Co-existence of GM and non GM arable crops: case study of the UK[1]

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Executive summary

This paper examines the issue of co-existence of GM and non GM crops, with specific applicability to the main arable crops grown in the UK.

Current co-existence

Although no GM crops are currently grown commercially in the UK, there have been 260 Farm Scale Evaluation field trials (FSEs) covering about 1,220 hectares (an annual average of 406 hectares) of oilseed rape, sugar beet and forage maize, over the last three years. This compares with the total area planted to the three crops of 693,000 hectares, of which 99.76% (691,350 hectares) is 'conventionally produced' and 0.24% (1,650 hectares) are organic.

The evidence to date shows that no conventional or organic crop located near to one or more of the FSEs have experienced any economic loss as a result of their proximity to FSEs[2].

Future co-existence

For the future, the likelihood of economic and commercial problems of co-existence arising remains very limited, even if there is a significant development of commercial GM crops and increased planting of organic crops because:

- the GM traits being commercialised in the next few years are in crops for which there is limited demand for non GM products (with the possible exception of sugar beet);
- the organic areas of the three crops (oilseed rape, sugar beet and forage maize) are extremely small (only 0.24% of the area planted to these crops in the UK);
- The organic area of these crops (and other combinable crops) is likely to continue to be a very small part of the total arable crop areas (even if there was a tenfold increase in plantings), with a very limited economic contribution relative to the rest of the UK arable crops. The likelihood of these (organic) areas expanding is limited due to a combination of adverse agronomic factors (eg, the nutrient demanding nature of crops like oilseed rape), limited demand, and market preference for competing (imported) produce (eg, cane sugar);
- The possibility of gene transfer to related wild and other crop species from any of the GM crops is extremely low[3]- this is also an issue examined before regulatory approval is given;
- UK arable farmers have been successfully growing specialist crops (eg, seed production, high erucic acid oilseed rape) for many years, near to other crops of the same species, without compromising the high purity levels required;
- some changes to farming practices on some farms may be required once GM crops are commercialised. <u>This will however, only apply where GM crops are located near non GM or organic crops for which the non GM status of the crop is important</u> (eg, where buyers do not wish to label products as being GM or derived from GM according EU labelling regulations). These changes are likely to focus on the use of separation distances and buffer crops (of non GM crops) between the GM crops and the nearby non GM/organic crop and the application of good husbandry (weed control) practices. GM crop planting farmers in the FSEs have already adopted these practices as part of applying the SCIMAC guidelines. Few GM planting farmers are however, likely to find

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[2] The organic sector had classified 277 organic farms 'at risk' from being near to the FSE field trials

[3] For example, the FSEs found no evidence for the transfer of the herbicide tolerance gene from GM oilseed rape to common wild relatives

themselves located near to non GM/organic crops for which the non GM status is of marketing importance. Hence, the need to apply all of these guidelines rigorously may not be necessary. For example, if a farmer planted GM forage maize next to a non GM forage maize crop and the non GM forage maize was fed to dairy cows whose milk produce was sold into markets where the buyers were not differentiating their milk sold according to the GM or non GM status of the feeding regimes used.

The different certification bodies in the UK organic sector can also take action to facilitate co-existence by:

- applying a more consistent, practical, proportionate and cost effective policy towards GMOs (ie, adopt the same policy as it applies to the adventitious presence of other non organic material). This would allow it to better exploit market opportunities and to minimise the risks of publicity about inconsistent organic definitions and derogations for the use of non organic ingredients and inputs damaging consumer confidence in <u>all</u> organic produce. This latter point is important given that the organic crops perceived to be affected by the commercialisation of GM traits in the next few years account for only 0.22% of the total organic farmed area in the UK; or
- applying the same testing principles and thresholds currently applied to GMOs to impurities (eg, introduce a *de minimis* threshold on pesticide residues and apply a 0.1% threshold on the limit for acceptance of all unwanted materials and impurities); and
- accepting that if they wish to retain policies towards GMOs that advocate farming practices that go beyond those recommended for GMO crop stewardship (eg, buffer crops and separation distances that are more stringent than those considered to be reasonable to meet the EU labelling and traceability regulations), then the onus for implementation of such measures (and associated cost) should fall on the organic certification bodies and their members in the same way as current organic farmers incur costs associated with adhering to organic principles and are rewarded through the receipt of organic price premia.

Lastly, it is important to emphasise the issues of context and proportionality. If highly onerous GM crop stewardship conditions are applied to all farms[4] that might wish to grow GM crops, even though the vast majority of such crops would not be located near to organic-equivalent crops or conventional crops for which the non GM status is important, this would be disproportionate and inequitable. In effect, conventional farmers, who account for 99.76% of the current, relevant UK arable crop farming area could be discouraged from adopting a new technology, that is likely to deliver farm level benefits (yield gains, cost savings) and provide wider environmental gains (reduced pesticide use, switches to more environmentally benign herbicides, reduced levels of greenhouse gas emissions: see appendix 1).

[4] For example the setting of substantial separation distances between GM crops and any conventionally grown equivalent

1 Introduction

Although EU level approval for the planting of the first GM crops (insect resistant (Bt) maize) was given in 1998, no commercial GM crops have yet been planted in the UK[5]. Since 1998, a de facto moratorium on the regulatory approval of new GMOs in the EU has operated, effectively stopping the development and commercialisation of GM crop traits that might be adopted by UK farmers. Nevertheless, a number of trials of GM crops have been undertaken in the UK. Most notably, over the last three years, there has been a series of (260) farm scale evaluations (FSEs) covering 1,221 hectares (an average of about 406 hectares/year) organised by the UK government. In addition, during this period, the UK has been annually importing about 1.3 million tonnes of GM soybeans/soymeal and maize derivatives from Argentina and the USA[6] containing GM events that are approved for importation and use in the EU.

Given the concerns of some consumers about the use of GM technology, the EU has agreed new legislation designed to pave the way for the lifting of the moratorium and providing consumers with the option to accept or reject GM derived crop products. The agreed labelling and traceability legislation provides for comprehensive auditing and testing from the farm to the final consumer. It is, however more onerous than EU legislation applied to other forms of agricultural production.

A key subject of current debate remains the economic and market implications of GM and non GM crops (including organic) being grown in close proximity (ie, co-existing).

This paper examines these issues from an economic perspective, with specific applicability to the main arable crops grown in the UK.

2 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). The issue is, therefore, not about product/crop safety (the GM crop having obtained full regulatory approval) but about the economic impact of the production and marketing of crops which are considered safe for the consumer and the environment.

Adventitious presence of GM crops in non GM crops becomes an issue where the consumer demands crop-based products that are non GM derived, including organic. The initial driving force for differentiating[7] currently available crops into GM derived and non GM derived material has came from consumers and interest groups who expressed a desire to avoid support for, or consumption of, GM crops and their derivatives, based on perceived uncertainties about GM crop impact on human health and the environment. 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

[5] The GM trait first approved in the EU (Bt maize) is of little relevance to the UK agricultural sector. Maize is a minor crop and the target of the trait (the corn borer pest) is not a problem in the UK

[6] In 2002, the UK imported about 0.26 million tonnes and 0.2 million tonnes respectively of soybeans and soymeal from the USA and Argentina and about 0.86 million tonnes of maize gluten from the USA

[7] Generally referred to either segregation of identity preservation

derived products. In addition, some food companies have withdrawn from using GM derived ingredients so as to minimise possible adverse impact on demand for their branded food products that might have otherwise arisen, after having been targeted by anti GM pressure groups.

To fully accommodate this perceived demand for product differentiation, 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 absolute purity of the segregated product is striven for, it is a fact of any practical agricultural production system that accidental impurities can rarely be totally avoided (ie, it is virtually impossible to ensure absolute purity).

