Co-existence of GM and non GM crops: economic and market perspectives

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The use of the technology of genetic modification (GM) in European agriculture and the food supply chain continues to be controversial. Due to strong anti-GM technology sentiments, the use of ingredients derived from GM crops have largely been eliminated from foods manufactured for direct human consumption by the food supply chain in much of the European Union (EU) and been removed from a minority of animal feeds used in the EU's livestock production sectors[1]. A de facto moratorium on the regulatory approval of new GMOs in the EU has also operated since 1998.

As new legislation designed to meet concerns expressed about the use of GM crops approaches finalisation (eg, relating to labelling and traceability), one of the main subjects of current debate is the economic and market implications of GM and non GM crops being grown in close proximity (ie, co-existing). This paper examines these issues from an economic perspective drawing on existing evidence and market developments.

1 What is co-existence?

Co-existence as an issue relates to '*the economic consequences of adventitious presence of material from one crop in another and the principle that farmers should be able to cultivate freely the agricultural crops they choose, be it GM crops, conventional or organic crops'* (EU Commission 2003).

Adventitious presence of one crop with another can arise for a variety of reasons. These include seed impurities, cross pollination, volunteers (self sown plants derived from seed from a previous crop), from seed planting equipment and practices, harvesting and storage practices on-farm, transport, storage and processing post farmgate.

2 Co-existence and GM crops

The issue of adventitious presence of GM crops in non GM crops has only become an issue because of the development of distinct markets for non GM derived products. The initial driving force for differentiating[2] currently available crops into GM derived and non GM derived material came from consumers and interest groups who expressed a desire to avoid support for, or consumption of, GM crops and their derivatives. This has subsequently been recognised by some in the food and feed supply chains (notably some supermarket chains, many with interests in organic farming and suppliers of GMO testing services) as an opportunity to differentiate their products and services from competitors and hence derive market advantage from the supply of non GM derived products.

To fully accommodate this it is important to segregate or identify preserve (IP) either GM or non GM derived crops and to label these and derived (food) products throughout the food supply chain. Whilst this, in principle, does not require any fundamental change to trading practices that have been used to segregate and label specific types of conventional, agricultural produce, the nature of some of the specific issues surrounding the GM versus non GM debate have proved novel. In particular, those wishing to avoid GM products:

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[1] This market development has focused on GM maize and soybeans into which agronomic traits of herbicide tolerance and insect resistance have been incorporated, the main crops genetically modified and approved for importation and use in the EU

[2] Generally referred to either segregation of identity preservation

- want to avoid both products containing GMOs and products derived from GMOs even if it is not possible to detect GM material in the end product. This requires segregation/IP and labelling on a *production process* basis even though, in some cases (eg, soy oil) it is not possible to detect the presence or otherwise of DNA/protein from GM derived crops. The only comparable and existing system to this is related to organic produce;
- want (non GM) products to have no detectible presence of GM material (ie, a zero presence of GM material). This is entirely unique as there are no food products (outside those possibly produced in a laboratory) traded and consumed anywhere that are 100% pure. This practical issue is also not widely known amongst consumers. Therefore, all products traded and consumed operate to descriptions that recognise tolerances for the presence of some other material, and as indicated above, this includes trade in organic produce. For example, in organic agriculture there are tolerances for the use of some non organic ingredients in processed products (5%), non organic inputs (eg, 100% conventional seed until the end of 2003), the use of some GMO derived processing aids are permitted and the *de facto* tolerance for the presence of GMOs in organic produce is 0.1% (the limit of reliable detection)[3].

In addition, some non GM producers, especially in the organic sector, raise the issue of possible negative economic consequences on their sector from co-existence with GM crops (ie, where an organic producer finds adventitious presence of GM crops in his/her crop above a given threshold and, as a result, perceives that they will lose an organic price premia or will incur additional costs on-farm to minimise the risks of adventitious presence of GM). In such a circumstance there is a question of who should bear the loss or additional cost?

An important point to note in the debate to date about co-existence (and presented above) has been the concentration on the economic consequences of adventitious presence of GM crops in non GM crops. What this omits to recognise is the equally relevant economic consequences that may arise from adventitious presence of conventional or organic material in GM crops or adventitious presence of conventional and organic crops with other conventional or organic crops. Lastly it is also relevant to note that the issue (of co-existence) is not new as it affects many aspects of conventional agricultural production systems – these two latter points are discussed further in sections below.

