk or yogurt. In each plant, they first produce organic and then GMO-free conventional. They have separate storage, cleaning and production sequencing. One company particularly highlighted the need for careful cleaning at all stages of the process to reduce risks of GM contamination.

- Training of staff: The aim of the training is to reinforce the position of the company on GMOs, to explain why from their point of view it is important to remain GMO-free, and how risks of contamination can be avoided.

- Monitoring of suppliers: Two companies monitor their suppliers through a survey; however one of them only monitors new suppliers to verify whether they meet all of eligible criteria. This questionnaire is then conducted every three years. In addition, suppliers are audited and the company has a detailed binding agreement with suppliers specifying all of their obligations.

- Sourcing: One company processes only French soy because production of GM crops is banned in France.

- Testing and cleaning: One company tests input products at their arrival at the plants. Every lot is systemically tested for seven GMOs. One company does not test all final products, but one time per year, all categories of their products are randomly tested.

- IP Certification: One company IP certified (Identity Preserved Certification) to guaranty their soya products are below a GM contamination level of 0.1% (organic and GMO-free). The company decided to impose on itself a performance obligation and not only an obligation of means. In case their products are contaminated beyond 0.1%, they are not marketed.

- Transport of raw material: One company requires cleaning certificates from the transport company they work with and provides a good practice guide for transport. Trucks must be cleaned every time as it is considered to be of high importance to avoid GM contamination in raw material.

ECONOMIC IMPACTS AND COSTS OF THE IMPLEMENTED STRATEGIES

Companies that were interviewed highlighted that costs of coexistence are mainly due to product testing, and to careful cleaning at every processing stage and certification. In the absence of issues related to GMOs, they could stop such controls and redeploy human resources to other tasks. Training costs were also mentioned, even though these trainings are not only related to GMOs.

One company reported a cost of certification of around €13,500 / year, for both organic and GMO-free production. This includes €10,000 for the organic certification and €3,500 for the IP Certification. This company also mentioned additional cost due to coexistence issues:

Testing:
- farm level, directly supported by the suppliers: €100 / test and 100 working hours per year
- Testing input products at their arrival at the plant: €1.67 / t
- Additional analysis to find out the contamination could cost up to €100 / t.

Cleaning:
- Cleaning and cleaning certificates for trucks: €10 / t
- Additional cleaning costs including transport, storage, and processing facilities: up to €100 / t.

Temporal segregation: €10 / t

Potential costs in cases of contamination:
- Destruction of final, semi-finished product and raw materials in case of contamination
- B2B, B2C relationships in case of contamination: GM contamination would potentially have huge impacts on relationships with customers and incurred costs might be due to the need for reorganizing the production planning and loss of credibility.
- The potential costs in cases of contamination can hardly be estimated. Companies assumed that costs incurred for destruction of contaminated products and cost of losing costumers and reputation could each be up to €1000 / t. Another assumption is that costs could double the price of the purchased goods. But the main impact is due to the damages on reputation and trust.

CONCLUSIONS AND PERSPECTIVES

The most important coexistence costs for European soy food processors are related to the monitoring of suppliers, the testing and certification costs, as well as costs related to segregation strategies. It was also reported that there were potentially very high costs in the case of contamination, due to the destruction of products and in damages to B2B and B2C relationships (trust, credibility…).

One of the most important avoidance strategies, as for maize and soya for feed, is to buy organic soya from well-known suppliers or safe origins. Other important strategies adopted by the interviewed companies are the segregation strategy with specific plants dedicated to GM or non-GM products, the cleaning of trucks and use of certified companies, and the need of organizing training for employees (one company said they train 35 of their employees annually).

With respect to the future on GMOs, it was said that insufficient information is available on new GMOs to give an opinion. But the interviewed companies also expect to have more problems related to GMO contamination in the future. Since the number of GMOs is increasing, the number of GMOs to test will also be increasing, potentially leading to additional costs. This is what the literature in the US situation suggests, but no irrefutable conclusions can be drawn here. One company also said that the legislators should react more quickly to clarify the legal situation of new GM techniques. They also argued that GMOs production should be banned as the cost of coexistence is quite high. They are concerned by the concept of "co-existence" as they think that more sensitive detection analysis is being developed and that we will discover more GM residues in raw materials in the future, which might damage the image of organic farming. The soy food processing companies interviewed highlighted that costs are mainly due to product testing, careful cleaning at every processing stage and certification.