Adventitious presence of one crop with another crop or unwanted material can arise for a variety of reasons. These include, for example, 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. Recognising this, almost all traded agricultural commodities accept some degree of adventitious presence of unwanted material may be found in supplies and hence have thresholds set for the presence of unwanted material. For example, in most cereals, the maximum threshold for the presence of unwanted material (eg, plant material, weeds, dirt, stones, seeds of other crop species) commonly used is 2%, although in durum wheat, the presence of non durum wheat material is permitted up to a 5% threshold.

3 How do current crops co-exist?

This section examines the extent to which existing crops grown to service different markets in the UK currently co-exist. It focuses on the main arable crops of relevance to the UK, for which GM traits may be commercialised in the next few years.

3.1 GM crop trials (the FSEs)

Are there any co-existence conditions or recommendations for farmers in the FSEs?
All of the FSEs comply with the Supply Chain Initiative on Modified Agricultural Crops (SCIMAC) guidelines. These 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. The SCIMAC separation distances (Table 1) are based on current seed production legislation, established practice (eg, for high erucic oilseed rape: see below), knowledge of pollen distribution and cross-pollination, practical experience of growing certified seed crops to high levels of genetic purity (see below) and 'best' available current scientific knowledge. They were set using a precautionary approach and with the intention that review would take place in the subsequent light of experience.

Table 1: SCIMAC separation distance for same species

Crop type	Non-GM crops	Certified seed crops	Registered organic crops
Oilseed rape	50 metres (100 metres for varietal associations and partially restored hybrids)	200 metres	200 metres
Sugar beet	6 metres	600 metres	600 metres
Forage maize	200 metres sweet corn	200 metres	200 metres

	80 metres forage maize		

Notes:

1. The non GM crops are effectively working to a threshold of 1%, whilst certified seed and organic crops operate to tighter thresholds (eg, no detectible residue for organics which is in effect 0.1%)
2. The 600 metre separation distance for sugar beet grown for seed is of no practical relevance to the UK because sugar beet seed used by UK sugar beet growers is not multiplied in the UK. This means that the sugar beet crops grown in the UK do not flower (being harvested after one season in the ground whereas flowering would not occur until the second year, if the crop was left in the ground). Hence, commercially grown sugar beet crops do not produce pollen. The only exception to this relates to weed beet derived from bolters (see sections 3.2 and 4.3)

Relevance of condition/recommendations
The approach taken by SCIMAC was formally endorsed by the UK government in May 1999 and independent enquiries by the Nuffield Council on Bioethics and Agriculture Committees in both Houses of Parliament, have expressed support for the SCIMAC approach. The independent Scientific Steering Committee for the FSE programme also praised SCIMAC and the farmers who participated in the trials for successfully managing over 260 sites of GM crops (1,221 hectares) with **no loss of organic or non-GM status** on neighbouring farms throughout the trials process.

Evidence from a survey of farmers in the FSEs and from the independent audit of grower compliance also found that the vast majority of farmers participating in the FSEs considered the guidelines to be very/fairly straightforward. The compliance audit (of eight critical points) also found very high levels of compliance (Pearsall 2003). As a result, 'the guidelines have been successfully applied, demonstrating they are workable in practice, robust in safeguarding the integrity of GM and neighbouring non-GM crops and capable of being audited' (NFU 2003).

3.2 Certified seed production

Are there any co-existence conditions or recommendations for farmers planting crops for seed?
A significant proportion of all seed used by commercial arable farmers in the UK[8] is certified seed (grown by specialist contract producers for seed companies) purchased from seed suppliers each year.

Against this background, certified seed production systems for all crops recognise different standards of seed according to various purity levels. These operate to threshold levels for the presence of non pure seed. They are based on specified seed separation distances and time intervals between the 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).

In relation to seed production for the main crops for which GM traits may be commercialised in the UK over the next few years, the key factors considered to affect purity levels are:

- *oilseed rape:* Cross pollination and volunteers are the main factors affecting purity. To ensure purity standards are regularly met, the minimum separation distance for seed crops is 100 metres, although for hybrid oilseed rape this is increased to 300 metres. To minimise the chances of volunteers compromising seed purity, no oilseed rape crop should precede a seed crop (of oilseed rape) for five years;

[8] This varies by crop, for example virtually all maize and sugar beet seed used is certified seed, whilst for crops such as oilseed rape and cereals, a proportion is farm-saved seed

- *sugar beet*: weed beet derived from bolters are the main problems for purity of seed (see section 4.3);
- *maize*. Cross pollination from adjacent (non seed) maize crops is the main factor affecting purity. As such a separation distance of 200 metres is typically applied to ensure maintenance of purity standards. Growers also use buffer rows, with one row considered to be approximately equal to 10 metres of non crop separation.

Relevance of condition/recommendations
As seed production systems have been established for many years, the conditions applied (eg, separation distances) generally deliver seed to the purity standards required. The conditions applied to certified seed production systems are based on practical field experience and take due account of year to year variations in prevailing weather conditions and the activities of bees and other pollinating insects. For example, in respect of oilseed rape seed production, there were 1,724 hectares of seed production in 2003. This production base has been found mostly in Lincolnshire, Norfolk and Essex, all regions where commercial oilseed rape is widely grown, without purity problems occurring (eg, from cross pollination). The separation distances applied and purity levels are:

- basic seed: 99.9% purity, 400 metres separation;
- certified seed, first generation, 99.7%, 200 metres.

A few instances have arisen in recent years where adventitious presence of GM material has been found in some non GM seed sold in the EU. For example, in 2000 some maize seed lots imported into France from North America were found to have low levels of GMO presence (under 0.2%) and some spring oilseed rape varieties imported from Canada into the UK had GMO presence levels of under 1%. The main effect of these instances has been a) re-evaluation of conditions and procedures by seed producers to reduce the likelihood of adventitious presence occurring[9] and b) the development of EU level proposals for legislation on threshold levels for labelling seed as derived from GM crops (0.3% for oilseed rape and 0.5% for other crops of relevance to the UK). These proposed thresholds for seed are designed to allow commercial crops (ie, not seed crops) to meet the 0.9% GMO labelling threshold recently agreed.

3.3 High erucic acid oilseed rape (HEAR)

Are there any co-existence conditions or recommendations for farmers planting HEAR?
HEAR varieties have desirable properties for the manufacture of industrial oils (it is used to produce erucamide which is mainly used as a ‘slip additive’ in polythene and polypropylene film and as a hair conditioner). However, the erucic acid is an anti nutritional product and should not be consumed on health and safety grounds. It is therefore most important that the cultivation of HEAR crops do not contaminate other oilseed rape (often referred to as double zero varieties) grown for uses in human food and animal feed. HEAR crops are 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 maximum thresholds 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, a separation distance of 50 metres is maintained from other oilseed rape crops sown in the same season[10], all cultivation and harvesting equipment are cleaned before use

[9] The latest (2003) GM Inspectorate annual report reported undertaking 59 audits of seed importers and producers and found no seed sold to farmers has had to be recalled or planting stopped because of unauthorised GM presence

[10] It is not necessary to have separation distances between crops sown in different seasons, eg winter sown double zero and spring sown HEAR

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%[11]. HEAR varieties typically contain about 50% erucic acid content.

Adherence to the 50 metre separation distance is also a condition for eligibility to receive area payments under the EU's arable area payment scheme.

Relevance of condition/recommendations
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 (eg, 50 metres is less than the width of an average field). Farmers growing HEAR usually discuss cropping plans with their neighbours, identify and set rotation patterns by mutual agreement.

