Chapter 1  Introduction and background to GM crop production

1.1  Introduction

The issue of the coexistence of genetically modified (GM) and non-GM crops first came to prominence in the European Union (EU) in the early part of 2003 when the EU initiated a policy discussion on the subject. The main issues arising from these discussions were that decisions on coexistence must be based on sound science and that coexistence is concerned with:

- Workable management measures to minimise the admixture of GM and non-GM crops.
- The cost of such measures.
- The potential economic impact where admixture occurs.
- The nature and extent of liability in relation to admixture.

At the request of Member States, the Commission prepared a set of guideline principles on coexistence which were published in Commission Recommendation 2003/556/EC of 23 July 2003 on — ‘Guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming’ (Appendix 1). These guidelines, (referred to as the ‘Commission Guidelines’ in the remainder of this Report), were intended to assist Member States in developing national strategies and approaches to address the coexistence of GM and non-GM crops. The Commission stipulated that, due to the diversity of the natural conditions, the farm structures and the farming systems under which farmers in the EU operate, it was best left to each Member State to develop and implement its own specific management measures for coexistence (i.e. subsidiarity).

The Commission emphasised that coexistence, does not relate to issues of food safety or environment, as ‘specific coexistence measures to protect the environment and human health, if needed, are included in the final consent of the authorisation procedure in accordance with Directive 2001/18/EC’ (Appendix 2). Such issues are addressed in the risk evaluation procedure carried out prior to the authorisation of a GM product for placing on the market.

Coexistence is, therefore, concerned with the potential economic impact arising as a result of the admixture of EU approved GM crops and non-GM crops, where the market value and accessibility of GM and non-GM crops are different. The adventitious presence of GMOs (above the tolerance thresholds set out in European Community legislation) triggers the need for a crop that was intended to be a non-GM crop to be labelled as containing GMOs. This could cause a loss of income to the grower of the non-GM crop due to a lower market value of the crop or difficulties in selling it. In addition, there may be possible implications for the following crops in the rotation. The economic loss is potentially greater for higher value crops such as organic produce and the loss may extend to following crops over a period of time. Such issues relating to economic loss necessitate the requirement to determine liability, assess the level of loss incurred and establish possible measures to redress such loss.

Focussing mainly on technical and procedural aspects, the Commission Guidelines provide a list of general principles to aid Member States in establishing best practices for coexistence.
The guidelines examine issues relating to the growing of GM crops adjacent to conventional and organic crops in the context of a series of legislative measures introduced with regard to the authorisation, growing and marketing of GM crops in the EU. The guidelines stipulate that farmers should be able to cultivate the types of agricultural crops they choose – be they GM, conventional or organic crops and that none of these forms of agriculture should be excluded in the EU, thereby providing consumers with a high degree of choice.

The guidelines also state that ‘Coexistence refers to the ability of farmers to make a practical choice between conventional, organic and GM crop production, in compliance with the legal obligations for labelling and/or purity standards’ ... and … ‘concerns the potential economic loss and impact of the admixture of GM and non-GM crops, and the most appropriate management measures that can be taken to minimise admixture.’

Given the possibility of admixture arising during the production of cultivated crops, and the requirement to distinguish between GM and non-GM crop produce for the purpose of labelling, it is necessary to establish management conditions for crop production that will minimise the admixture of GMO in non-GM crops at levels not exceeding the prescribed labelling thresholds. This is the minimum requirement. However, all possible precautions should be adopted to ensure GMO content in non-GM crops at the lowest possible level. Increased costs will accrue to farmers if they have to adopt monitoring programmes, testing for the presence of GMO and, implement management measures to minimise the admixture of GM and non-GM crops.

To develop national coexistence measures appropriate for growing GM, conventional and organic crops in Ireland, the Department of Agriculture and Food (DAF) established an inter-departmental/inter-agency Working Group in August 2003. The Working Group had the following remit:

1) To identify and evaluate issues and implications for crop production in Ireland that will arise from the cultivation of GM crops:

   and

2) To develop proposals for a national strategy and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming.

The Working Group examined the main agricultural crops cultivated in Ireland and specifically those GM crops that are, or are potentially close to, commercial availability worldwide, namely: maize, potato, beet, cereals and oilseed rape. A brief overview of horticultural crop production in Ireland is also included. However, significant production of GM horticultural crops is not expected in the short to medium term.

Other crops of agricultural importance in Ireland, including grasses, clovers, peas, beans and linseed are not addressed in this Report, as it is not anticipated that there will be a significant degree of production of GM varieties of these crops in Ireland in the short to medium term. The main thrust of GM grass research at present relates to grasses for amenity use and any commercial production would have major significance for agricultural grass production in Ireland and would require a specific study in relation to coexistence.
The remainder of Chapter 1 of this report examines the general background with regard to the production of GM crops to date and the sequence of legislative and policy developments that have led to the requirement to introduce coexistence measures as recommended in the Commission Guidelines.

1.2 The technology of crop genetic modification

A genetically modified organism, or ‘GMO’ is defined in EU legislation as:

‘any cellular entity capable of replication or of transferring genetic material in which the genetic material has been altered in a way that does not occur naturally by mating or by natural recombination’.

The cells of all living organisms comprise of genetic systems, which are programmed by strands of a chemical known as deoxyribonucleic acid (DNA). Genes are segments of DNA and are found in the nucleus of the cell. Since the 1970’s, it has become possible to modify the genetic information of living organisms by transferring one or more gene-sized pieces of DNA from one living organism to another. Such transfers are now commonly used in biological research and have commercial applications in drug and food development. In plants, genetic modification can involve gene transfer from another plant species, or from a completely different organism such as a bacterium or virus. Thus, it is now possible to enhance the ability of an organism to produce an existing product, or prevent it from producing a product, or produce an entirely new product.

Crops have been genetically altered for many years, in the sense that conventional crop breeding effectively changes their DNA sequences. While there are similarities with traditional breeding techniques, genetic modification has unique and indeed profound differences in the range and nature of modifications that can be achieved. In particular the transfer of genes between species would not normally occur in nature.

Traditional crossing techniques rearrange and transfer genes across related varieties, and occasionally between species. Man has been instrumental in assisting such crossing to develop new varieties of crops with agricultural potential. Triticale, for example, is a cross between the species rye and wheat. In the past, chemicals have been used to induce genetic mutation in plants to alter their agronomic characteristics. Since the 1960’s irradiation has been used to generate new gene combinations that confer traits not usually present in the parent plant. This technology underpinned the ‘Green Revolution’ through the creation of new improved maize, wheat and rice varieties in order to meet the increased need for food, especially in developing countries.

On a worldwide scale there have been considerable improvements in agricultural productivity over the last 50 years, due to selective breeding programmes, the use of fertilisers, pesticides and herbicides, advances in agricultural equipment and machinery, improvements in management techniques and the use of irrigation programmes. However, this has also given rise to problems such as increased genetic uniformity and a consequent reduction in biodiversity. In nature, genetic mutation is the process that underpins all natural evolutionary processes and which is key to being able to continually adapt to the changing environment. Countering this loss of diversity is one of the challenges faced by modern agricultural plant
breeders. Creating novel gene combinations is one way of countering this reducing diversity in the gene pool of cultivated crop species.

A common characteristic of conventional breeding and irradiation is that the number and manner in which the genes are combined is random and often unpredictable. There is no way of determining the exact outcome of particular crosses, as in addition to the transfer of targeted traits (such as disease resistance, protein content and quality, flower colour, etc.) there may also be the transfer of other undesired traits. Traditional plant breeding is also very time consuming – a new crop variety may take in excess of 10 years to develop.

In recent years, it has become possible to introduce genetic changes in a more precise manner, over shortened timescales using recombinant DNA technology, or transgenesis. The ‘new’ DNA typically contains additional genes that are obtained from another variety (or even the same variety) or organism (plant or animal), but replicated.

1.3 Current status of GM crop production

Research on gene transfer through recombinant DNA techniques commenced in the early 1970’s, while the first GM crops were released commercially in 1996. Most of the transgenic crops planted so far have incorporated a limited number of genes aimed at conferring insect resistance and/or herbicide tolerance. Significant progress has also been made in developing GM crops that express tolerance to acid and saline soils, drought and temperature extremes. These latter crops are more likely to be of benefit to agricultural production in the developing world.