THE AMERICAN EXPERIENCE OF GMO CO-EXISTENCE

The USDA conducted a survey in 2014 to gather experiences of US farmers in relation to GM contamination, and to estimate the cost of contamination cases (Greene *et al.*, 2016). In the USA, the vast majority of cultivated cotton, maize and soy are GM crops. In 2016, GM crops were grown on 72.9 million ha UAA, which corresponds to around 40% of the US arable area (Inf'OGM, 2017). Greene *et al.* (2016) report that between 2011 and 2014, 87 US farmers suffered economic losses because of GMO contamination. This economic loss amounted to $6.1 million in total (0.4% of the total sale value for 9 crops partly GM) or $70,099 on average per farm. In Illinois, Oklahoma and Nebraska 6 – 7% of the organic farmers had economic losses due to GMO contamination as in these states, a high percentage of organic farmers produce organic corn, soybeans, and other crops with GMO counterparts. In California, Indiana, Maine, Minnesota and Michigan the share of affected organic farmers was less than one percent (Greene *et al.*, 2016).

Based on answers from 1,500 US organic grain farmers, the Food and Water Watch and Organic Farmers' Agency for Relationship Marketing (2014) estimated the annual coexistence cost for US farmers of between $6,532 and $8,500 per US farm. This cost constitutes as follows:

- Cost of buffer strips: $2,500
- Delayed planting (to avoid pollen contamination): $3,312 to $5,280
- Testing for GMOs: $200
- Other measures: $520

In the same study, experts of organic grain marketers were interviewed and pointed out that GM contamination is one of the first motives for refusing batches. They mentioned in particular an important contamination problem in 2003 when between 10% to 20% of the production was rejected due to the fact that the strategy of delaying planting to avoid cross pollination was undermined by weather circumstances (Food and Water Watch and Organic Farmers' Agency for Relationship Marketing, 2014; Inf'OGM, 2017). One company reported to have developed a testing program, which costs around $19,000 / year.

Other sources of costs are as follows (Food and Water Watch and Organic Farmers' Agency for Relationship Marketing, 2014):

- To clean up trucks to reduce risks of contamination in shipping: One company estimated a cost of around $45
- Opportunity cost: contaminated lots have to be sold on alternative markets
- Time spent to look at new potential buyers
- The cost of shipping back contaminated batches to farmers or new purchasers. One company estimated a cost of between $500 and $900 per load

4.4 COTTON

INTRODUCTION: SITUATION AND PROBLEMS

For the cotton supply chain, two structured interviews were conducted: one company from Germany and another one from India. In addition to this, more informal contacts have been established with two other German companies that provided some information. Cotton, including organic cotton, is mainly produced in India, China, and in the United States. Other producing countries are for instance Uganda and Kirgizstan. In Europe, cotton is produced in the South of Spain, in Andalusia.

Most of the coexistence costs for the cotton supply chain incur in the production country and in the first stages of cotton processing (delivery and ginning). In fact, European companies which process organic cotton for the textile sector stressed that their cotton was certified after the ginning process (separation of seeds from fibres) and before the spinning process. The 0.9% GMO threshold mentioned in the EU organic farming regulation relates to the labelling obligation of the GM food and feed regulation (Regulation (EC) No 1829/2003), and therefore does not apply to cotton. Organic cotton supply chain actors often rely on private certification standards such as the Global Organic Textile Standard (GOTS), which prohibits all inputs and raw materials which contain or are made from GMO. One company from Germany stressed the high difficulty of complying with this requirement. The private GOTS standard helps cotton processors from Asia to sell cotton to European sellers or textile industry. European importers, in turn, can rely on products already GMO-free certified. Therefore, they have no need to test their final products for potential GM contamination.

STRATEGIES IMPLEMENTED TO ENSURE GMO-FREE PRODUCTION

The following strategies are undertaken by actors from organic cotton supply chains in order to the reduce risks of contamination with GMOs.

Learning process:

- A specific research project on organic cotton farming is being implemented in India in order to help farmers and processors to produce organic cotton, including to avoid GMO issues. An association works with groups of farmers to give advice, organize training sessions and field visits.
- An Indian association stressed that they do help farmers to choose non-GM crops where organic cotton is mostly produced, in order to limit risks of contamination.