Evidence from Germany (JRC study) suggests that a 100 metre separation distance (the separation distance typically required in Germany) delivers 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%. Research conducted in the UK by Kings[12] in 1993-95 which planted HEAR varieties in plots adjacent to double zero varieties (maximum distance between plots was 9 metres) found that the level of erucic acid found in double zero crops was less than 0.5%.

3.4 Organic crop production

Are there any co-existence conditions or recommendations for farmers planting organic crops?
For a crop to be marketed as organic, it must have been cultivated on land that has been through a period of conversion (typically two years) and grown according to organic principles such as only using selected (natural) pesticides and fertilisers from farm manure or nutrient enhancing crops. These organic principles do, however, not restrict the use of crop varieties or species developed by methods such as 'alien gene' transfer (eg, used to breed yellow rust resistance and bread-making qualities into wheat from unrelated species or the cultivation of triticale, a man-made hybrid of wheat and rye[13]).

Baseline organic requirements are set at an EU level although each organic certification body may set its own principles and conditions that may be stricter than the legal baseline. In the UK there are 14 bodies registered to undertake organic certification, of which 11 are currently active. Each of these bodies is responsible for its own standard setting and interpretation. As a result, there may be several different organic standards operating in the UK, each striving for market differentiation relative to others. Within the range of certification bodies, three dominate the certification of the UK organic farmed area, with the largest share (52%) accounted for by the Scottish Organic Producers Association (SOPA: Table 2).

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[11] To breach the 2% threshold for erucic acid in the oil would require a 4% cross pollination of seed

[12] The leading supplier of HEAR seed in the UK

[13] Triticale is an artificial hybrid of wheat and rye and is a popular organic crop – there were 3,350 hectares of organic triticale planted in the UK in 2002-03. Triticale is an example of a wide-cross hybrid, made possible solely by the existence of embryo rescue (a method of recovering embryos in laboratory culture) and chromosome doubling techniques (the restoration of fertility using mutagenic chemicals). The triticale crop could not exist without human manipulation of the breeding process, nor could wheat varieties produced using alien gene transfer techniques

Table 2: UK active organic certification agencies, end of 2002

Certification body	Number of farmers & growers	Number of processors & importers	UK organic area certified (ha)	Share of UK area certified (%)
Scottish Organic Producers Association (SOPA)	558	0	378,697	52
Soil Association Ltd (SA)	2,308	1,435	215,367	30
Organic Farmers & Growers (OFG)	945	6	123,173	17
Others (8 active)	246	502	7,286	1
Total	4,057	1,943	724,523	100

Source: Defra

In relation to the adventitious presence of GMOs, the base EU Regulation covering organic agriculture (2092/91) states 'there is no place for GMOs in organic agriculture' and that '(organic) products are produced without the use of GMOs and/or any products derived from such organisms'. The legislation made provision for a *de minimis* threshold for unavoidable presence of GMOs which should not be exceeded, but did not set such a threshold. In the absence of such a legal threshold having been set, the general threshold of 0.9%, laid down in the 2003 Regulation on labelling and traceability, is the current legally enforceable threshold.

Although the current legally enforceable threshold for GMO presence labelling is 0.9%, some organic certification bodies wish to apply a more stringent *de minimis* threshold on their members (0.1%, the limit of reliable detection).

In the UK, the Soil Association, the second largest certifier of organic farming in the UK (Table 2) also stipulates that separation distances of up to 6 km should be maintained between organic and GM crops. This does, however represent a 'warning limit' with ultimate risk of adventitious presence being determined by a risk matrix. Within this matrix the specified separation distances are 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). These matrix guidelines are based on information supplied by the National Pollen Research Unit and relate to the distance by which pollen can travel by wind and insect vectors and are assumed to result in the receptor crop (eg, non-GM or organic crop) being down-graded or re-classified as GM. The estimated separation distances assume no (absence of) minimum acceptable level of cross pollination. However, some level of GM presence or a threshold does exist because of the limits of reliable detection (0.1%). The National Pollen Research Unit recommendations are therefore based on what they classify as 'very low risk distances'. We do not know what thresholds this implies, although other research (see sections 3.2 and 4.4) shows that very low thresholds are usually deliverable at smaller separation distances (eg, basic seed for oilseed rape at 400 metres, maize at less than a 0.5% threshold at about 50 metres).

Relevance of condition/recommendations

The relevance of the organic sector's current policy towards GMOs can be examined from two main perspectives:

a) Incidence of GMO adventitious presence to date

Against the background of the recommended 6 km separation distance between an organic and GM crop advocated by certification bodies such as the Soil Association, there are reported[14] to have been 277 organic farms within this distance of one or more of the GM FSE sites over the last three years. The majority of these have not been classified at risk because they were either less than their respective crop-specific separation distances (eg, 3,000 metres for maize) and/or were crops different to the GM crop trials. No information is publicly available about how many of these 277 sites had been classified as 'at risk' and/or what actions have subsequently been taken (eg, changes to farming practices to minimise the possibility of adventitious presence occurring) or whether any formal testing (for GMO adventitious presence) has been undertaken. No organic crop located near to a GM FSE, or anywhere else in the UK has lost its organic status due to GMO presence having been found in the (organic) crop.

b) Context of organic farming

For the three crops for which GM traits suitable for use in the UK are currently in the regulatory approval process (oilseed rape, sugar beet and maize), the relative importance of the organic sector is as follows (Table 3):

- *Oilseed rape*. The organic area is about 200-250 hectares, compared to total oilseed rape plantings of 418,000 ha in 2002 (0.06% share)[15];
- *Sugar beet*: organic sugar accounts for 0.28% of the total area planted (ie, 500 hectares) out of a total of about 175,000 hectares in 2002[16]);
- *Maize*: the organic maize area is about 900 hectares (of which about 500 hectares is forage maize), relative to a total area of about 100,000 hectares (0.9%).

Table 3: UK organic area 2003 (hectares)

Crop/Use	Area (hectares)	% share of total organic area
Grassland	663,000	89.5
Arable crops	40,000	5.4
Of which		
Cereals (excluding maize)	*36,600*	*4.9*
Maize	*900*	*0.12*
Oilseed rape	250	0.03
Sugar beet	500	0.07
Pulses/forage, peas, beans (excluding maize)	13,870	1.9
Fruit & vegetables	2,750	0.4
Set-aside/fallow	7,150	1.0
Woodland	6,670	0.9
Other uses	7,560	0.9
Total	**741,000**	**100**

Sources: Defra, Soil Association, Defra
Note: Other uses include conservation, agri-environment schemes, lucerne, lupins, linseed, game cover

Overall, the organic share of these three crops grown in the UK is only 0.24%. The share of the total organic area is also very small at 0.22%. This very low proportion of total plantings and

[14] Source: Soil Association web-site
[15] The organic oilseed rape area is also similar to the average annual area planted to GM oilseed rape in the FSEs of 266 hectares
[16] Comprising 169,000 hectares of sugar beet and 6,000 hectares of fodder beet

production reflects a number of reasons, some of which are common to all three crops and some that are crop-specific:

- In all three crops, weeds are a major problem and can cause significant yield loss and downgrading of a crop. Organic growers, therefore need to use rotation, mechanical methods, hand labour and land with a low incidence of weeds to minimise weed establishment when the crop canopy is not well established. These organic practices are constrained by the availability of resources, such as land and labour, and lead to increased costs (which require price premia to maintain profitability);
- In arable crops such as organic sugar beet, effective weed control is highly dependent on mechanical control and hand labour. It is difficult to find adequate amounts of labour willing to do hand weeding (eg, the requirement in organic sugar beet is an estimated 60 hours/ha) for short periods in the spring. Hand labour requirement also adds considerably to total weed control costs;
- Soil nutrients, notably nitrogen is a key factor impacting on yield in all crops. In the case of organic oilseed rape, it is not grown as readily as organic wheat because it demands high levels of soil nitrogen which are limited in an organic rotation. In conventional arable production, oilseed rape is usually grown as a break crop in rotation with wheat and allows farmers to maximise the yield potential of first year wheat;
- Levels of production risk tend to be higher in organic arable crops than conventional crops. This acts as a disincentive to convert to organic production for many combinable crops;
- the market for organic rapeseed oil is very small. A significant proportion of the rapeseed oil used is in the non-food sector where there is virtually no organic market for any vegetable oil. Also, in the human food sector rapeseed oil is widely considered by consumers to be an inferior product relative to alternatives like sunflower oil (even though its health profile may be superior). The high degree of substitution between different vegetable oils used as food ingredients also means that the lowest cost organic oils dominate market use and contribute to limiting the level of organic premia obtainable;
- similarly, organic sugar beet faces competition from organic cane sugar which can be produced much more cheaply than organic beet (and is attractive in the high priced UK organic sugar market, even after payment of import duties) and is preferred by most refiners and food users of organic sugar.