To date genetically modified crops occupy a relatively small proportion of the world’s agricultural acreage but the area has been increasing steadily in recent years. During the nine-year period from 1996 to 2004, the global area of GM crops increased from 1.7 million hectares to 81.0 million hectares (ha). This equates to 5% of the 1.5 billion ha of global cultivatable cropland. In 2004, GM crops were cultivated by some 8.25 million farmers in 17 countries, with a 20% increase in the area cultivated to GM crops from 2003 to 2004. Almost all (98%) of this was grown in only six countries: USA (59%), Argentina (20%), Canada (6%), Brazil (6%), China (5%) and Paraguay (2%). Other countries with significant plantings include India (1%) and South Africa (1%), while Uruguay, Australia, Romania, Mexico, Spain and the Phillipines have less than 1% each.

Figure 1.1 Global distribution of GM crops 2004

Source: James, C. 2004
Four crops dominate the land area under GM cultivation: soybean (60%), maize (23%), cotton (11%) and canola (6%).

**Figure 1.2** Global GM crop type 2004

![Graph showing the distribution of GM crops in 2004 with Soybean at 60%, Maize at 23%, Cotton at 11%, and Canola at 6%](image)

Source: James, C. 2004

Traits achieved by genetic modification primarily involve herbicide tolerance (72%) – deployed in soya, maize, cotton and canola, and insect pest resistance (19%), or a combination of both (stacked genes) in cotton and maize (9%).

**Figure 1.3** Global GM traits 2004

![Graph showing the distribution of GM traits in 2004 with Herbicide Tolerance at 72%, Insect Resistance at 19%, Combination HT/IR at 9%](image)

Source: James, C. 2004

A global perspective of the current significance of GM crops may be seen in the adoption rates for the four principal GM crops as a percentage of their respective total global areas. In 2004, 56% of the 86 million ha of soybean planted globally was genetically modified. Twenty eight percent of the 32 million ha of cotton was genetically modified, while the area planted to genetically modified canola in 2004 was 16% of the 23 million ha planted globally. Of the 140 million ha of maize grown globally in 2004, 14% was GM – equivalent to 19.3 million ha (James, 2004).

The first GM crops authorised in the EU were grown commercially in 1998. At present, Spain is the only EU Member State with a significant commercial production area with 32,000 ha of GM forage maize produced in 2003 and 58,000 ha in 2004 (James, 2004). For other EU Member States, planting has been mainly for experimental and testing purposes.

Seventeen GM maize varieties were included in the EU Common Catalogue of Agricultural Plant Varieties in 2004 and, under EU legislation, it is now possible for seed of these varieties to be marketed in any Member State.
To date, no GM crops have been grown commercially in Ireland. Some herbicide efficacy testing was conducted on herbicide tolerant GM sugar beet varieties in the late 1990’s (Mitchell, 2000). While no GM crops have been grown commercially, some GM-derived products have been imported for inclusion in food and feed such as soya meal and oil from oilseed rape.

Only some GM crops are likely to be relevant for commercial cultivation in Ireland and, of those, only certain GM traits will be of benefit to Irish farmers. The Irish climate is not suitable for the growing of soyabean and cotton, while many of the insect pests of other crops for which resistance has been developed, are not prevalent in Ireland.

The area planted to maize and oilseed rape in Ireland is a relatively small proportion of the tillage area and a minor proportion of the overall agricultural land, so arable crops are generally well dispersed between farms but with some concentrations in the east and south of the country. Only the herbicide tolerant crops such as maize, sugar beet and oilseed rape are likely to be of interest to Irish growers in the short term, although the range could expand significantly over the next 10 – 15 years. This expansion could include possibilities such as:

(i) The application of GM technology to a wider range of crop types suitable for Irish conditions such as GM wheat and GM potatoes giving improved yield and quality.

(ii) A range of more valuable agronomic traits, such as resistance to common pests (e.g. aphid vectors of virus diseases) and diseases (e.g. potato blight, fusarium in cereals), or improvements in the efficiency with which crops can assimilate nutrients.

(iii) GM foods with consumer benefits, such as longer shelf life, or health benefits, such as improved nutritional content or reduced allergenicity.

(iv) A wide range of non-food crops, which could include the production of pharmaceuticals, industrial oils, renewable materials and crops which could be used directly in the production of energy and fuel. Production for fuel could become increasingly attractive in the event of more favourable revenue conditions applying to biofuels.

1.4 Future development of GM crops

Antibiotic resistant marker genes are currently used to identify where in the genome the new gene has been implanted. These genes are linked to the gene introduced to create the GM plant, hence, testing for antibiotic resistance can be used as an easy way of testing for the presence of the transgene. The EU has decreed that the use of antibiotic resistance marker genes are to be phased out for use in GMOs due to concerns that they may have adverse effects on health and the environment.

The use of GM technology in crops does not necessarily have to involve the addition of new genetic material from an outside source. Currently scientists are researching different approaches, which include:
- Using a transferred gene to accelerate conventional breeding, then eliminating it before commercial use of an approved variety.
- Modifying plants with variants of their own genes and/or regulatory processes.

Other approaches include -
- Using ‘Clean vector’ technology, where imported, non-payload DNA is eliminated.
- Introducing the pay-load gene into a plant organelle that does not disseminate through pollen flow.
- Altering the flowering time of a GM plant, thus reducing the risk of cross-pollination with its non-GM neighbours.

The possible timescale for the commercialisation of GM crops was outlined in March 2003, in which the Joint Research Centre (JRC) of the European Commission published a review of GMOs under research and development and in the pipeline in Europe (Lheureux, et al 2003). The earliest timescale for commercialisation of GM crops in Europe was broadly divided into three groups:

(i) Crops at the most advanced stage of development:
   - Herbicide-tolerant maize, oilseed rape, sugar beet, fodder beet, soya bean, cotton and chicory
   - Insect-resistant maize, cotton, potato
   - Modified fatty acid content in oilseed rape, and modified starch content in potatoes
   - Modified fruit ripening
   - Modified colour/form of flowers

(ii) The second group with potential to be commercialised include:
   - Herbicide resistant wheat, barley and rice
   - Fungi-resistant wheat, oilseed rape, sunflower and fruit trees
   - Virus-resistant sugar beet, potato, tomato, melon and fruit trees
   - Modified starch content in maize,
   - Modified fatty acid content in soyabean
   - Modified protein content in oilseed rape, maize and potatoes
   - High erucic acid content in oilseed rape

(iii) The third group are not expected to be commercialised within the next 10 years and include:
   - Tolerance of abiotic stress factors such as low temperature, salinity and drought. These traits may be used in a broad range of crops but particularly in cereals, grasses and potatoes
   - GM plants with enhanced yield (all crops)
   - Development of health related ingredients in crops such as tobacco, maize, potato and tomato
- Enhanced ‘functional’ ingredients in plants (e.g. higher vitamin content) in crops such as rice and vegetables to prevent nutrition-related diseases in humans
- Use of plants as bio-reactors for the production of a broad range of high value substances (e.g. substances for bio-remediation)
- Modification of tree lignin content
- GM hypoallergenic crops

While a number of these crops and GM traits will not be relevant to Irish agriculture, the timescale for the introduction of those that are, is unlikely to be significantly different from that of other EU Member States should suitable markets develop over time. However, given the level of consumer sentiment opposed to the introduction of GM crops in many EU Member States, the proposed timescale, especially for food-based crops, is likely to be considerably extended.

1.5 Concerns relating to GM crops

The objections to the use of genetic modification in the production of agricultural crops are several. The main concerns over the use of GM crops centre on their implications for food safety and human health, environmental effects and the general ethics of transferring genes, particularly between non-related species. They revolve around issues of: - who benefits? - what is their effect on the environment? - what is the effect on human health when they are consumed? Many of the GM crops now being grown around the world have been engineered for traits that benefit the economic return from production – such as Bt maize, which is resistant to the corn borer pest, or the ‘Roundup Ready’ crops, which are tolerant to the herbicide ‘glyphosate’. Unlike other applications of transgenic technology, these benefits are perceived to be more limited and mainly to the advantage of the grower, while the advantages to wider society are perceived as being less clear.