3 Co-existence in conventional and organic agriculture

Almost all agricultural commodities traded recognise some degree of adventitious presence of unwanted material may be found in supplies. Tolerances are invariably set for the presence of unwanted material because of the impossibility, in any practical agricultural crop product and food processing/handling chain, of ensuring absolute purity of products. Examples include:

- a specified grain variety may contain up to a threshold level of other grains (eg, maltsters quality requirements for malting barley include a maximum admixture of 2% of other seeds and varieties). This threshold recognises that adventitious presence may arise during harvest, transport and storage on-farm and further down the supply chain;
- certified seed production systems that recognise different standards of seed according to various purity levels. These operate to tolerance levels for the presence of non pure seed and are based on specified seed separation distances and time intervals between the

[3] The Commission's March 2003 Communication on co-existence of GM, conventional and organic crops acknowledges that the EU regulation on organic farming (Reg 2092/91) allows for the setting of such a threshold for the adventitious presence of GMOs in organic produce although to date no level has been set

seed crop and any other crop of the same species grown on a plot, backed up by seed inspection and testing agencies. Failure to meet the purity standards results in seed not being certified and the relevant seed premium being lost to the grower (ie, the crop has to be sold as a non seed crop). Compliance with these standards shows that in more than 96% of cases the procedures adopted (isolation, cleaning, rotations, and separation of harvest) are sufficient to meet the stringent purity standards[4];

- production of specific types or varieties of crops that deliver 'quality traits'. For example, high erucic acid oilseed rape (HEAR) varieties which have desirable properties for industrial oils. However, the erucic acid is what is known as an anti nutritional factor in animal feed and therefore it is important that HEAR does not mix with other oilseed rape being grown for uses in human food and animal feed. HEAR tends to be grown on contract to processors with contracts recognising that there may be adventitious presence of non erucic oilseed rape in deliveries via the establishment of specific tolerances for the presence of non erucic oilseed rape material. The contracts also usually require that only certified seed is used, seed drills have been cleaned prior to use, separation distances of between 100 metres (UK, Germany) and 400 metres (France) are maintained from other oilseed rape crops, all cultivation and harvesting equipment are cleaned before use and post harvest segregation is maintained to minimise admixtures. Prevention of cross contamination is promoted by contract testing and the use of penalties (including rejection of crops) if the set parameters for the oilseed fatty acid content are not met. The threshold for admixture of HEAR in other (double zero) oilseed rape is 2%[5]. Evidence from Germany[6] suggests that a 100 metre separation distance tends to deliver more than 95% of double zero seed lots with a erucic acid level of below 0.2% and only a few seed lots contain more than 0.5%. Adherence to the contractual requirements and in particular the separation distances, comes (where applicable) by voluntary arrangements between adjacent farmers, although in many instances there is no need to involve other farmers, as separation distances can be adequately dealt with on-farm.

In addition, tolerances play an important role in organic production systems. There are tolerances for the presence of non–organic material allowed in some processed foods[7] derived from and labelled as being made from organic ingredients and tolerances or allowances relating to the presence of non organic material used as agricultural inputs (eg, in animal feed and seed). Also, the current right to market and label produce as organic in the UK (and certified by an independent accredited body as organic) is fundamentally based on the adherence to organic production and husbandry principles rather than on any testing regime of produce (eg, to identify if produce contain x% of unwanted material such as pesticide residues).

It is also important to note that the burden of any additional costs incurred in meeting tolerances for the adventitious presence of unwanted material have, to date, invariably fallen on the product or sector that seeks to gain a market or economic advantage from the crop subject to 'integrity preservation' (eg, specialist, quality trait oilseed, organic produce).

4 GM crop co-existence and economic consequences

The economic implications of co-existence for GM and non GM crops have two main elements:

[4] JRC 2002
[5] To breach the 2% threshold for erucic acid in the oil would require a 4% cross pollination of seed
[6] JRC 2002
[7] Including possibly products of GM technology like processing aids

- the costs involved in meeting tolerances for the adventitious presence of unwanted material (eg, by having to change farming practices, initiating on-farm segregation of crops) and/or;
- the economic consequences of not meeting tolerances (eg, possible loss of non GM or organic price premia).

a) Costs involved in meeting tolerance thresholds

In general, the tighter (lower) the tolerance, the higher the cost involved in meeting that tolerance (and vice versa)[8]. Within the GM market context this principle is clearly evident in respect of the current EU non GM market premia for soybeans and soymeal, where the average premium for non GM soybeans and meal (to a tolerance of 1% presence of GM material) in 2002-03, has been 2% to 5%, whilst the average non GM premium to a tolerance of 0.1%, has been 7% to 10%.