4 Co-existence of GM, conventional and organic crops in the future

In the future (eg, next 5-10 years), the commercial availability and adoption of GM crops in the UK will require co-existence strategies to be put in place. This section examines this issue.

4.1 Possible GM technology use in the UK agricultural sector

The extent to which GM technology may be adopted by UK farmers will depend on several factors including which traits are commercialised in crops commonly grown in the UK, the level of demand (for non GM products and hence the extent to which there is a market for GM-derived crops), the price of the technology to farmers and the benefits to farmers (eg, possible increases in yields, reductions in costs, additional convenience, reduction in production risks: see appendix 1).

Table 4 below summarises our forecasts for when reasonable volumes of seed containing GM traits in the leading arable crops of relevance to the UK are likely to be available to UK farmers.

The key point to note is that it is likely to be another 1-2 years before GM seed is widely available to UK producers of maize and possible 2-3 years before GM seed is widely available for other crops like oilseed rape and sugar beet. GM wheat and potatoes are unlikely to be available until after 2010.

Table 4: Forecast GM crop commercial availability for leading agronomic traits in the UK

Crop/Trait	Commercially available to EU farmers
Herbicide (glufosinate) tolerant maize	2004-2006
Herbicide (glufosinate) tolerant oilseed rape	2005-2007
Novel hybrid oilseed rape	2005-2007
Herbicide (glyphosate) tolerant sugar beet	2006-2008
Herbicide (glyphosate) tolerant wheat	After 2010
Fungal tolerant wheat	After 2010
Nematode & fungal resistant potatoes	After 2010
Fungal resistant oilseed rape	After 2010

Source: PG Economics

Note: The glufosinate tolerant trait in maize has received regulatory approval in the EU but seed varieties containing the trait have yet to receive varietal approval for use in any member state

4.2 Future demand for non GM derived products

As indicated above, one of the factors affecting adoption of GM technology will be the level of demand for non GM products. Currently, whilst some perceive that there is little or no demand for GM-derived products in the UK (ie, that there is a perception of very strong demand for non GM-derived products), this (perception) fails to take into consideration several factors that suggest otherwise. These include:

- the market for non GM derived crops and derivatives has, to date been largely restricted to soybeans and to a lesser extent maize and oilseed rape, the three main arable crops used in the human food and animal feed chains for which GM technology has been applied (outside the EU). In relation to these crops, usage is mostly found in the animal feed sector and/or for industrial uses. In these markets, most users have not required their raw materials to be certified as non GM and hence the level of positive demand for non GM crops and derivatives has been limited. For example, in the soybean and derivative markets, where the market for non GM is widely perceived to be the most developed, demand for non GM material accounts for about 25% of total consumption across the EU and is found mostly where ingredients are used directly in human food and as feed ingredients in the poultry sector;
- where markets have actively required the use of non GM crops and their derivatives to be used, these have, to date been relatively easily obtained at prices that are similar to, or trade at only a small positive differential relative to their GM alternative. Any additional cost associated with this supply (relative to a cheaper GM-derived alternative) has largely been absorbed by the supply chain upstream of retailers, with no impact on consumer prices. When the supply chain has been able to demonstrate difficulty in absorbing even small additional costs involved in using only non GM ingredients (eg, in some of the livestock product sectors) to their customers in the retail sector, the non GM requirement has tended to be dropped or made less demanding (eg, applying only to premium ranges of products rather than all produce) rather than the additional cost being accepted by retail chains and/or passed on to final consumers. This behaviour suggests that the level of demand amongst end consumers for non GM products is highly price sensitive and

would fall substantially if a consumer price level differential were to develop between GM and non GM derived products;

- consumer market research studies that have examined factors of importance to consumers when buying food[17] (eg, Institute of Grocery Distribution 2003) suggest that for a significant majority of people, the issue of whether their food is derived from GM crops is not important. For example, the IGD research found that 74% of respondents 'are not sufficiently concerned about GM food to actively look to avoid it' and it is not seen as a priority. An additional 13% of respondents indicated that they would welcome GM products on supermarket shelves.

For the three crops for which GM traits will be commercialised in the next few years (of applicability to the UK) the level of demand for non GM is likely to vary by crop, market and use:

- non GM demand will probably be highest where the crops are going into human food. Sugar beet is probably the crop most affected here, especially as British Sugar is the monopoly buyer of sugar beet and can effectively dictate what varieties are planted by growers. Whilst British Sugar maintains a policy of not accepting GM sugar beet (its current policy) there will be no market for GM sugar beet in the UK. If this policy changes by the time of commercialisation (eg, for use in non food sectors such as bio-ethanol) and/or export opportunities in the bio-ethanol market arise, a GM market may develop;
- In contrast, a significant part of the animal feed and industrial sectors (about three-quarters of the ingredients used in EU animal feeds) are largely indifferent as to whether crops used are derived from GM crops or not. For crops destined for these markets, the level of active demand for crops/derivatives that have certified non GM status is likely to remain limited. Both forage maize and oilseed rape fall into this category of crop;
- The nature of competition also affects the demand for non GM crops. In markets where (low) price is considered to be the primary driver of demand (this is relevant to both domestically consumed foods and to export markets), access to the lowest priced products and raw materials is the main criteria used for purchasing. In such markets (eg, frozen rather than fresh poultry), GM based feed ingredients tend to be attractive because they are often cheaper to produce than the non GM alternative, and hence the demand for non GM alternatives is small.

Overall, this points to the level of demand for crops and derivatives, for which the non GM status is important, being limited and found mostly in the sugar sector.

4.3 Future context of organic production

The certified organic production area in the UK of the main crops for which GM traits will be commercialised in the next few years is currently very low (1,650 hectares or 0.24% of the combined total area of the three crops of oilseed rape, sugar beet and forage maize).

[17] We draw an important distinction here between consumer market research that examines factors affecting actual food buying habits/factors of influence and more simplistic surveys of consumer views on GMOs. Most of the latter form of research has been of very limited value because findings have been biased by the language used in questions, the existing (poor) knowledge of respondents and failure to explore and verify actual buying behaviour relative to views expressed

In the future it is possible that the organic area of combinable crops could expand[18], although, as indicated earlier there are a number of constraints to this:

- 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 sugar beet and cereals, which are largely processed before consumption, the UK sector is faced with intense competition from imported sources of (raw material) supply which tend to be 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 UK). Access to lower cost and more readily available sources of labour also contribute to competitive advantages in many third countries;
- An important part of demand for combinable crops also comes from the livestock sector. Here the development of demand for organic produce has not matched growth experienced in the fruit and vegetable sector and is showing signs of having peaked (eg, up to 40% of organic milk has recently had to be sold into the conventional market without an organic price premium: (Wise 2003)).