One of the main concerns centres on the possible lack of stability in the GM plants created, both in relation to food safety and the stability of plants in the environment. Issues such as the potential for novel molecular interactions, which may fall outside our current scientific knowledge, have also been highlighted. The issue is further complicated by the use of gene-stacking and their possible interactions over time, in particular, as plants respond and adapt to different environmental conditions, giving rise to altered expression of their genes.

Some have questioned whether the current level of testing as carried out under EU regulations is sufficiently robust to identify possible food safety or environmental issues. Concern has been expressed that the absence of evidence of harm should not be treated as evidence of the absence of harm. Food safety scares in recent years have heightened public awareness of unforeseen developments in food safety and diminished public confidence in scientific and other authorities to anticipate and prevent such scares. While many millions of hectares of GM crops have been grown without difficulties arising over the past nine years, some argue that this period is not sufficient to come to a definitive conclusion on their stability and overall safety.
1.5.1 Human health concerns

Human health concerns have arisen over the possible long-term effects that may arise from the bringing together of gene combinations not occurring naturally in the environment. In particular, concern has been expressed at the possibility that GM foods may be more toxic or carcinogenic compared to food derived from conventionally produced crops. The issue of transgenes surviving digestion and establishing or recombining with genes in the host genome, especially in the gut microflora, has also been highlighted. The possible decrease in the nutritive value, or the occurrence of anti-nutritional effects of GM food have also raised concerns, but in general this has been offset by the potential for improved nutritive value or medical applications from certain GM products.

The use of antibiotic resistance marker genes in plant genetic modification has given rise to concerns about the possible risk to human health due to these genes decreasing the effectiveness of prescribed antibiotics through the establishment of antibiotic effects in the food chain. The possibility of increasing and unpredictable exposure to allergens and toxins through new gene combinations has also given cause for concern. These concerns also relate to animals through the consumption of GM derived animal feed and the possibility that such harmful impacts could subsequently be transferred to humans who consume such animal products.

1.5.2 Environmental concerns

Some of the primary concerns with regard to the environment, centre around whether GM crops will be invasive and establish themselves outside the confines of their normal cultivation, thereby developing into ‘superweeds’, capable of reproducing and increasing population size exponentially. Genes conferring herbicide-tolerance might also migrate to other cultivated crops or to their wild relatives, thereby reducing the range of herbicides available to give effective control. There is concern that GM herbicide-tolerant crops will encourage farmers to use more broad-spectrum herbicides to achieve total weed control. This may lead to a reduction in food sources for insect and bird life at critical times of the year and thereby result in a reduction in overall biodiversity.

Other concerns relate to whether GM crops will give rise to the development of resistance in pests and diseases, which would then prove difficult to control using conventional methods. The question has also been raised as to whether GM plants will be poisonous to non-target species including herbivores, pollinators, soil inhabiting organisms and biological predators.

1.5.3 Economic concerns

While the production of GM crops may give rise to certain direct economic return in the form of increased yield, improved quality due to control of pests or reduced input costs, concern has been expressed that any such economic return will be more than offset by a reduction in market value of the produce of GM crops. In addition, concern has been expressed that the cultivation GM crops in a region may lead to a reduction in the value and competitiveness of conventional and organic crop produce from that region. The ability of non GM crop growers from a GM crop-growing region to market their produce may also be diminished due to a reduction in the number of market outlets available. The perceived benefits in relation to
increased yield, improved quality and reduced input costs have also been questioned as short-term gains, which may not be maintained over time. In particular, the initial savings in the use of pesticide inputs following the introduction of a GM crop, have been shown to diminish over time. (Benbrook, 2004).

1.6 Benefits of GM crops

1.6.1 Human health benefits

Genetically modified organisms have been used in food and pharmaceutical production for over 30 years. For example, rennet, used in cheese making, is no longer sourced from the stomach of calves but is produced by genetically engineered bacteria. Insulin, for the treatment of diabetes, is obtained from genetically engineered microbes as opposed to donated human pancreases. The human health benefits accruing when the technology is applied in a confined, controlled manner have been largely welcomed.

GM crops may be used to produce safer, nutritionally enhanced foods by removing or decreasing anti-nutritional factors, toxins and allergens. They may also be used to introduce or increase health-promoting factors, or modify the ratios of macro- or micro-nutrients. GM crops may also offer an alternative approach for the production of chemical pharmaceuticals. The use of GM bananas as a production and delivery system for Hepatitis B vaccine is one such development.

The EU 6th Framework research project ‘LIPGENE’ aims to develop approaches to combat the increasing levels of hypertension and coronary heart disease in the European population, through dietary means including supplementation with beneficial fish oils such as Omega-3. These fish oils are implicated in the reduction of blood cholesterol levels, associated high blood pressure and coronary heart disease. The increasing demand for such fish oils cannot be met in a sustainable manner from current fish stocks. Part of this research involves the development of a genetically engineered linseed variety, designed to produce the Omega-3 oils usually found in fish.

In the longer term, scientists see potential for using GM technology to improve the nutritional profile of certain foods by removing genes that code for allergenic compounds, such as those found in peanuts or common allergens found in grasses.

1.6.2 Environmental benefits

Some economic benefits may also result in environmental benefits – such as a reduction in the use of pesticide inputs. There is also scope for using herbicide products with a more benign toxicity profile, or an improved environmental profile.

The development of GM crops that can be grown in adverse conditions (high salt, drought susceptible conditions, etc.) and utilise water and nutrients more efficiently, reduces the dependency on non-sustainable intensive high input agriculture. This is particularly important where such adverse conditions exist and where water is in short supply.
Bio-remediation of land polluted with heavy metals is now possible using GM crops, which have been engineered so that they can ‘fix’ the heavy metals in their roots, after which they can be harvested and the heavy metals removed. This technology has yet to be commercialised.

Genetic diversity is being eroded by the widespread introduction of commercial crop varieties and the trend towards monocropping. One solution has been to store germplasm (seeds, cuttings etc.) from local varieties and wild species in genebanks, to give breeders access to this material. GM technology could supply useful traits, transferred from these genebanks directly into existing varieties, thereby increasing genetic diversity, a possibility currently being researched within the EU.

While proponents of the biotech industry frequently cite the reduced applications of pesticides as one of the main advantages of using GM crops, the evidence to support this is largely inconclusive. Theoretically one would expect a considerable reduction in the overall quantity of pesticides used. In Canada, research published in ‘Pest Management Science’ (cited in AgraFood Biotech, Issue No 139) showed a decrease of 42.8% in the amount of herbicide used in herbicide resistant GM canola in the years 1995-2000. However, a recent survey conducted in the US (Benbrook, 2004) indicated that while there was an initial reduction in the quantity of herbicide used in the first three years following the introduction of herbicide-tolerant crops of GM soya, maize and cotton, the rates of herbicides used subsequently increased. This resulted from an increase in resistant weed species and a reduction in the price of competing herbicides. However, the amount of insecticide used decreased over the nine-year period of the survey.

Any claims made in relation to pesticide use need to be determined on a case-by-case basis and will depend on a number of factors including rates of use on existing conventional crops, price relativity of pesticide products, value of crop, climatic conditions in individual years, relative toxicity of pesticide products, build-up of resistant weed species, etc. Definitive conclusions in relation to pesticide use in GM cropping will not become clear until a longer-term perspective is available and the indications at present are that implications may be positive or negative depending on crop, season, GM trait and pesticide programme used.

1.6.3 Economic benefits

Enhanced economic return will be one of the primary incentives for a farmer to grow a GM crop. The reduction in soil cultivations associated with GM cropping, has led to the improvement of soil conditions with a reduction in soil erosion and also an improved profile of beneficial soil organisms. Other benefits include improved crop yield and quality, either directly or through a reduction in pest damage and reduced mechanical cultivation inputs such as mechanisation and energy. GM crops are also being developed which can be cultivated in adverse environmental conditions (e.g. high salt, high acid soils, etc.).