GMO-free seeds:

- For companies producing seeds for farmers, there is a need for testing the seeds for GM contamination before sowing. A few lots are to be excluded and sold on alternative markets.
- It was reported that some farmers decided to multiply seeds themselves through a cooperative in order to reduce risks of contamination.

Testing: Plants have to be checked and tested for GM contamination through the season:

- Strip tests are often undertaken at the delivery of cotton seeds and at the ginning phase (separation of seeds from fibres). Sometimes, PCR tests, which are more robust, are also done. An Indian association, for instance, performs such tests with some working groups of farmers.
- Farmers' batches proved to be contaminated by GM are rejected at delivery.

Cleaning:

- It was underlined that there is a need to separate all batches and clean very carefully before each lot is processed. Since some lots are contaminated, they all have to be separated to avoid cross contamination. This cleaning process takes around 3 – 4 hours after each lot is processed.

ECONOMIC IMPACT AND COSTS OF THE IMPLEMENTED STRATEGIES

GMO-free seeds:

- It was not possible to estimate economic consequences of seeds testing at the beginning of the season, on the basis of interviewees' answers. Two sources of costs are the testing themselves but also the opportunity cost of selling some of the seeds on alternative markets, less profitably.
- The fact that some farmers decided to multiply seeds themselves leads to additional costs, however no estimation was provided in this respect.

Testing:

- Strip tests at the delivery have a cost of around €20 per farmer in countries like Kirgizstan. In India, PCR tests cost around €93 / PCR test. An Indian association conducts for example 50 PCR tests for 25 farmers (2 times per year) selected from a group of 625 farmers. The total cost of these tests equals around €4,650 / year for this association.

- The rejection of batches contaminated by GM-cotton can lead to important economic losses. One company reported that rejections of contaminated batches lead to an economic loss of around 30% of the annual returns.

Cleaning:

- The cleaning cost after each lot is processed was reported to be around €0.35 / kg according to one of the interviewee. Another company reported that the cleaning cost to completely avoid GM contamination, for seed companies, appears to be very high, but no precise estimation could be provided. In fact, the share of this cost due to GM issues remains unknown since the cleaning is also necessary between varieties to keep purity and also to remove all foreign matters.

In addition, one company dealing with the ginning process in the country of origin, reported total certification cost by GOTS of around €24,000 / year which however are not specifically related to GMOs. For India it was reported that lack of official data on GM-cotton production and due to the absence of a legal framework on this issue, many farmers do not produce organic cotton in order to avoid risks of contamination.

A case study from the region of Andalusia in Spain (Messéan *et al.*, 2006), where 80.000 ha of cotton are produced, has shown that, in order to respect a GM-threshold of 0.5%, existing cleaning practices on machinery required for certified cotton seeds production would be sufficient. Model simulation and expert interviews were undertaken and according to the authors, since cotton is mainly autonomous and since cross pollination is relatively insignificant, there would therefore not be extra costs for farmers (Messéan *et al.*, 2006). One company we interviewed in the frame of this study reported that dealing with GOTS requirements for cotton in countries like Kyrgyzstan is very difficult, so that we may imagine the same potential situation for Spain and Europe in case GM cotton would be produced in this part of the world in the future.

CONCLUSIONS AND PERSPECTIVES

In a nutshell, challenges in terms of GM contamination across EU cotton supply chains are shifted to the countries of origin, i.e. where cotton is produced and in which both the ginning and certification process are affected. Economically relevant avoidance practices are mainly the rejection of contaminated batches, to the necessary cleaning before each lot is processed, and to training in producer countries. These costs can be very high, depending on the country of origin and on the share of GM crops, but no precise estimation could be provided, especially as a control group would be necessary to compare situations with and without additional cleaning associated to GM issues.

With respect to the future of GMOs, it was stressed by the interviewed companies that additional problems might occur with an increasing number of countries authorise GMO cotton production and an increasing share of GM cotton worldwide. It must be underlined however that contamination of cotton by GMOs above 0.1% was reported to be extremely rare in countries like India, where GM cotton is broadly cultivated. This remains below the mandatory labelling threshold of 0.9% fixed by the EU for food and feed products.

Most of the coexistence costs for the cotton supply chain incur in the production country and during the first stages of cotton processing (delivery and ginning). The most relevant measures to avoidance GMO contaminations are the rejection of contaminated batches and cleaning before each lot is processed.