However, the example cited above in respect of the soybean and derivative markets essentially relates to a market for imported products rather than GM versus non GM crops grown in the EU. Due largely to the moratorium, the area planted to GM in Europe is limited. Commercial plantings of insect resistant maize can be found in Spain (about 20-25,000 hectares in 2002) in close proximity to non GM maize plantings, otherwise GM crop plantings are largely limited to field trials and farm scale evaluations (eg, in the UK). This means that the body of evidence relating to possible co-existence costs is limited. Nevertheless, there are a number of important points that can be derived from the evidence to date.

i) Commercial growing of GM crops in Spain

In Spain, the issue of adventitious presence of GM maize in supplies of non GM maize has essentially not been important (see also b) below). Where GM maize has been grown this has tended to be sold off farm, mixed with non GM maize to customers in the animal feed sector, without any requirement to segregate the GM from the non GM maize. Where, in a minority of cases, there are users which require the use of non GM maize, these users have sourced their maize from regions of Spain (and imports) where GM crops are not currently planted. Overall, the net cost of meeting any tolerance thresholds for the presence of GM maize in non GM maize in the GM maize growing regions of Spain has been negligible[9].

ii) Co-existence research

A study undertaken for the EU Commission's Joint Research Centre (JRC) in 2002 on co-existence is probably the most detailed piece of research on the subject in the EU to date. The main points drawn from the work include:

- Estimates for possible levels of adventitious presence of GM crops in non GM crops (based on computer modelling and expert opinion), are likely to vary significantly depending on the crop and farm type (eg, as much as 2.2% for a conventional intensive maize producer to as low as 0.1% for an organic potato farm). In general the analysis expects lower levels of adventitious presence of GM crops on organic farms because segregation systems are already in place[10];

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[8] This has general applicability and is not GMO-specific

[9] Any examination of the costs involved in meeting tolerances associated with the adventitious presence of GM material in non GM crops should also bear in mind the benefits that the GM farmers may be deriving from growing GM crops (ie the primary reasons for adoption). In the case of bt maize these include, for most farmers, higher yields, lower costs of crop protection, greater convenience and reduced production risk

[10] The notable exception to this was winter oilseed rape for seed production, where organic farms are perceived to probably face higher levels of adventitious presence because of problems of controlling volunteers with organic practices

- the scope for changing farming practices to reduce levels of adventitious presence and the associated costs of such actions are directly related to the tolerance thresholds applied – the study concluded that the a 0.1% tolerance would be difficult to meet for any of the farm and crop combinations examined (winter oilseed rape for seed, maize and potatoes) but that all farm types would be able to meet thresholds of 1% for maize and potatoes and 0.3% for winter oilseed rape for seed provided some change to current farming practices were made. Some farms would probably not have to change practices (notably potato farms and some maize producers, like organic) whilst other would have to initiate changes. Also some changes (eg, relating to changing flowering times for maize) might also require co-operation with adjacent farms;
- Estimates of additional costs associated with meeting the thresholds examined[11] were; for meeting a 0.3% threshold for the presence of GM material in non GM oilseed rape crops used for seed, €126/hectare for conventional oilseed rape and €232/hectare for organic oilseed rape, for meeting a 1% threshold for the presence of GM material in non GM maize crops, €55.3/hectare for conventional maize and €92/hectare for organic maize; and for potatoes, the total cost of meeting a 1% threshold for the presence of GM material in non GM potato crops were estimated to be between €107/hectare for conventional earlies and €274/hectare for organic early potatoes.

These estimates relating to the possible costs of changes in farming practices to meet these thresholds should however, be treated with caution (acknowledged by the authors of the JRC report) as they are highly dependent on the assumptions used, especially relating to the tolerances applied. Also, the costs are probably overstated - in particular, relating to monitoring costs (which account for an important part of total costs). If a monitoring system was established and run by a third party independent body (as occurs for most quality assurance schemes), the likely additional monitoring costs would probably be substantially lower than the values quoted. Also, where the possible requirements for changes to farming practices include implementing more robust segregation and traceability of produce, there may be an element of double counting to take into consideration. In recent years there has been a general trend towards farmers being members of independently accredited quality assurance schemes (see below). In such schemes farmers are required to comply with standards and information requirements relating to storage, segregation, husbandry and traceability and hence many may already have incurred most of these costs simply to meet general market requirements, regardless of whether crops are derived from GMOs or not.