Current evidence suggests that the above benefits depend very much on the GM crop being cultivated. In particular, any advantages arising in the case of reduced pesticide use, or improved toxicity or environmental profile of these pesticides, are likely to be crop specific.
1.7 The EU regulatory framework on GMOs

1.7.1 The EU response to public concerns

In 1998, a number of EU Member States expressed concern at the inadequacy of the appraisal procedures for GM products and requested the EU Commission to develop an enhanced risk evaluation procedure to examine each GM food, feed or crop prior to their being placed on the market within the EU. The procedure was designed to address the food safety and environmental concerns, taking a precautionary, science based, case-by-case approach to regulatory approval.

Pending the finalisation of such a procedure, a ‘de facto’ moratorium was placed on the authorisation of new GM products and as a consequence no new GM food, feed or crop variety was approved until this risk evaluation procedure was fully operational. The moratorium ended with a resumption of approvals of GM events in July 2004.

The EU has responded to these concerns by introducing a series of legislative measures in the period 1998 to 2003. This strengthened regulatory process has now been adopted by EU Member States. The main aspects of this legislation are outlined as follows:

**Directive 2001/18/EC** (Appendix 2) sets out the rules governing the deliberate release of GMOs into the environment. It puts in place a step-by-step approval process, based on a case-by-case assessment of the risks to human health and the environment before any GMO or product consisting of, or containing a GMO, can be released into the environment or placed on the market. [This Directive has been transposed into national legislation in Ireland in SI 500 of 2003. (Appendix 3). (CA: EPA)].

Of particular relevance to coexistence in Directive 2001/18/EC (as inserted by Article 43 of Regulation 1829/2003), is Article 26a, which provides for the setting of guidelines on the coexistence of GM crops with non-GM crops. The implementation of coexistence measures has been left to each Member State to address individually. To assist Member States, the Commission has adopted guidelines in the form of Commission Recommendation 2003/556/EC.


**EU Regulation 1829/2003 on GM Food and Feed** sets down the procedure for the authorisation, labelling and traceability of GM food and feed and updates the provisions of EU Regulation 258/97 concerning novel foods and novel food ingredients. (CA’s: FSAI, DAF)

**EU Regulation 641/2004/EC** sets down detailed rules on the implementation of the labelling and traceability Regulation 1829/2003.

**EU Regulation 1830/2003** introduces a more transparent authorisation procedure for GM food than its predecessor (Regulation 258/97) and a single authorisation procedure for feed consisting of, containing, or produced from GMOs. It also sets down the requirements for the Traceability and Labelling of GMO products, including food and feed products derived from
GMOs. [SI 424 of 2004 provides national implementing powers in relation to GMOs in animal feedstuffs – further SIs are being drafted in relation to foods and other products. (CA’s: EPA, FSAI and DAF)].

**EU Regulation 1946/2003** on the transboundary movement of GMOs, sets down procedures on prior informed consent in relation to the export of GM products, as provided for in the Cartagena Protocol. [National implementation of the EU Regulation is facilitated by SI 54 of 2004. (CA’s: EPA, FSAI and DAF)].

**Directive 98/95/EC**, amending the various Seeds Marketing Directives, sets down certain conditions for the marketing of seed of GM varieties, in particular that the GM event must be authorised under the appropriate procedures, and that packages of the seed must be clearly labelled as being GM. (Appendix 4)

### 1.7.2 Regulatory process for the authorisation of a GM variety for production and marketing within the EU

Directive 2001/18/EC together with EU Regulation 1829/2003 are key parts of the framework to approve and market GM crops and GM foods and feed in the EU. The authorisation procedures under the Directive and the Regulation are complementary.

In general terms, companies seeking authorisation to market a GM variety or food product must first submit a notification to the Competent Authority (CA) in the Member State in which it is first proposed to market the product. This must include a scientific assessment of the impact on human, animal and plant health and the environment.

The approval process operates on a Community-wide basis and involves the CA’s of all Member States and the European Food Safety Authority. The procedures seek unanimity in decision-making. However, should unanimity not be achieved, the proposal comes before a Regulatory Committee comprising of all Member States for decision under qualified majority voting. Should a decision not be possible at the Regulatory Committee, the proposal is referred to a meeting of the Council of Ministers at which a decision on the basis of qualified majority voting is taken within three months. Where a decision to accept or reject the application cannot be achieved at Council, responsibility for a decision on the product reverts to the European Commission.

### 1.7.3 Regulation of GMO movement between countries outside of the EU

Ireland and the EU are parties to the Cartagena Protocol on Biosafety to the Convention on Biological Diversity, which entered into force on 11 September 2003. The overall purpose of this United Nations agreement is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking into account risks to human health, and specifically focusing on transboundary movements.

The implementation of the Cartagena Protocol on Biosafety under EU legislation relies on a wide range of biotechnology legislation applying to the use of GMOs within the European
Union, including imports. The central part of the legislation on transboundary movement of GMOs, in addition to Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms, is Regulation 1946/2003/EC on transboundary movements of GMOs. Due to the operation of the single market in the EU, underpinned by Community-wide decision-making in relation to GMOs, the provisions of the Protocol in relation to import and export apply to movements between the Community and non-Member States but not to movements between Member States.

The main elements of the Regulation are:

- The obligation to notify exports of GMOs intended for deliberate release into the environment and secure express consent prior to a first transboundary movement.
- The obligation to provide information to the public and to our international partners on EU practices, legislation and decisions on GMOs, as well as on accidental releases of GMOs.
- A set of rules for the export of GMOs intended to be used as food, feed or for processing.
- Provisions for identifying GMOs for export.

1.8 National policy and responsible Departments/Bodies

Public policy on biotechnology in Ireland was set out in a Report prepared by the Inter-Departmental Group on Modern Biotechnology published in October 2000. The Group included representatives from the Department of Enterprise, Trade and Employment (DETE) (Chair); Department of Health and Children (DHC); Department of Agriculture, Food and Rural Development; Department of the Environment and Local Government (DELG); Food Safety Authority of Ireland (FSAI); Enterprise Ireland; Forfas and the Department of Education and Science.

The overall conclusion of the Report was summarised as ‘a positive acceptance of the potential benefits of biotechnology tempered by a precautionary approach to the potential risks...... and to ensure that, so far as is possible, the benefits of biotechnology are maximised and the risks minimised without compromising on safety for people and the environment’.

The Inter-Departmental Group based this policy principle on four main considerations:

- an appreciation of the long-term strategic importance of biotechnology
- an acceptance of the need for a precautionary approach, guided by scientific principles and procedures, to the development and application of biotechnology
- a commitment to an independent, well resourced regulatory system operating on the basis of the best available scientific expertise and advice
- an acknowledgement of the need for more effective mechanisms of public information, communication and consultation on biotechnology.
Prior to the establishment of the Inter-Departmental Group, a national consultation debate was conducted under the auspices of the DELG focusing on GMOs and the environment and this led to the publication of the Report of the Chairing Panel on the National Consultation Debate on Genetically Modified Organisms and the Environment (1999). Based on this Report, the Minister for the Environment and Local Government issued a policy statement ‘placing primary emphasis on precaution, well grounded in scientific assessment and management’.

The adoption and use of modern biotechnology potentially impacts across a range of sectors. Arising from this, a number of Government Departments and agencies are involved in different aspects of regulation of, and policy formulation relating to, GMOs.

The **Department of the Environment, Heritage and Local Government (DEHLG)** is responsible for legislation in relation to the contained use of GMOs, the deliberate release of GMOs into the environment and transboundary movement of GMOs. The **Environmental Protection Agency (EPA)** is the national Competent Authority (CA) for the purposes of the EU Directives concerned.

The **Department of Agriculture and Food (DAF)** has responsibility in relation to the production of approved GM crops, including variety evaluation, the use of GM seeds, coexistence and GM produce in animal feedstuffs. The DAF is also responsible for the implementation of authorisation, labelling and traceability regulations relating to animal feedstuffs.

Protocols for the conduct of **variety evaluation** of genetically modified crop varieties have been prepared by the DAF. However, to date no GM variety has been submitted for evaluation with a view to inclusion in the National Catalogue of Agricultural Plant Varieties.