5. CONCLUSIONS

The aim of this study was to identify coexistence strategies of non-GM and organic supply chain actors to ensure GMO-free products and estimate the involved co-existence costs, i.e. the costs of measures that different operators have to take to prevent or minimise the risk of contamination of their products with GMOs.

The assessment of the overall socio-economic impacts of GMOs on organic supply chains is very difficult: it is not always possible to quantify and allocate the specific costs linked to GMOs as some implemented strategies (e.g. segregation strategies) are developed to meet different requirements (such as organic certification, avoiding contamination by pesticides, by GMOs…).

Co-existence in breeding and seed production is considered to be unfeasible. A potential GM-contamination case is a tremendous risk to the companies as losing a line means that long-term investment in the breeding and the business to pay off the investment are lost. As official testing is perceived to be insufficient, additional testing is implemented. The situation is easier in countries with a national GMO ban.

Results from the food, feed and cotton companies interviewed tended to show that in the current European context, the costs of coexistence are not negligible but not very high either, and still manageable for the organic sector. This is easily explained by the near absence of GMOs cultivation in the European Union, which limits the risk of contamination via cultivation and cross pollination. GM crops have never been grown on any significant scale in the EU, and since 2015, 17 countries and 4 regions have decided to opt-out from GM maize cultivation. Spain is the only country where GM maize is cultivated on a relevant commercial scale, amounting to around 30% of the total Spanish maize production.

However, imported GMOs circulate on the European market, and the EU also imports commodities and products from countries where there is large-scale cultivation of GMOs. The organic and the conventional GMO-free sectors therefore have to take measures to avoid contamination. Testing and certification, cleaning process, and the careful choice and monitoring of suppliers, are the most important sources of costs across the different supply chains. In the case of maize and soya for feed, for instance, the estimated cost for testing and certification ranges for instance from 7€/t to 21€/t depending on situations. One of the most important avoidance strategy implemented is to source GMO-free commodities from well-known suppliers or safe origins and only to operate GMO-free commodities on the plant (spatial segregation).

The situation is more difficult in countries where GMOs are cultivated, and where companies are obliged to develop strategies to remain GMO-free. We found two different strategies: i) to source from specific suppliers from countries where GMOs are banned or ii) to substitute certain raw material when the risk of contamination is too high; e.g. replace maize with wheat. But strategies of product substitution are not always possible due to a) animal nutrition requirements, b) farmers' acceptance, and c) availability. In any case, it puts the GMO-free sector in a situation in which operators may lose flexibility and business options and may need to invest in new products to avoid high risk raw material.

For the different supply chains, except for cotton, the interviewees indicated potentially very high costs in a potential case of contamination by GM materials. These costs are due to the decertification of organic products, to the interruption of the business for a certain period to trace contaminated batches and make further analysis, to a loss of trust and credibility from clients and to a possible legal liability.