This suggests that any further expansion in the UK organic area will be concentrated in higher value products that have characteristics such as being bulky (raises cost of transport and hence reduces the competitiveness of imports, eg, potatoes), perishable and more commonly consumed without processing (eg, fruit, vegetables). Even if it was assumed that there was a substantial (eg, tenfold) increase in the UK organic area planted to combinable crops in the next 5-10 years (to perhaps move towards the aspirations of the Organic Action Plan), the sector would remain very small relative to total arable crop production. It is also important to recognise that in the sectors where the organic share is higher (notably fruit and vegetables) that no GM agronomic traits applicable to fruit and vegetables grown in the UK are 'on the horizon' for at least ten years.

Overall, this points to the future likelihood of organic crops being grown near to GM crops (and hence risking possibilities of adventitious presence of GM material being found in organic crops) is very small.

4.4 Possibility of adventitious presence occurring and measures to minimise this

Whilst the context of future GM, conventional and organic cropping examined above suggests a very low likelihood of adventitious presence of GM material in non GM or organic crops being found[19], it is possible that some instances could arise. Research literature examined for the three arable crops of relevance to the UK for which GM traits are currently in the regulatory process, identified the following points of relevance:

[18] In line with the aspirations of the Organic Action Plan

[19] This refers to presence of GM material being found that may impact economically on the grower. In other words, GM material may be found in non GM crops grown on adjacent land to a GM crop, but is not of relevance to the non GM farmer if the market the crop is sold into (or its use) is indifferent to whether it is GM derived or not, or the level of GM presence is below the 0.9% labelling threshold

a) *Cross pollination*

- *Oilseed rape*. This crop is mainly self pollinating although out-crossing is estimated to occur at levels between 12% and 47%[20]. In the UK, research undertaken for Kings (1993-95) into cross pollination between HEAR and double zero oilseed rape (in 1 metre plots up between zero and 9 metres apart) identified that oilseed rape pollen does not travel far (it is very heavy and sticky) and relies on bees and contact with neighbouring plants to spread. As a result, levels of cross pollination were found to have an average of less than 0.5% across all of the plots, with the impact of bees being negligible (a spot effect only). A 50 metre isolation distance was therefore considered suitable to protect against the risk of HEAR pollen being transferred to neighbouring crops[21]. Other UK-based research identified included Simpson (2000) who found that levels of cross pollination were 0.86% at 5 metres, 0.68% at 11.5 metres, 0.23% at 41 metres and 0.12% at 81 metres (this does, however not equate to these levels of cross pollination being found on a whole field basis, where the levels are lower). Lastly Ingram (2000) estimated the separation distances required to maintain cross pollination of whole fields at below threshold levels of 1% and 0.5% to be 1.5 metres and 10 metres respectively for conventional varieties and restored hybrids (the most commonly grown types of oilseed rape in the UK)[22]. Ramsey et al (2003) also indicated that even though minute levels of cross pollination can occur at significant distances (up to 26 kms), this can be kept below 0.1% with relatively small separation distances. It is also interesting to note that in Australia, where the technology providers of herbicide tolerant oilseed rape are proposing that growers should operate a five metre separation distance between GM and non GM oilseed rape, the Australian Gene Technology Grains Committee has proposed that GM and non GM oilseed rape production systems can co-exist without causing problems of adventitious presence of GM material in non GM seed at this level of separation distance (GTGC 2002);
- *Maize*. The level of possible cross pollination occurring depends on plot sizes and isolation distances, with a rapid decline in the level of cross pollination occurring as the distance between a GMO and non GMO maize field increases. Maize pollen is also heavy and does not travel far[23]. Roughly half of all pollen travels no further than 4 metres and between 99% and 99.5% travels no further than 50 metres[24]. Viability of pollen to cross pollinate also falls rapidly with distance. This suggests that provided vulnerable non GM or organic crops have a non GM buffer crop between themselves and the GM crop, there is unlikely to be any significant incidence of adventitious presence of GMO material. If separation distances of over 50 metres are applied the chances of adventitious presence of GMOs being found are very low and, if found, would probably be below 0.5%[25], well below the new EU labelling threshold of 0.9%. Henry C et al (2003) suggest that an isolation distance of 24.4 metres would be sufficient to meet a 0.9% threshold. The key to minimising possibilities of adventitious presence occurring is

[20] Becker et al (1992), cited in JRC (2002). Kings (UK seed supplier and processor of HEAR) estimate that oilseed rape naturally outcrosses by 30%

[21] Bearing in mind here that HEAR is poisonous if found at too high a level in oilseed rape consumed by animals or humans. This contrasts with commercially available GM oilseed rape which has been approved as safe for human and animal consumption

[22] The separation distance for achieving a 1% threshold for varietal associations was 100 metres. No recommendation was made for achieving a 0.5% threshold, due to insufficient information being available

[23] Defra (2003) Review and knowledge of the potential impacts of GMOs on organic agriculture

[24] The furthest recorded (isolated) instances of cross pollination occurring identified are 305 metres (Colorado State University (2003)) and 800 metres (cited in JRC 2001, based on Salamov (1940)). The distance at which pollination is zero is however impossible to determine with accuracy (Defra 2003)

[25] Research into pollen flow from GM maize is also currently being undertaken in Spain by the Department of Agriculture, Fisheries and Livestock of the Catalonian government

the depth of the (conventional) maize crop barrier. The first five rows of such a barrier are the most effective method of minimising adventitious presence because this is where the vast majority of GMO pollen will disperse. Also pollen from the non GM crop used in the barrier tends to 'flood' adjacent crops and hence acts to 'crowd out' any GMO pollen that may have travelled beyond the refuge/barrier crop (and hence minimise the scope for introgression occurring);

- *Sugar beet*. As the crop is normally biennial (produces seed only in the second year) but is harvested at the end of the first growing season, plants rarely flower. This means that cross pollination tends to be a minor medium for adventitious presence of GMOs occurring. The only scope of cross pollination occurring comes from bolters (see below)[26].

b) Seed mediated pollen flow (eg, volunteers)

- *Oilseed rape*. Significant seed loss can occur in oilseed rape because of natural shedding of seed and crop disturbance at harvest. Losses of 2%-5% are considered to be 'best case' and losses of 20%-25% are commonplace[27]. Seeds can persist in the soil for at least five years and possibly up to ten years[28], although there is considerable variation by type of seed. As a result of shed seed losses being significant, volunteers can become a problem in subsequent crops (usually cereals), field margins and roadsides, necessitating the use of weed control measures to remove them. Feral rape populations are less common, mostly dieing out quickly (Crawley et al, 1993). Control of oilseed rape volunteers is however, relatively easily undertaken and is generally considered to be a part of good agricultural practice. Research undertaken by Kings in 1993-95 also examined the issue of volunteers from HEAR in subsequent crops over a five year rotation. It found that volunteers peaked in the second year and then declined. After five years of good agronomic practice, the number of volunteer plants declined to less than one per square metre (it would require 6 plants per metre to compromise the integrity of a HEAR crop). In seed crops, the chances of volunteers compromising seed purity are minimised by not allowing an oilseed rape crop to precede a seed crop (of oilseed rape) for five years. The issue of herbicide tolerant volunteers has been examined in Australia (Niknam et al 2002), in respect of non GM herbicide tolerant crops (triazine tolerant and imidiazolinone tolerant). This work concluded that volunteers of oilseed rape (conventional or herbicide tolerant) were not a significant weed in cereals or pulses (conclusion based a survey of farmers in Victoria) and where farmers did experience problems, they had many alternative herbicide options for dealing with the volunteers. Recent UK work by Squire et al (2003), using simulation techniques suggested that if a grower cultivates GM oilseed rape and then, later in a four year rotation plants a non GM oilseed rape in the same field, a threshold of 1% GM presence is attainable provided rigorous weed management practices are applied. However, if a grower was to plant a non GM oilseed rape in the same field after two GM oilseed rape crops in a conventional rotation, attaining a 1% threshold would be more difficult;
- *Maize*. This is not an important media for gene flow. The probability of a volunteer weed problem arising is very low due to the inability of the maize plant to shed seed naturally, limited dormancy and inability to survive low winter temperatures;