The **DHC** leads on GM foods, with the **FSAI** designated as the CA for the purposes of the EU Regulations on food. **Food safety** issues were examined in a report issued by the FSAI in 1999 and deals with the regulation and use of GMOs in the food chain.

The **DETE** is the lead Department in relation to the development of modern biotechnology in the context of ensuring that Ireland is competitive, forward looking and progressive in terms of the requirements of a knowledge-based economy.

The **Irish Council for Science, Technology and Innovation** (ICSTI), in response to the Chairing Panel Report on the National Consultation Debate on Genetically Modified Organisms and the Environment and the Report of the Inter-Departmental Group on Modern Biotechnology, established a task force of scientists, clinicians and industrialists to examine the information available on biotechnology and, in particular, genetic modification from a scientific, medical, political, economic and regulatory perspective.

In relation to agriculture, the ICSTI Report concludes that genetic modification has the potential to further reduce the use of chemicals for disease and pest control in crop production, to increase crop yields, and to develop crops that are tolerant to drought, non-optimal temperatures and poor quality soils. In addition, genetic modification has potential to improve the texture, colour, flavour and shelf life of a variety of foods. The Report also highlights concerns relating to the development of weed species, which may be difficult to
control, insects resistant to insecticides and an over-reliance on a small number of herbicides. Also issues relating to seed ownership and the potential impact on organic farming are noted.

A broad overview of the biotechnology industry – present position and future developments – with particular reference to Ireland, was published in 2000 (McGloughlin and Burke, 2000). The main areas covered include: crop production, animal biotechnology, the environment, industrial biotechnology, animal and human health, regulation and intellectual property issues.

1.9 The requirement to develop national coexistence measures

In the intervening period between the commencement of a de facto moratorium in 1998 and the authorisation of the first new GM event (Bt 11 sweetcorn for food use), which was approved for marketing under the new risk evaluation procedure in 2004, significant new GM legislation (see 1.7) was adopted under the co-decision procedure of the Council of Ministers and European Parliament (EP). This legislation is binding on all Member States. It establishes a risk evaluation procedure in relation to food/feed safety and also for the impact of GM food and feed and crop cultivation on the environment. It also covers labelling and traceability rules for GM food and feed, and specifies obligations placed on Member States when exporting GM products to Third Countries.

However, a number of issues are not addressed by the current legislation and include:

(i) What technical agronomic measures are required to grow GM crops alongside conventional and organic crops, to achieve the minimum practical adventitious presence in non-GM crops, while also ensuring thresholds for labelling GM content in non-GM crops are not exceeded?

(ii) What is the possible economic impact arising from admixture or cross-pollination between GM and non-GM crops?

(iii) What are the liability implications where thresholds for GMOs in conventional and organic crops are exceeded?

These are the main issues now referred to as ‘coexistence’.

In March 2003, the EU Commission stipulated that, given the diversity of landscapes, farm structures, climatic conditions and agricultural practices throughout the Community, coexistence was best left to each Member State to develop and implement its own management measures in accordance with the principle of subsidiarity. To give legal effect to this viewpoint, the Commission proposed the insertion of an additional paragraph to EU Directive 2001/18/EC on the deliberate release of GMOs into the environment. This paragraph was accepted by the EP and Council of Ministers as follows:

(Article 26a: Measures to avoid the unintended presence of GMOs

1. Member States may take appropriate measures to avoid the unintended presence of GMOs in other products.)
2. The Commission shall gather and coordinate information based on studies at Community and national level, observe the developments regarding coexistence in the Member States and, on the basis of the information and observations, develop guidelines on the coexistence of genetically modified, conventional and organic crops.

The Commission Guidelines set out a series of measures designed to assist Member States in drawing up their national strategies and best practices for the development of efficient and practical coexistence procedures. These Guidelines state, inter alia, that approaches to coexistence need to be developed in a transparent way, based on scientific evidence and in co-operation with all stakeholders concerned. They are intended to ensure an equitable balance between the interests of farmers of all production types. Furthermore, they state that management measures to facilitate coexistence should be efficient and cost-effective, without going beyond what is necessary to comply with EU threshold levels for GMO labelling. They should be specific to different types of crop, since the probability of admixture varies greatly from one crop to another. For example, for oilseed rape the probability of admixture is high, while for potatoes the probability of admixture is relatively low. In addition, local and regional aspects should be fully taken into account.

The Commission Guidelines also stipulate that farmers should be able to choose the production type they prefer, without imposing the necessity to change already established farming patterns in the neighbourhood. As a general principle, during the phase of introduction of a new production type in a region, growers who introduce the new production type should bear the responsibility of implementing the actions necessary to limit admixture.

Priority should be given to farm-level management measures and to measures aimed at co-ordination between neighbouring farms. If it can be demonstrated that these measures cannot ensure coexistence, regional measures could be considered (e.g. restriction on the cultivation of a certain type of GM crop in a region). Such measures should apply only to specific crops whose cultivation would be incompatible with ensuring coexistence in the region, and their geographical scale should be as limited as possible. Region-wide measures must be justified for each individual crop and crop type (e.g. seed production versus feed production of the same crop).

Continuous monitoring and evaluation and the timely sharing of best practices are indicated as imperatives for improving measures over time.
Chapter 2  Towards the development of a national strategy and best practice for coexistence of GM crops and non-GM crops in Ireland – the key issues

2.1  Position of other Member States and cross-border issues

In the preparation of this Report, the Working Group considered it imperative that measures in place are not only the most effective, but also that they can be amply demonstrated as such by reference to international best practice. In this regard, the Working Group was particularly cognisant of the strategies and measures being adopted in other Member States, as many of the issues relating to coexistence extend beyond national boundaries. To date, a number of Member States including Germany, Denmark, Italy, The Netherlands, Portugal, Luxemburg and Austria have set out arrangements for the coexistence of GM crops with non-GM crops while plans are well advanced in other Member States.

Under the subsidiarity approach to the development of measures for coexistence, difficulties may arise at the borders between states, especially where farm boundaries do not coincide with national borders. Therefore, the Working Group has worked closely with the Department of Environment, Northern Ireland (DOENI) and the Department of Agriculture and Rural Development, Northern Ireland (DARDNI) to harmonise the approaches to the coexistence measures introduced North and South. One of the primary objectives of this collaboration was to ensure compatibility of measures for farmers on both sides of the border. Since the Northern Ireland measures have not been finalised as yet, some additional work is still necessary in this area.

2.2  Possible GM crops for production in Ireland

One of the first tasks of the Working Group was to identify the crops of importance in Ireland for which there is significant GM research and development worldwide. Only some GM crops are likely to be suitable for cultivation in Ireland and of those, only certain traits will be relevant to Irish farmers. Hence, this Report specifically focuses on those crops for which there is potential for GM varieties to be cultivated in Ireland in the short to medium term.

The main agricultural crops with potential for future GM commercial production in Ireland include beet (sugar and fodder), maize, oilseed rape, potato, wheat and barley. Each of these crop types has varying potential for impact in relation to coexistence. Each crop type has its own distinctive characteristics of pollen production, dispersal and potential outcrossing, giving varying levels of gene flow (see Chapter 5).

(a)  Maize

Maize has increased in importance in Ireland in recent years. It has proven attractive to beef and dairy farmers as a source of high-energy forage with 11,583 ha of maize declared to the DAF in 2004 (Area Aid Unit, DAF) and a total area of 15,600 ha grown according to data from the Central Statistics Office. (CSO, 2004). The area planted to maize may increase if more suitable varieties for Irish conditions become available, although this could also be
influenced by the value of milk and beef post-decoupling. Of the genetically modified traits in maize to date, only herbicide tolerance will be of consequence in the short term.

(b) Beet

As sugar beet is grown under contract, there is little deviation in the total area planted each year. The area of sugar beet and fodder beet declared to the DAF in 2004 was 26,692 ha and 4,050 ha respectively. The area of sugar beet was 31,500 ha in 2003 according to CSO data. (CSO, 2004).