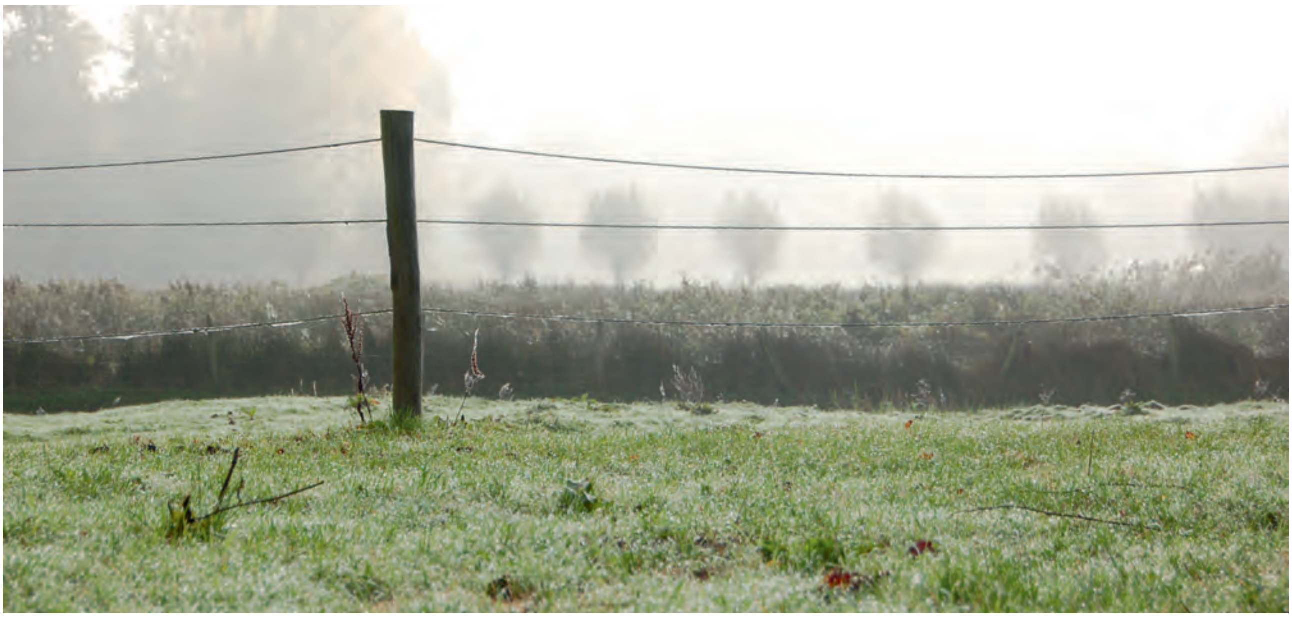
The case of cotton is quite specific since this crop is mostly autonomous, with relatively minor cross pollination, and also because producers' countries are largely located outside of Europe. Spain produces some cotton, but no GM varieties are authorized for cultivation in the EU. Thus, the problem of coexistence is shifted to non-European countries, mainly from Asia. Quite important costs for cotton, depending on cases, are linked to the rejection of contaminated batches and to the cleaning process.

Thanks to the absence of GMO cultivation in the EU, costs of coexistence are still considered manageable in most cases of the food and feed sector. Since the first authorisations of GMOs and first contamination cases, companies seem to have adapted their strategies and to have learnt from past experiences and past contamination cases across Europe. Important strategies adopted by the interviewed companies consist in producing only IP certified products, or in having totally segregated plants. These results also make it clear that banning the cultivation of GM crops is an efficient strategy and a pre-requisite to maintain coexistence costs to a manageable level. The companies interviewed fear that problems related to GMOs and coexistence costs might increase in the future if the area under GM production grows worldwide. Indeed, in the USA, coexistence costs are higher because the share of GM crops is more important requiring more sophisticated measures to ensure GMO-free products. New genetic engineering techniques are also a growing concern amongst seed companies, and organic and conventional non-GM processors: to let the GMO-free sector be able to remain GMO-free, it is crucial that these new techniques are regulated within the scope of the GMO legislation[7], and that they are subject to mandatory traceability and labelling. The availability of detection methods for new genetic engineering techniques will depend on the political willingness to address this through a research program.

The study showed, that coexistence affects the organic and conventional GMO-free sectors in terms of additional costs and in managing insecurity or the permanent prevailing risk of a contamination case respectively. As a consequence, European non-GM operators are forced to find solutions to minimise this risk by additional testing, limiting sourcing to GM-free countries and specific suppliers or by even abandoning commodities. Thus, GMO-free businesses face constraints and lose options for their business. Following the polluter-pays-principle, the costs of coexistence should be borne by the companies that place GMOs on the market, and not by the organic and GMO-free sectors.

On the other hand, as the vast majority of European consumers rejects GMOs, there is an increasing demand for GMO-free seeds, feed and food. Thus, providing GMO-free products is also a business opportunity for European seed companies, farmers and processors, who may obtain a price premium for their certified GMO-free products, which may counteract the additional operating costs.

The adoption of efficient coexistence measures by Member States should be made mandatory at European level and mechanisms to compensate all disadvantages caused by contamination should be established. This is a minimum and essential necessity. The unprecedented development of organic agriculture in the European Union[8] is a clear message from European citizens in favour of a more sustainable agriculture, without GMOs nor chemicals. The Commission and the EU Member States should thus provide the regulatory framework that allows developing competitive non-GM businesses.



[7] http://www.ifoam-eu.org/sites/default/files/ifoameu_policy_npbts_position_final_20151210.pdf

[8] We hypothesized a selling price of €250 / t for organic maize and €120/t in conventional. Operational production costs were derived from FADN data (2013). We hypothesised pesticides costs of €75 / ha in conventional.

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