[26] Bolters are growth on a plant that leads to flowering if not prevented. Bolter incidence varies according to when a crop is sown, weather conditions and the varieties of beet used. If bolters are allowed to flower, both sugar beet and fodder beet can cross by wind pollination with other flowering beet varieties or with their close relative sea beet

[27] Price et al (1996)

[28] Sauermann (1993)

- *Sugar beet*. This is the main medium for possible gene flow in sugar beet. In sugar beet crops the potential problem of volunteers or weed beet occurs mainly because weed beet produces seed every years, unlike true beet seed which would only produce seed every other year (if allowed). Once weed beet becomes established it tends to be self-perpetuating and can produce an average of 2,000 seeds/year (of which about 50% survive). The main origin of weed beet is bolters. Control of weed beet and bolters are, therefore important activities on sugar beet growing farms and considered to be good agricultural practice. Control of bolters is also key to seed production of sugar beet.

c) Other possible sources of adventitious presence

- Seed purity can affect the levels of adventitious presence, the higher the purity level (eg, 0.1% adventitious presence) the lower the 'knock-on' level in the final product. As indicated in section 3.2, a few instances have arisen where adventitious presence of GMO material has been found in some non GM seed sold in the EU. However, seed companies have subsequently tightened up their procedures to minimise such problems occurring and the EU will shortly introduce legislation on threshold levels for labelling seed as derived from GMOs (0.3% for oilseed rape and 0.5% for other crops of relevance to the UK). These proposed thresholds for seed should allow commercial crops (ie, not seed crops) to meet the 0.9% GMO labelling threshold recently agreed;
- post harvest handling could also represent an additional source of adventitious presence if crops from GM and non GM growing farms are dried, cleaned and stored in central (often co-operative) facilities. This has however not been a problem in countries where GM crops are grown (eg, Spain). It is also not expected to be an important source of possible adventitious presence occurring in the UK, mainly because farmers are increasingly undertaking practices to minimise adventitious admixing of crops (ie, keeping crops and specific varieties segregated) as 'normal practice' for meeting contractual supply obligations, to derive price premia attached to produce meeting specific standards (eg, organics) and as members of quality assurance schemes.

d) Other points of relevance

In the case of oilseed rape, two other factors further reduce the likelihood of adventitious presence of GMOs being found on non GM oilseed rape crops. These are i) where organic oilseed rape is grown, it is mostly spring sown (because of the additional weed problems experienced with winter sown crops), in contrast to conventionally grown oilseed rape, where over 90% is winter sown – GM plantings are expected to be mostly winter sown crops reflecting this historic practice and because the scope for cost savings is likely to be greater than in spring sown crops, and ii) risk of cross pollination occurring is greatest for varietal association, which probably account for less than 5% of all varieties planted (conventional varieties account for the majority along with hybrids), a share that has rapidly fallen in recent years.

Lastly, the likelihood of adventitious presence of GMOs arising from gene flow from herbicide tolerant oilseed rape to wild relatives and back into conventional or organic oilseed rape crops is extremely small. Research by Boffey and Daniels (2003) from fields in the FSEs found no evidence for the transfer of herbicide tolerant genes from GM crops to wild relatives.

Overall, this suggests that it is very unlikely that cases of adventitious presence of GMOs will be found in non GM crops (including organic crops) to levels that cause economic disadvantage (to non GM crop growers), provided that crop barriers, separation distances (see above) and good husbandry (weed control) practices are adhered to in the small number of cases where a GM crop may be sited near to a 'sensitive' non GM or organic crop[29].

4.5 Can the organic sector co-exist with GM production?

The analysis above suggests that the number and frequency of co-existence problems occurring for UK organic crop growers vis a vis GM arable crops is likely to be very small. This does, however imply that some problems could arise. The questions to ask here are:

- *can measures be taken to reduce further the chances of problems occurring?*
- *given the context of organic crop production and the very low probability of GM adventitious presence, what is proportionate and reasonable[30]?.*

Answers to these questions can be found within the organic sector. Specifically by adopting principles and practices towards GMOs that are consistent with other organic principles and practices, any residual 'problem' over co-existence could be largely eliminated. More specifically:

a) *Testing of organic produce for the presence of GMOs*. Organic certification is based on certifying the production method rather than giving an end product guarantee as to the product's freedom from GMOs or impurities. Adventitious presence of such material can occur from circumstances beyond the reasonable control of the organic producer and therefore, the identification of such material (via end product testing) is not used to de-certify organic status on produce provided growers can demonstrate their adherence to the organic farming practices and rules. Whilst this pragmatic principle should apply to possible adventitious presence of GMOs (see for example IFOAM position paper on genetic engineering and GMOs; www.ifoam.org, page 2), practice advocated by some organic certification bodies (and currently applied in countries like Spain) is to undertake some testing for GMO presence, with all crops found to have detectible GMO presence de-certified. This practice is inconsistent with the treatment of other unwanted material and with the treatment of crop protection products for which thresholds for their safe use exist[31]. This (practice) may, therefore, be unfairly penalising organic farmers whose crops are found to contain very low levels of GMOs through no fault of their own. It may also probably lacks any legal basis. Furthermore it is possible that positive GMO presence in an organic crop might even be of naturally occurring DNA (found in the soil) or GM plant material that has not introgressed with the organic crop (ie, pollen on the surface of a crop);

b) A*doption of a de facto threshold for the presence of GMOs of 0.1%.* Against a background of no legal, *de minimis* threshold existing for the presence of GMOs in organic produce (other than the 0.9% labelling threshold applicable to GMO presence in any product), this is inconsistent with other thresholds and derogations operated in the organic sector. For example, organic standards allow thresholds[32] of up to 5% for the presence of non organic ingredients in some processed foods, buyers of organic produce invariably operate to the same thresholds as apply to conventionally produced crops in respect of the presence of foreign material (eg, 2% for materials like dirt, weeds, stones in maize) and there are derogations for the use of:

[29] Sensitive refers to a crop sold into markets where the certified non GM status of the crop is important

[30] Also, bearing in mind that co-existence is about the existence of approved (safe) crop products

[31] It is also interesting to note that all pesticides approved for use have safety-based maximum threshold levels for presence in crops. Conversely, GM crops approved for commercial use do not require the application of such thresholds for safe use

[32] There is also no requirement to label for the presence of these 'allowed' non organic ingredients/products, provided the thresholds are met

- some pesticides such as copper-based fungicides on potatoes and BT (bacillus thuringiensis), a bacterial fungicide used for the control of caterpillars. For example, in 2003, in Northern Ireland, organic potato producers have a derogation from their certification body (Soil Association) to make up to three applications of copper oxychloride[33], a powder-based fungicide, at a rate of 8kgs/ha, equivalent to three applications during the growing season. Similarly, organic maize growers can spray their crops with the bacterial fungicide (Bt) to control caterpillars. The Bt sprays are obtained by mass producing (using fermentation methods) the bacteria, which is then sprayed onto crops, killing caterpillars when they eat the (Bt) bacteria which contain a natural toxin to caterpillars. This naturally occurring toxin is the same element expressed in GM (Bt) maize, which is not permitted in organic agriculture;
- non organic seed can be used (this derogation was set to finish at the end of 2003 but will be extended further (Regulation 1452/2003));
- crop species and seed varieties derived from 'unnatural' plant breeding techniques are permitted (eg, triticale, a crop derived from the use of embryo rescue and chromosome doubling techniques);
- straw from conventional cereals can be used for livestock bedding – this is subsequently spread on organic production land as an important source of crop nutrients;
- up to 10% of ingredients used in organic animal feed can be derived from non organic ingredients[34], and
- some ingredients derived from GMOs may be allowed by certification bodies because of the lack of availability of non GM derived alternatives; this relates to possible use of some GM derived processing aids in some food products and veterinary medicines.