Research to date on transgenic sugar and fodder beet has centred on developing herbicide tolerant and virus resistant varieties. The development of herbicide tolerant sugar beet allows ‘total’ broad spectrum herbicides to be used to control weeds in a more efficient and timely manner and may therefore, prove an attractive prospect for Irish growers, as the currently employed chemical control methods are complex and can be less than satisfactory in some seasons.

(c) Oilseed Rape

Oilseed rape is a relatively minor crop in Ireland and cultivation has decreased significantly since 1998, when over 5,500 ha were grown. In 2004, the total area planted to oilseed rape was in the region of 2,000 ha (DAF, 2004). No official data is available for the area grown in 2005, but there is renewed interest in the production of oilseed rape for oil for biofuel and the area planted is estimated to be over 5,000 ha.

Significant research has been invested in GM oilseed rape, which is evident in the 367 notifications, which were lodged to the EU under Directive 2001/18/EC. The principal modifications of GM oilseed rape of interest to Irish farmers will be disease and insect resistance and enhanced oil content. The incorporation of delayed pod shatter would also be regarded as advantageous.

(d) Cereals

Cereals are the most important tillage crops produced on Irish farms. Total cereal production for food and feed is in the region of two million tonnes annually. Total cereal area declared for production in 2004 was 311,702 ha (DAF, 2004). Barley (mainly spring sown) accounts for more than 60 % of the total cereal area. Wheat accounts for over 30% while oat production ranks third at approximately 7%. There is a renewed interest in the production of triticale mainly as a low-input crop for whole-crop forage but total production is negligible. Triticale is of particular interest for organic cereal producers.

In terms of development of GM cereals, wheat is at the most advanced stage, examples of which include herbicide tolerance and fungal resistance. However, it is not expected that any application to grow GM wheat will be made in Ireland for the next 5-7 years. To date, there has been less research devoted to the production of GM barley or oats compared to wheat. In the medium term, research may concentrate on improving the malting and brewing characteristics of barley, while oats has certain nutritional and health attributes, which may attract GM research in future.
(e) Potato

Commercial potato production utilised approximately 12,600 ha in 2004 with over 300,000 tonnes of potatoes harvested annually. Production may be categorised into first and second early crops, maincrop and processing categories. No GM potato has been approved for placing on the EU market, however, a significant amount of field-testing has taken place, especially in relation to the modification of starch content. A potato variety with resistance to late blight (*Phytophthora infestans*) would be of particular interest to Irish farmers, given our favourable climatic conditions for the spread of potato late blight. Research on GM potato with resistance to late blight has proved promising and the appearance of GM potato in Ireland could be accelerated if a resistant variety became available.

(f) Field vegetables, fruit, protected and amenity crops.

Horticultural crops comprising field vegetables, fruit, protected crops (grown under glass or polytunnels) and amenity crops account for an important share of gross agricultural output. Horticultural crop production is positioned third in value after beef and milk. There is a significant level of research and development in GM technology in the non-food amenity crops sector at present.

2.3 Thresholds for the adventitious presence of GMOs

The Working Group, in considering its recommendations, was bound by the EU legislative provisions already in place in relation to GMOs. This legislation is formulated at EU level and is binding on all Member States. According to EU Regulation 1829/2003/EC, a threshold value of 0.9% for inadvertent admixture of EU authorised GMO events is set under which labelling as GM food or feed is not required. Where a product has a GMO content below 0.9%, it can then be marketed without labelling. The prime focus of the Working Group therefore, is to recommend measures to ensure that farmers growing non-GM crops will be able to produce harvested crops with as low a GMO content as practical, and at most, contains less than the 0.9% GMO content above which labelling is required.

Before proposing specific measures, it is necessary to consider the routes whereby GMOs may appear in harvested crops where non-GM seed is sown. These include the:

(i) adventitious presence of GM seed in non-GM seed

(ii) GM plants establishing from the soil seed bank

(iii) cross-pollination from nearby GM crops, volunteers or wild relatives that contain the GM constructs and,

(iv) transfer of seed through physical or mechanical means

The aim of the Working Group is to assess the magnitude of GMO presence expected via particular routes and to ensure that the nearby GM crops are managed accordingly, such that the GMO content in the non-GM crop is kept as low as possible and at most, within the threshold.
The Working Group must first consider the adventitious presence of GMOs in seed, as this represents the baseline from which coexistence measures are determined. In order to meet the labelling threshold requirement of 0.9% in GM products, maximum threshold levels for the adventitious presence of GMOs in seed are to be set at lower levels by the EU. These provisions on threshold values will be included in the directives on the marketing of seed. The consequence will be that seed with a GMO content exceeding the threshold value must be labelled as GM when sold. These values must be set so that it is possible to meet the maximum threshold value for the labelling of feed and food and that a number of possible sources of admixture in the production route from seed to food/feed are taken into account.

There is a wide divergence of opinion among Member States regarding the level at which GMO maximum thresholds should be set for seed. The EU Commission propose thresholds in seed that are ‘agronomically possible and economically viable’. Accordingly, the Commission has proposed maximum threshold values for adventitious presence in cross-pollinated species at 0.3% and for self-pollinated species at 0.5%. These thresholds have, however, yet to be agreed by Member States.

In the compilation of this Report, the Working Group examined conventional seed production in terms of the necessary management measures to ensure that the harvested crop is within the proposed thresholds i.e. 0.3% and 0.5%. If the proposed threshold values are altered by the EU, this will change the pre-conditions for coexistence and hence some of the measures recommended by the Working Group will require further consideration.

Under the organic farming regulations, the use of genetically modified organisms is not permitted for the production of organic produce. Concerning seed, point 2.2.3 of Regulation (EEC) No 2092/91, states that "The organic farming regulation establishes that no GMOs shall be used in production. Thus, materials, including seeds, which are labelled as containing GMOs cannot be used. However, seed lots containing GM seeds below the seed thresholds (which would not need to be labelled for this GMO presence) could be used. The organic farming regulation does allow for the setting of a specific threshold for the unavoidable presence of GMOs, but no threshold has been set. In the absence of such a specific threshold, the general thresholds apply."

For the purposes of this Report, the Working Group has, therefore, applied the general seed thresholds to the production of organic seed. Consequently the production of organic seed crops are treated no differently than conventional seed crops in this Report. However, it is possible that a lower threshold will apply to the production of organic seed, should specific regulations pertaining to organic seed be introduced. If/when this transpires, it will necessitate a re-evaluation of the measures proposed in relation to organic crops.

2.4 GM crops – issues and implications for existing farming practices

Changes to current farm management practices are inevitable if GM crops are to coexist successfully with conventional and organic farming. In devising a strategy for coexistence, the Working Group attempted to put in context the implications for existing farming practices in order for conventional and organic crop production to successfully coexist, if/when GM crops are introduced. In doing so, the Working Group examined the potential or ‘risk’ for GM gene dispersal within current Irish cropping systems. In this regard, crop specific gene
dispersal, the distribution of crops including organic, extent of GM cropping, farm size, fragmentation and land rental/lease are all important factors.

2.4.1 GM crops and existing farming practices – the issues

2.4.1.1 Crop-specific gene dispersal

The ability of a crop to disperse its genetic material (gene dispersal/flow) is principally mediated through pollen transfer and/or seed dispersal. The potential for pollen-mediated gene dispersal depends not only on whether the crop is self- or cross-pollinating, but also on the crop species, as cross-pollinating crops differ in their propensity to disperse pollen.

Seed-mediated gene flow typically occurs over shorter distances than pollen, although it can occasionally occur over very long distances through mechanical or water transfer. For coexistence, an equally important dispersal route is the persistence of dormant seeds in the soil, allowing gene-flow over both time and distance.

The following is a summary of the potential for gene dispersal through pollen and seed for each of the crops covered in this Report (see Chapter 5).

(a) Oilseed rape

Oilseed rape is both cross- and self-pollinating and presents a high risk for cross-pollination between source and recipient fields and also has the potential to outcross with a number of wild relatives indigenous in Ireland. Pollen dispersal in oilseed rape can occur both by insects and by air flow. There has been little or no seed production in Ireland in recent years.