A more recent study conducted in Denmark[12] also concluded that for several crops, co-existence based on the proposed thresholds for adventitious presence of GMOs in end products (0.9%) was perceived to be possible. However, considerable differences were identified between crops in the extra costs that might be necessary to take in order to adhere to the various thresholds examined. Little additional change to existing practices was perceived to be required for most of the arable crops with the exception of oilseed rape. The study also suggested that current farming practices play a significant part in influencing the level of additional costs that might be expected. Here organic and specialist farms, like seed producers, already operate to rules that are similar to those suggested (in the report) for meeting the thresholds examined for adventitious presence of GM material.

[11] This included costs associated with implementing on-farm segregation, a new monitoring, testing and checking system and taking out insurance to cover short term losses (from possibly having crops downgraded from non GM status)

[12] Working Group on co-existence of GM crops with conventional and organic crops (2003)

In relation to separation distances that may be required to minimise the scope for adventitious presence of GM crops in non GM crops via cross pollination[13], work in the UK (Ingram 2000) has estimated the separation distances required to meet various tolerance levels for sugar beet, maize and oilseed rape. These are shown in Table 1.

Table 1: Recommended separation distances to ensure cross pollination is below specified limits in non seed crops of sugar beet, maize and oilseed rape

	Threshold levels of cross-pollination		
	1%	0.5%	0.1%
Oilseed rape (B. napus and rapa)	1.5 metres	10 metres	100 metres
Maize grain	200 metres	300 metres	Insufficient information to make a recommendation
Maize silage	130 metres	200 metres	420 metres
Sugar beet	0	0	0

Source: Ingram 2000

These separation distances show that:

- For oilseed rape, the recommended separation distance required to meet 1% threshold (close to the likely 0.9% that may be set in the EU labelling and traceability regulations) is 1.5 metres, although for varietal associations and partially restored hybrids, the recommended separation distance is 100 metres. For meeting a 0.1% threshold the recommended separation distance is 100 metres;
- For grain maize, the recommended separation distances are 200 metres (1% threshold) rising to 300 metres (0.5% threshold);
- For silage maize, the recommended separation distances are 130 metres (1% threshold) rising to 420 metres (0.1% threshold);
- For sugar beet there are no recommended separation distances, as the crop is usually harvested before flowering. The only caveat to this is in relation to bolters, which can occur at a rate of 1% - here it is good agricultural practice to remove them and such action is recommended.

Lastly in relation to oilseed rape, the crop often cited as 'the problem crop from a co-existence perspective', there is useful evidence to drawn on from Australia. In Australia, studies have been conducted in recent years into pollen movement, oilseed rape volunteers and gene transfer from herbicide tolerant crops that have been planted for several years[14]. Key findings from such work include:

- Pollen flow measured from non GM herbicide tolerant oilseed rape was reported to move up to 2.6 kms. Despite this presence, the highest frequency of cross pollination measured within this radius was a sample of 0.225%, with 69% of samples tested showed no out crossing at all and only five samples having herbicide tolerant seedlings of more than 0.1% presence (Rieger et al 2002). Based on these levels of adventitious presence the

[13] It should be noted that separation distances are not the only method available for limiting cross pollination (eg, use of barriers, different timing of planting and flowering)

[14] Herbicide tolerance derived from conventional, not GM technology

authors concluded that pollination between commercial fields occurs only at very low levels;

- Herbicide tolerant oilseed rape volunteers are not a significant problem and where they have occurred, farmers have had a variety of herbicides available for use to control them (Nikman et al 2002);
- Whilst there is a possibility of transfer of genes between different cultivated brassica species, the potential for hybridisation in the field, introgression of a herbicide tolerant trait and then stable expression in the progeny of weeds is considered a very low and manageable risk (Green & Salisbury 1998).