In all these cases, the organic status of the crop is <u>not</u> de-classified and consumers pay the full organic premium for these products.

Some in the organic sector seek to justify the practice of testing for GMO presence in organic produce to a 0.1% threshold as being necessary to maintain organic product integrity and consumer confidence. However, the inconsistency of this practice and the operation of wider tolerances and derogations for the use of non organic inputs/ingredients, undermines this consumer confidence argument. The more consumers are made aware of these 'allowances' for the use of non organic ingredients and inputs, the greater the potential for loss of confidence in the integrity of all organic products.

If the organic sector was to move to a more consistent approach towards the adventitious presence of GMOs (ie, adopting a more practical, cost effective threshold), which is proportionate to the health and environmental risk attached to the use of allowed organic inputs (eg, synthetic and natural pesticides, unnatural varieties and crop species) and treated GMO presence in the same way as other unwanted materials are treated, this would potentially overcome the current 'perceived' co-existence problem. This is also unlikely to compromise the integrity of organic products with consumers[35]. Alternatively, the organic sector could apply the same testing

[33] This product is harmful to livestock, fish and other aquatic life and should not contaminate surface water or ditches (source: The UK Pesticides Guide 2003)

[34] This is a common threshold used by certification bodies. The legal maximum for the use of non organic ingredients can be higher (eg, 20%)

[35] Conversely, adherence to a test-based regime for GMOs to a 0.1% threshold may well open up the organic sector to potentially damaging publicity about organic definitions and the use of non organic ingredients and inputs. The lack of legal foundation to this threshold (unless given as a condition in a contract of supply) also opens up the possibility of legal challenge to de-certification by an organic farmer

principles and thresholds currently applied to GMOs to impurities (eg, introduce a *de minimis* threshold on pesticide residues and apply a 0.1% threshold as the limit for acceptance of all unwanted materials and impurities).

5 Conclusions

The evidence to date shows that GM trial crops, including the FSEs have co-existed with conventional and organic crops without economic and commercial problems – no conventional or organic crops near to GM crops have found any adventitious presence of GMOs.

For the future, the likelihood of economic and commercial problems of co-existence arising remains very limited, even if there is a significant development of commercial GM crops and increased plantings of organic crops because:

- the GM traits being commercialised in the next few years are in crops for which there is limited demand for non GM material (with the possible exception of sugar beet);
- the organic areas of the three key crops (oilseed rape, sugar beet and forage maize) are extremely small (only 0.24% of the area planted to these crops in the UK);
- The organic area of these crops (and other combinable crops) is likely to continue to be a very small part of the total arable crop areas (even if there was a tenfold increase in plantings), with a very limited economic contribution relative to the rest of the UK arable crops. The likelihood of these (organic) areas expanding is limited due to a combination of adverse agronomic factors (eg, a need for sites with few weed problems and the nutrient demanding nature of crops like oilseed rape), limited demand, and market preference for competing (imported) produce (eg, cane sugar);
- The possibility of gene transfer to related wild and other crop species from any of the GM crops is extremely low[36]- this is also an issue examined before regulatory approval is given;
- UK arable farmers have been successfully growing specialist crops (eg, seed production, high erucic acid oilseed rape) for many years, near to other crops of the same species, without compromising the high purity levels required;
- some changes to farming practices on some farms may be required once GM crops are commercialised. <u>This will however, only apply where GM crops are located near non GM or organic crops for which the non GM status of the crop is important</u> (eg, where buyers do not wish to label products as being GM or derived from GM according EU labelling regulations). These changes are likely to focus on the use of separation distances and buffer crops (of non GM crops) between the GM crops and the 'vulnerable' non GM/organic crop and the application of good husbandry (weed control) practices. GM crop planting farmers in the FSEs already adopt these practices as part of applying the SCIMAC guidelines for growing GM crops in the UK and would be provided with 'GM crop stewardship programmes' by seed suppliers, post commercialisation[37]. Few GM planting farmers are however, likely to find themselves located near to 'vulnerable' non GM/organic crops and hence the need to apply all of these guidelines rigorously may not be necessary. For example, if a farmer planted GM forage maize next to a non GM forage maize crop and the non GM forage maize was fed to dairy cows whose milk

[36] For example, the FSEs found no evidence for the transfer of the herbicide tolerance gene from GM oilseed rape to common wild relatives

[37] 60% of farmers in the FSEs indicated that the SCIMAC audit procedures were are in line with requirements in other farm assurance schemes (Pearsall 2003)

produce was sold into markets where the buyers were indifferent to the GM or non GM status of the feeding regimes used.

The different certification bodies in the organic sector can also take action to facilitate co-existence by:

- applying a more consistent, practical, proportionate and cost effective policy towards GMOs (ie, adopt the same policy as it applies to the adventitious presence of other non organic material). This would allow it to better exploit market opportunities and to minimise the risks of publicity about inconsistent organic definitions and derogations for the use of non organic ingredients and inputs damaging consumer confidence in all organic produce. This latter point is important given that the organic crops perceived to be affected by the commercialisation of GM traits in the next few years account for only 0.22% of the total organic farmed area in the UK; or
- applying the same testing principles and thresholds currently applied to GMOs to impurities (eg, introduce a *de minimis* threshold on pesticide residues and apply a 0.1% threshold on the limit for acceptance of all unwanted materials and impurities); and
- accepting that if they wish to retain policies towards GMOs that advocate farming practices that go beyond those recommended for GMO crop stewardship (eg, buffer crops and separation distances that are more stringent than those considered to be reasonable to meet the EU labelling and traceability regulations), then the onus for implementation of such measures (and associated cost) should fall on the organic certification bodies and their members in the same way as current organic farmers incur costs associated with adhering to organic principles and are rewarded through the receipt of organic price premia.

Lastly, it is important to emphasise the issues of context and proportionality. If highly onerous GM crop stewardship conditions are applied to all farms[38] that might wish to grow GM crops, even though the vast majority of such crops would not be located near to organic-equivalent crops or conventional crops for which the non GM status is important, this would be disproportionate and inequitable. In effect, conventional farmers, who account for 99.76% of the current, relevant UK arable crop farming area could be discouraged from adopting a new technology, that is likely to deliver farm level benefits (yield gains, cost savings) and provide wider environmental gains (reduced pesticide use, switches to more environmentally benign herbicides, reduced levels of greenhouse gas emissions: see appendix 1).

[38] For example the setting of substantial separation distances between GM crops and any conventionally grown equivalent

Appendix 1: Summary of likely farm level impacts of adopting the GM traits likely to be commercialised in the UK in the next few years – applicable to oilseed rape, sugar beet and forage maize

Oilseed rape

The main GM oilseed rape traits likely to be commercialised in the next few years are GM derived hybrid varieties, also containing herbicide tolerance (to glufosinate). The potential applicability, adoption and impact on UK farming profitability of this product is summarised in Table 5. For further details the reader should read section 5.2 and appendix 5 of 'PG Economics (2003) Consultancy support for the analysis of the impact of GM crops on UK farm profitability, report for the Strategy Unit of the Cabinet Office'.