Oilseed rape poses a high risk of seed loss through pod shatter both before and at harvest and also dispersal via agricultural and transport equipment, due to the small size and spherical shape of the seeds. This is further underlined by the ability of oilseed rape populations to compete and persist in agricultural and non-agricultural habitats, giving rise to high populations of volunteers for several years post-harvest and feral populations in non-cultivated areas. Ireland’s temperate climate also encourages the germination and survival of oilseed rape plants over winter giving rise to significant populations of volunteer plants in following crops.

(b) Sugar/fodder beet

Beets are grown as vegetative crops in Ireland and present a low to medium risk for cross-pollination both with other cultivated beet crops and wild relatives. Beet crops are biennial and grow vegetatively in the first year and do not normally flower within the annual harvesting regime. However, some plants (bolters\(^1\)) will flower (< 1%) giving the potential for limited gene flow from the beet crop but these can be controlled by removal before flowering. As there is no commercial production of beet seed in Ireland, there is little risk of cross-pollination with cultivated crops and the subsequent production of viable progeny.

\(^1\) Bolters are beet plants that flower and produce seed in the first year of their biennial life cycle
Beet poses a medium risk of gene dispersal through seed. Beet plants can over-winter and flower the following year dependent on temperature. While the survival of such plants is limited, they constitute a potential source of persistence and dispersal. The size of the pollen source, corresponding to the number and density of bolters, is of great importance and the extent to which they are controlled will determine the potential degree of dispersal. Bolters are also a potential source of pollen for cross-fertilisation with wild beets. Complete control of bolters in GM crops will be crucial to achieving coexistence with non-GM beet.

(c) **Maize**

Maize presents a low - medium level of risk for cross-pollination with other maize crops. The crop cannot outcross with any other crop and does not have any wild relative growing in Ireland. There is no maize seed produced in Ireland.

As the Irish maize crop is harvested for forage, the crop presents a low risk of seed dispersal. Additionally, maize is a weak competitor outside cultivation and has a poor survival rate over winter and in succeeding crops in the rotation.

(d) **Potato**

Potato is a tuber crop and presents a low risk of gene flow. There is a significant production of potato ‘seed’ in Ireland but this is produced vegetatively as tubers. In addition, potato cannot outcross with any other Irish crop or wild relatives.

There is a low risk of seed/tuber dispersal with potato. However, dispersal in time poses a significant risk through groundkeepers, which could be a source of admixture for several successive years. The establishment of plants and tubers from ‘true seeds’ is not regarded as a major problem, due to low levels of seed formation in most varieties and a low level of establishment of such true potato seeds.

(e) **Cereals**

Cereals are mainly self-pollinating and present a low risk of cross-pollinating with other plants. Wheat and barley are not known to outcross with wild relatives and form viable seed, however, cultivated oats has the capacity to cross-pollinate with wild oats (*Avena fatua*), which is a common weed in Ireland.

Cereals present a high risk of seed-mediated gene flow as cereal seed is easily lost during harvesting, handling and transportation. Cereal seed may persist in the seed-bed for up to 3-4 years if left uncultivated, although most seed remaining on the soil surface will germinate in the weeks after harvest.

2.4.1.2 **Distribution of conventional crops**

The last full Census of Irish Agriculture (June 2000) recorded a total of 141,527 active farm units in the country and showed the vast majority of farms were involved in the production of livestock, either in beef, dairying or sheep production. Specialist tillage farms accounted for only 3%, while mixed crops plus livestock farms accounted for a further 3% (Figure 2.1).

2 True seeds are occasionally formed in some varieties through cross-pollination but are generally sterile
The total area farmed in 2003 was 4.4 million ha consisting of a total of 136,500 farm units, giving an overall mean farm size of 32.23 ha. Approximately 10% of the total area was sown to crops, fruit and horticulture.

Area Aid Applications to the DAF provide an indication of the number of farmers and area grown on an individual crop basis. Applications to DAF for cereal production in 2004 were in excess of 15,000 and represented all 26 counties. Since the early 1990’s, the geographical incidence of tillage has become concentrated, with specialised tillage farms most significant in north Dublin, Louth, south Kildare, south Cork and south Wexford. Counties Wexford and Cork account for over 30% of the total production area, with significant production in counties Kildare, Meath, Tipperary, Louth and Kilkenny.

**Figure 2.1** Breakdown of farms by production type

![Farm Production Type](image)

Source: Central Statistics Office, Census of Agriculture, 2000

Maize was grown mainly on mixed enterprise farms and production was concentrated in the east, south-east and south of the country (DAF, 2004). Production was highest in Cork (23.6% of total area) with Meath accounting for 12.7% of total area and Wexford and Waterford accounting for 9.7% and 9.2% respectively. Counties Tipperary, Kilkenny and Louth each accounted for over 5% of total area.

In 2004, 2,965 growers in 19 counties grew sugar beet (DAF, 2004). Sugar beet production was concentrated in the east and south of the country with Wexford and Cork accounting for 54% of total sugar beet production area. Fodder beet production is concentrated in the south and east of the country and 4,050 ha of fodder beet was declared in Area Aid Applications to the DAF by 1,122 applicants in 2004.

Potato crops totalling 12,604 ha, were grown by 732 commercial growers in 24 of the 26 counties in 2004. However, potato production is highly concentrated in a few counties and the trend towards further concentration is continuing. Leinster accounts for 75% of the production area with 58% of total production area located in Meath, Dublin and Louth. In 2004, 150 of the largest growers accounted for 76% of the total production area (Bord Glas National Potato Census, 2004). The counties with the highest number of potato growers are located in Donegal, Cork and Wexford.
A total of 127 oilseed rape growers, with a mean area of 15.8 ha per grower, applied to DAF for arable area aid in 2004 on a total of 2,001 ha. Oilseed rape was grown in 14 of the 26 counties with Meath, Wexford, Louth and Westmeath growing in excess of 100 ha each. Meath, Wexford and Louth had 22, 42 and 26 growers respectively, while other counties had only 7 farmers or less sowing the crop.

2.4.1.3 Distribution of organic crops

The total area of land devoted to organic production is c. 30,000 ha, which represents 0.7% of the farmed area of the country. This is considerably lower than the EU (15) average of 3.5% in 2002. The vast majority of organic farmers are livestock producers with beef and sheep as the major enterprises.

A census of organic operators taken by the DAF in 2002 (DAF Census of Irish Organic Production, 2002) identified 923 organic producers registered in Ireland. The sector is concentrated in the south and west of the country, with Munster and Connacht accounting for three-quarters of all organic producers (Figure 2.2).

There were 139 growers of organic crops, (some producing a number of crops), widely dispersed throughout the country: 77 producers growing vegetables, 40 growing cereals, 30 growing potatoes and 22 producing fruit. The total area devoted to organic crop production was 618 ha. The average crop area was 10.4 ha for cereals; 3.8 ha for potatoes; 1.5 ha for vegetables and 0.4 ha for fruit crops. While there was no breakdown available of what forage crops are grown on organic farms, there is little/if any organic cultivation of oilseed rape, beet and maize. There is some market gardening activity in the production of other members of the Chenopodiaceae family i.e. beetroot, spinach and chard. There were c. 3.6 hectares of protected cropping (polytunnels and glasshouses) of salad crops and fruit.

Organic cereal production is centred in Wexford (18% of all cereal producers), Kildare (13%) and Tipperary (13%). The main counties for organic vegetable production are Cork (16% of all vegetable producers), Galway (12%), Wicklow (9%) and Clare (9%).

Figure 2.2 Location and percent of registered organic growers

Source: Central Statistics Office, Census of Agriculture, 2000
2.4.1.4 Farm size, fragmentation and land rental/leasing

While the majority of Irish farms are farmed by the land-owner, there is a significant proportion of land ‘rented-in’ by farmers in the tillage growing areas. Much of this land is rented on a short-term annual basis and may involve several leaseholders over time. The location and percent of rented-land farmed to owned-land farmed is outlined in Figure 2.3, while a breakdown of rented land by farm numbers and size is detailed in Table 2.1.