What is interesting to note about the Australian research is how this has evidently impacted on the guidelines set for the forthcoming commercial launch of GM oilseed rape in Australia. Recommended management plans developed by Monsanto and Bayer CropScience for using herbicide tolerant oilseed rape propose that farmers should keep a five metre buffer zone from adjacent non GM crops to minimise the possibilities of cross pollination. This level of buffer zone has subsequently been endorsed by the Australian Gene Technology Grains Committee (after having conducted a comprehensive review of international research into pollen flow) as sufficient for allowing GM and non GM oilseed rape production systems to co-exist without causing problems of adventitious presence of GM material in non GM seed (GTGC 2002).

iii) GM crop trials

In the UK, where Farm Scale Evaluations of GM crops have been conducted, co-existence cost issues can be examined from two perspectives; costs incurred by farmers to comply with conditions for growing GM crops and costs incurred by farmers growing non GM crops near to GM FSEs:

- All farmers participating in the FSEs are required to comply with the Supply Chain Initiative on Modified Agricultural Crops (SCIMAC). These guidelines specify practices to adopt for crop management and harvesting, storage and planting of seed, neighbour notification, monitoring and record keeping and separation distances to be adopted when growing GM (herbicide tolerant) crops. In terms of the costs involved in complying with the SCIMAC guidelines, most of the requirements represent the application of good agricultural practices and/or are the type of activities that many farmers in quality assurance schemes already undertake. As such, it was not surprising that 60% of the growers in the FSEs have indicated that the SCIMAC audit procedures are in line with those in other farm assurance schemes[15]. The only 'new' cost involved in growing the GM crop has been the compliance audit requirements set by the UK government. The current audit charges for the FSEs are £800/site (charged by the Central Science Laboratory) although these costs are currently covered by the biotechnology companies participating in the FSEs and are not incurred by the farmers. This level of charge therefore represents a benchmark cost that might be incurred in future, by farmers growing GM crops commercially, although if this independent auditing activity were to be opened to wider competition, the level of audit fees paid might reasonably be expected to fall to levels in line with membership of quality assurance schemes (eg, £0.44/ha to £1.4/ha for farmers in the UK's Assured Combinable Crops Scheme that covers nearly 60% of the UK's cereal crop);
- The focus of attention relating to possible co-existence costs incurred by non GM producers located near to the FSEs in the UK has related to organic farming. Here organic accreditation bodies such as the Soil Association recommend that, to minimise

[15] Piersall 2003

the chances of mixing of GM and organic seed and pollen dispersal, that separation distances should be up to six kilometres depending on wind direction, time of flowering and local topography. The 6 km separation distance is, however, a 'warning limit' with risk of adventitious presence being determined by a risk matrix. Within this matrix the Soil Association has specified separation distances in the range of 3,000 metres to 6,000 metres (oilseed rape including seed 6,000 metres, sugar beet 3,000 metres for organic seed production and 1,000 metres for 'no weed beet' (ie, bolters), maize including seed 3,000 metres, potatoes 500 metres and wheat 500 metres. This means that in most cases where organic production has been found within 6 kms of a FSE site (the Soil Association's web-site states there have been 88), the majority have not been classified at risk because they were less than these separation distances and/or were crops different to the GM crop trials. The author is not aware of any of these 88 sites having had to take actions (eg, changes to farming practices) to minimise the chances of adventitious presence of GM material occurring in organic crops or of any such organic crops having lost their organic accreditation.

b) The economic consequences of exceeding GMO thresholds for adventitious presence

i) Non GM producers in general

The incentive for any non GM producing farmer (including those growing part GM and non GM crops) to implement measures to minimise adventitious presence of GM material in non GM crops will be directly influenced by the relative costs involved compared to the consequences (eg, possible loss of non GM price premia, inability to sell the non GM crop in a given market).

Where the consequence of not minimising adventitious presence is significant (eg, a significant non GM price premia, inability to sell produce to a buyer that insists on a very tight tolerance as a condition of supply), then it is likely that farmers will be prepared to change farming practices and incur the associated costs. However, where the non GM price premia is low (eg, 1%-3%) and it is reasonably easy to sell produce that may have to be labelled as derived from GMOs (even if the crop is effectively non GM but may have GM presence in it at levels at/near the threshold for labelling), it is probable that most farmers will not feel it necessary to incur costs of monitoring or changing farming practices. This can be clearly seen in the example of Spanish farmers growing GM maize – here the economic consequences of allowing GM and non GM maize to mix are negligible because GM maize trades at the same price as non GM maize in the GM maize growing regions. As a result, there is no incentive (or requirement) for GM maize growing farmers to keep GM and non GM maize separate.