Table 5 Summary of possible farm level economic impact of GM hybrid vigour and herbicide tolerant (to glufosinate) oilseed rape

Impact on costs of production	May offer reduced variable costs from lower herbicide use costs but this depends on baseline current costs and number of glufosinate applications made. Current costs of £36-£45/ha compare with possibilities of £21-£65/ha for glufosinate use depending on volume of herbicide used, assumed price of herbicide and number of applications. Using the assumptions presented in the PG Economics report, cost savings will only emerge if farmers use one application or, if they use two applications, are above average spenders on herbicides. These calculations also do not take into consideration the cost of technology. Overall, cost savings are only likely for a minority of users and take up will be driven by other factors – see below
Impact on yield	Main source of farm level benefit. Yield gain expected anywhere between 10% and 15%. This comes mostly from the improved hybrid vigour but may also come from improved weed control and reduced 'knock-back' experienced from existing herbicide treatment of crops. A yield gain of 10% would result in an increase in the gross margin of 9.5% relative to 2002 (+14% at a 15% yield gain)
Impact on rotation	Possible benefits for subsequent crops like wheat, especially as may offer improved control of difficult and expensive to control weeds like black grass (which are resistant to a number of herbicides). Could lead to savings across the rotation on herbicide costs and reduced carry over of residual herbicides in the soil (which may damage crop growth)
Facilitation of low/non tillage practices	May re-enforce this husbandry trend which offers scope for lower energy use, less ploughing and higher profitability

Sugar beet

The main GM sugar beet trait likely to be commercialised in the next few years is GM herbicide tolerance (to glyphosate). The potential applicability, adoption and impact on UK farming profitability of this product is summarised in Table 6. For further details the reader should read section 5.2 and appendix 5 of 'PG Economics (2003) Consultancy support for the analysis of the impact of GM crops on UK farm profitability, report for the Strategy Unit of the Cabinet Office'.

Table 6: Summary of possible farm level economic impact of GM herbicide tolerant (to glyphosate) sugar beet

Impact on costs of production	May reduce average level of expenditure on herbicides – amount subject to debate/dispute. May (2003) estimates that the likely herbicide costs for a

	farmer using herbicide tolerant sugar beet would be between £26/ha to £40/ha. This compares with the current average herbicide costs (including application) for conventional sugar beet of £129/ha-£149/ha using May's data, £84-£104/ha using FARM data, £102/ha using ADAS data and £167/ha using Velcourt data. Assuming a technology fee/seed premium of £20-£30/ha (May 2003), this would result in an approximate net saving on herbicide costs of £80/ha based on May's data, £36/ha using FARM data, £44/ha using ADAS data and £109/ha using Velcourt data;
Impact on yield	Based on trials data and existing analysis such as May 2003, Dewar et al 2000 & 2003 and Gianessi et al 2002, an increase in yield is likely. This could be within a range of 5% to 10%. At 5% (relative to an average yield of 50 tonnes/ha) this is equal to an additional £75/ha in gross margin and at 10% it is equal to an additional £150/ha
Other possible cost savings	Possible cost savings from reduced use of crop consultants, greater management flexibility, adoption of minimum tillage practices, improved rotational weed control and reduced stubble control. These possible savings will vary by farm and could be within the range of zero to £32/ha (these boundaries are based on the respective views of FARM and May)
Facilitation of low/non tillage practices	May re-enforce this husbandry trend which offers scope for lower energy use, less ploughing and higher profitability
Increased management flexibility	Efficient weed management is critical to sugar beet because of its vulnerability at early stages of growth to weed competition (can affect yield) and crops are typically sprayed 4 to 5 times to a strict timetable in line with weed stage development. A move to a glyphosate based system (2 sprays) would offer increased flexibility on timing

Forage maize

The GM trait currently closet to the marketplace is GM herbicide tolerant (to glufosinate) forage maize. The potential applicability, adoption and impact on UK farming profitability of this product is summarised in Table 7. For further details the reader should read section 5.2 and appendix 5 of 'PG Economics (2003) Consultancy support for the analysis of the impact of GM crops on UK farm profitability, report for the Strategy Unit of the Cabinet Office'.

Table 7: Summary of possible farm level economic impact of GM herbicide tolerant (to glufosinate) forage maize

Impact on costs of production	The range of current herbicide costs is between £15/ha to £42.2/ha. The likely cost under the glufosinate tolerant crop is (one application) £25/ha to £30.44/ha rising to between £54-£60.88/ha for two applications. However, the current ' alternative' costs are likely to rise because the main herbicide currently used (atrazine) is being banned. As such, costs could rise to about £55.01/ha. On the basis of these costs, glufosinate tolerant forage maize would provide the largest cost savings for farmers who currently use two sprays and could revert to one application of glufosinate (also it would be attractive if atrazine were to be banned). Where farmers would need to use two applications of glufosinate the cost savings would be significantly reduced and may be marginal.
Impact on yield	Current herbicides used may adversely affect yield via 'knock back' (eg, slow down rate of seed germination). Detailed data is not available on this impact but the use of a post-emergent contact broad-spectrum herbicide, such as glufosinate, that does not "knock-back" the plant could increase yields by between 10% and 20%. A 10% increase in yield equates to an additional 1.19 tonnes of maize dry matter which costs £46.70 (based on £39.38/t X 1.19) to produce.

	Given the limited nature of the possible cost saving benefit identified above, take up of this technology in forage maize will probably depend on its ability to deliver the yield benefits suggested above. If not, and after taking into consideration the technology fee, the benefits will be limited to only some farmers. It may necessitate a fairly low technology fee and/or be accompanied by a reduction in the herbicide price (of glufosinate) to facilitate take up. This analysis is however speculative and is not based on empirical evidence of herbicide tolerant forage maize grown in the UK (as no publicly available empirical evidence was identified).

Wider benefits likely to be derived from the crops
The main broader benefits to be derived from the adoption of these GM crops are:

a) *Environmental benefits*. These accrue from reduced levels of herbicide use (number of spray runs and amount of product applied). The farm scale trials (2003) and other research (eg, May 2003, Dewar et al 2003) highlight the reductions in herbicide use that arise from adoption of the technology. They also demonstrate a move away from the use of more persistent, residual herbicides to more environmentally benign products. In turn this reduction in use is resulting in improvements to biodiversity in GM forage maize crops (see for example the Farm Scale Trial results) and general reductions in the level of herbicides that can enter groundwater supplies. It also offers scope for (via the yield gains) current UK production volumes to be derived from a smaller area. If the 'surplus' land area was diverted into uses that maximise bio-diversity (ie, were taken out of agriculture or were managed extensively), the bio-diversity gains from this would probably more than offset the small negative impact on bio-diversity (arising from improved weed control) in GM herbicide tolerant spring oilseed rape and sugar beet suggested in the FSEs.

   In addition, reduced frequency of spraying results in lower fuel use and additional facilitation of the adoption of low/no tillage systems. Both have the potential to deliver reduced levels of greenhouse gas emissions. In the case of GM forage maize, it is also possible to under-sow the maize with a grass crop to 'soak up' nitrates during the over-winter period. This option is not possible when atrazine is used as the main form of weed control. Lastly, the switch to using broad spectrum herbicides like glyphosate and glufosinate provides farmers with additional flexibility in the timing of when to apply herbicides. This offers extra scope for balancing the provision of effective weed control with local biodiversity requirements.

b) *Contribution to lower real costs of products derived from these crops*. The GM crop traits discussed in this paper are intended to be cost reducing. This means that if the majority of producers switch to this technology, there will be a cost and price reducing effect on the baseline price of the crop commodity and/or derivatives. Whilst it is difficult to identify this impact or to attribute it to the adoption of a specific piece of technology, it nevertheless occurs. To date this has probably only occurred in the soybean market but would be equally applicable to other crops.

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