This same principle applies to the decision to take out insurance against possible market losses (assuming that it is possible to take out such insurance cover), as it is unlikely that conventional producers would feel it necessary to take out insurance cover where the economic/market consequences are low. If however, the market consequences are high (eg, there is a large price differential in favour of non GM supplies) then producers are more likely to take out insurance costs.

ii) The organic sector

In relation to organic farming there are a number of points of relevance that affect the economic consequences. These are:

- *Organic certification is currently based on adherence to principles* such as not using pesticides or GMOs - organic status is not determined by testing of produce to see if standards have been met. This means that organic produce are not routinely subject to testing for the adventitious presence of 'non organic' material like pesticide residues although in a small number of cases, some market operators do occasionally test organic produce for adventitious presence of pesticide residues. Thus organic farmers are judged according to their adherence to the principles and standards, not by systematic testing of produce against threshold levels for adventitious contamination. It is therefore possible that if the same approach is applied in a post GM approved scenario, very few organic farmers would be subject to penalties associated with adventitious presence of GMOs (above the limits of reliable detection: 0.1%), as only a few market operators might initiate tests and reject/downgrade delivery failures, with the majority of organic produce being judged on their adherence to the organic principles. It is clearly difficult to assess whether this practice would apply in a future scenario where GMO crops could be more widely grown commercially although if a principle-based approach is applied to pesticide residues and a testing based approach is applied to GMOs, this might be perceived by consumers to be inconsistent and therefore could damage the overall integrity of the organic label;

- *the context of organic farming* in the sectors where GM technology is being developed and may be commercialsed in the next few years. Although the sector has experienced rapid expansion, it remains a small part of EU arable crop agriculture. For example, the current areas of organic wheat, oilseed rape and sugar beet in the UK account for 0.5%, 0.06% and 0.34% respectively of the total UK areas planted to these crops. Even if it was assumed that there was a substantial increase in the UK organic area planted to these crops in the next 5-10 years, the sector would remain small relative to total arable crop production[16]. The number of (organic) farmers possibly affected would therefore be small relative to the total number of farmers in the UK. Many would not be producing crops for which GM alternatives are available (the primary reason why the majority of organic farms found to be within 6 kms of the FSEs were not classified as being 'at risk' by the Soil Association). Also the area classified as being, 'at possible risk', would probably be very low. For example the category of crop identified as having the greatest possible risk of adventitious presence identified in the JRC study is winter oilseed rape <u>seed</u> production. Based on estimated[17] 2002 plantings of oilseed rape in the UK (200-250 hectares), the area of seed required to service this is only 0.5 hectares, which could be supplied by one specialist grower (ie, one field of crop required). It would therefore not be difficult to site such a specialist enterprise in a region where there is limited planting of commercial varieties (eg, Wales) and hence minimise the possibility of adventitious presence of GMOs occurring. This siting of specialist seed enterprises in remote areas, to deliver crop isolation and maximise seed purity is not new – it is already applied in conventional seed production, most notably in the potato sector;
- At present, the EU Regulation on organic farming does not stipulate any formal tolerance for the adventitious presence of GMOs - it has become *de facto* 0.1%, the limit of reliable testing. However, it is by no means clear that this level of tolerance will be maintained once GM crops are more widely available for commercial planting in the EU. As indicated above, this level of tolerance is extremely low and carries with it the highest level of compliance costs. This means that the organic sector has, to date, effectively set itself the toughest 'gold plated' standards to adhere to, which may prove to be more

[16] It is unlikely that the organic area of arable crops like oilseed rape, sugar beet and cereals will expand substantially. Crops like oilseed rape tend to be of limited interest to organic farmers because of the crop's high nitrogen requirement relative to other break crops and the market for organic oilseed rape is very small (those demanding organic oils prefer alternatives such as sunflower). For crops like sugar beet and cereals, which are largely processed before consumption, the EU sector is faced with competition from imported sources of (raw material) supply which are often more competitively priced (eg, underlying competitive advantages of producing organic sugar cane relative to organic sugar beet, or organic wheat produced in countries like Argentina relative to the EU).
[17] Source: Soil Association

costly and difficult to achieve than less stringent tolerances[18]. *The question here is how important is a 0.1% tolerance for the presence of GMOs to the organic sector and how consistent is this level of tolerance with other tolerances adhered to in the organic sector?* Examination of current organic farming principles and regulations shows that this level of tolerance (0.1%) is inconsistent with others operated to in the sector and it clear that market factors play an important role in setting pragmatic tolerances and standards that balance principles with economic factors. For example organic standards allow tolerances/levels of up to 5% for the presence of non organic ingredients in some processed foods, some non organic inputs (eg, non organic seed until the end of 2003 and up to 10% of animal feed ingredients) are permitted and some products that maybe derived from GMOs/GMO processing aids can also be used. These tolerances and derogations essentially reflect limited availability of some organic products and/or prohibitively high costs of obtaining/using only organic ingredients. In effect, market factors have influenced the setting of tolerances and/or derogations from the full organic principles and these do not appear to have adversely affected consumer confidence in the integrity of organic produce. Given this, the organic sector may be making life unnecessarily difficult for itself (and others) if it maintains its position of operating to a 0.1% tolerance for the adventitious presence of GMOs. Moving to a less stringent tolerance would be more practical, cost effective and would be unlikely to compromise the integrity of the product to consumers.

Overall, these points suggest that the economic consequences for organic farming of the wider planting of GM crops in the EU will be limited, especially if the sector adopts tolerances and practices for GMO adventitious presence that are consistent with other organic tolerances and principles.

5 Co-existence and liability

In the discussion above, examples have been presented about the possible costs of adhering to specific tolerances for the adventitious presence of GMOs in non GM crops, without considering the issue of who should pay such costs (if any are incurred). In relation to this issue, the following points should be taken into consideration:

- Regulations, laws, guidelines and standards, which originate from government or industry can also affect the costs involved. These usually set baselines for acceptable behaviour and practice (from the government perspective these are usually founded on health and safety issues but also extend to issues such as competition, equity and reasonableness (of behaviour)). Complying with such regulations imposes costs on producers and failure to comply with them may result in possible legal action (criminal or civil) or market losses;
- All imposition of regulation reflects a need to balance reasonable protection (eg, of human health and safety, the environment) with reasonable cost burden;
- In the context of GM crops, the establishment of any regulatory based compliance requirements (eg, relating to farming practices) on farmers considering growing GM crops will be taken into consideration when weighing up the perceived benefits (eg, from possible yield gains, reduced costs of production) against the costs (eg, seed premium, compliance costs). Consequently, the higher the compliance costs, the lower the incentive to adopt and vice versa. As such, this principle is not unique to GM technology and applies equally to other forms of agriculture (eg, farmers considering switching to

[18] This does not necessarily imply that the cost will be very high or that meeting a 0.1% is not possible. The research conducted to date suggests that the costs and degrees of difficulty vary by crop

organic production systems will weigh up the costs of conversion (eg, impact on yields, costs of production, compliance with organic standards/principles) relative to the benefits of possible higher price premia;

- In most markets for agricultural produce, the burden of costs associated with maintaining the integrity of a product or 'preserving its identity' falls on the sector that produces that product and which is seeking to benefit from its production. For example, producers of quality assured or regional produce, organic produce, quality trait crops (eg, HEAR, high oil maize, malting barley). In all these cases, the respective products trade at a premium to the majority of produce traded and this premia provides the incentive to initiate actions to preserve integrity and identity;
- If regulation of GM crops included provision for imposing liability on GM crop growers for possible impact on non GM growers (eg, adventitious presence of GMOs above a given threshold leading to loss of a non GM price premia), this would probably be setting a new precedent in EU agriculture. Any such precedent would, however, on equity grounds also have to apply to all farmers, including non GM and organic crop producers, whose activities might have an adverse impact on GM crop producers. For example, the hypothetical scenario of a farmer growing a crop with a GM quality trait that loses its (quality trait) price premia because of adventitious presence of non GM material above an agreed threshold.

6 Concluding comments

As EU legislation designed to meet consumer concerns about the use of GM crops approaches finalisation, one of the final points of controversy surrounds the issue of co-existence of GM and non GM crops. Opponents of GM technology in the EU portray a future of difficulties in which non GM, and especially organic farmers, may suffer significant economic and market disadvantage if GM crops become more widely grown in the EU. This paper has sought to contribute to this debate by examining the economic and market evidence to date. Overall, the findings suggest that GM crop planting will have a fairly limited economic impact on non GM and organic farming - the difficulties portrayed for organic and non GM farmers by many in the anti GM lobby are probably substantially over stated.

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