**Figure 2.3** Percent of farmed land rented

![Percentage of the Agricultural Area Used (AAU)]

- 30 – 37%
- 20 – 30%
- 13 – 20%

Source: Central Statistics Office, Census of Agriculture, 2000

The use of rented land for farming has become more prevalent in recent years, with a significant proportion of land ‘rented-in’ in the main tillage growing areas. 41% of arable crops were grown on short-term rented land with a further 10% on long-term leased land (DAF, Area Aid, 2002–2004). Of the 4,736 ‘specialist tillage’ farmers, 46% had land rented (96,783 ha) in 2000 (CSO, 2000). The equivalent figure for ‘mixed crops and livestock’ farmers was 43% (41,979 ha). Specialist tillage farms had a greater proportion of the total holding as rented compared with mixed crops/livestock farms. 1,180 ‘specialist tillage farms’ had greater than 50% of the total holding rented compared with 492 for mixed crop/livestock farms. The number of farms with less than 50% of the total area of land rented was 982 and 1,079 for ‘specialist tillage’ and ‘mixed crops/livestock’ respectively.

**Table 2.1** Tillage farms with land rented-in

<table>
<thead>
<tr>
<th></th>
<th>Total Farms</th>
<th>Total ha</th>
<th>100% Rented</th>
<th>75%-99.9% Rented</th>
<th>50%-74.9% Rented</th>
<th>25-49.9% Rented</th>
<th>0-24.9% Rented</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specialist Tillage</strong></td>
<td>2,162</td>
<td>96,783</td>
<td>485</td>
<td>17,956</td>
<td>279</td>
<td>32,311</td>
<td>416</td>
</tr>
<tr>
<td><strong>Mixed Crops &amp; Livestock</strong></td>
<td>1,571</td>
<td>41,979</td>
<td>128</td>
<td>4,233</td>
<td>79</td>
<td>6,698</td>
<td>285</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

The relatively small farm size (by comparison with some neighbouring continental tillage growers) and the regular changes in tenant-owner leases, will require comprehensive monitoring and control in order to track crop changes between fields and thus enable coexistence measures to operate effectively. In addition, many Irish farm units are
fragmented, thus adding to the requirement to establish comprehensive tracking procedures. According to the CSO Census of Irish Agriculture 2000, just 28% of farms consist of a single parcel of land, with 18% of farms possessing 5 or more separate parcels of land (land parcel average is three). Undoubtedly, ongoing infrastructural developments will create a further permanent fragmenting effect on farm holdings.

2.4.1.5 Future extent of GM cropping

There are no GM crop growers in Ireland at present. Large-scale commercial GM cropping is highly unlikely in the short-medium term. Market take-up of GM crops will depend on a range of factors but is likely to be very slow initially. Take-up of any new crop technology tends to be gradual, as farmers experiment with the suitability of the technology for their own farm or, note the experiences on experimental or neighbouring farms. In addition, when a new crop becomes commercially available, it will take some time to develop varieties that are suitable for Irish conditions. Furthermore, with the present range of GM crops, there would appear to be only limited economic benefit to Irish farmers, while at the same time, there is little or no market demand for GM crop produce at present.

Sugar beet has been the only genetically modified crop cultivated in Ireland to date. This consisted of a trial conducted at a number of centres in the late 1990’s to assess crop tolerance following treatment with glyphosate. Trials involving genetically modified beet, maize, potato, oilseed rape, wheat, soybean, cotton, chicory and tomato have been carried out across the EU in recent years. GM maize has been the main crop grown commercially in the EU, mainly in Spain where 33,000 ha was planted in 2003 and 58,000 ha in 2004. The main GM trait relevant to the Spanish maize crop is insect resistance (European Corn Borer), an insect that is not prevalent in Irish maize crops.

Future developments in GM crops may have the potential to offer more wide-ranging options to both farmers and consumers in the longer-term. Possibilities include: GM crops with agronomic traits more suited to Irish conditions; GM crops delivering direct health benefits e.g. improved nutritional content; or non-food GM crops used as a source of energy, pharmaceuticals, vaccines, fibre and industrial feedstocks e.g. modified starch potatoes.

At present, where no GM crops are cultivated and where there is no demand for such produce, coexistence is not an issue. The extent to which GM varieties are grown in the future and their distribution compared with non-GM crops of the same or related species will influence the scale to which management practices on Irish farms may change.

2.4.2 GM crops - the implications for existing farming practices

2.4.2.1 Implications for conventional crop production

(i) The growing of GM crops is likely to be in regions where existing conventional counterparts are prominent.

(ii) Due to the fragmented nature of Irish tillage farms and a high degree of short-term land rental (conacre), the growing of GM crops in coexistence with non-GM crops will require a very high level of communication between neighbouring farmers. In
some cases, a GM crop grower will not be in a position to grow a GM crop independently of his neighbour while at the same time observing appropriate separation distances. Accurate records of rotation and other farm practices will be essential to operate coexistence successfully.

(iii) In the short-term, when the initial uptake of GM crops is likely to be low, it is envisaged that adjustment in crop rotations in order to comply with separation distances will be limited.

(iv) With more widespread cultivation of GM cereals, beet and potatoes, it is not anticipated that significant changes in cultivation practices will be required, as the separation requirement for these crops is low. However, widespread cultivation of GM maize and oilseed rape will require a significant management input for coexistence.

(v) In sites where a non-GM crop is grown after a GM crop, adherence to recommended time intervals and control measures will be essential to control GM-derived volunteer plants.

(vi) Seed purity and a code of practice regarding machinery hygiene, transport and the segregation of GM seed will be essential for coexistence.

(vii) Appropriate measures will need to be developed on a case-by-case basis for GM horticultural crops.

2.4.2.2 Implications for organic crop production

(i) Given the present low level of organic crop production, a limited introduction of GM crops should not pose a significant risk to organic crop production in the short-term. In addition, the range of GM crops currently available for commercialisation (oilseed rape and maize) are not grown to any significant extent by the organic sector in Ireland.

(ii) Coexistence implications for organic farming from the introduction of GM crops in the longer-term will depend on:

a) The degree of expansion in organic farming units and the overall production area
b) The extent of production and number of growers of GM cereals, potatoes and other horticultural crops and,

c) A change in current organic production practices where organic production of oilseed rape, beet and maize may develop and where there is also cultivation of GM varieties of these species.

(iii) Where GM crop species are grown in proximity to their organic equivalents, similar adjustments in current farming practice, as those outlined for the coexistence with conventional production, will be necessary.
2.5 Stakeholder consultation

In accordance with the Commission Guidelines, which state: *national strategies and best practices for coexistence should be developed in cooperation with all relevant stakeholders in a transparent manner*, the Working Group provided all relevant stakeholders with an opportunity to contribute to the development of a coexistence strategy through a process of consultation. Stakeholders were invited, in writing, for submissions outlining the issues that affect them and their views in relation to the development of coexistence measures. Many of the stakeholders availed of the opportunity to meet with representatives of the Working Group to discuss the issues in greater detail. In addition to stakeholders formally notified by the Working Group, submissions were received from additional interested parties.

**Stakeholder Consultation on Coexistence**

*Submissions were received from the following stakeholders (Appendix 6):*

- Agricultural Consultants Association (ACA)
- Agricultural Science Association (ASA)
- Animal and Plant Health Association (APHA)
- An Taisce
- An T-ionad Glas Organic College, Dromcollogher, Co. Limerick
- Bord Bia
- BTEI, Tralee, Co. Kerry
- Cavan/Leitrim Environmental Awareness Network (CLEAN)
- Con Cremin, Ardaghs, Co. Limerick
- Dylan Keating, Fort William, Milford, Co. Cork
- Federation of Irish Beekeeping Associations
- Green Party
- Irish Cattle and Sheep Farmers’ Association (ICSA)
- Irish Doctors Environmental Association
- Irish Grain Assurance Scheme (IGAS)
- Irish Organic Farmers and Growers Association (IOFGA)
- Irish Seed Savers Association Ltd.
- Irish Seed Trade Association (ISTA)
- Kerry Earth Education Project
- Organic Trust Limited
- Scoil Nuachabhail, Co. Kerry
- Syngenta
- Teagasc
- The Consumers Association of Ireland
- Vegetable Unit, Oughterard, Co. Galway
- Vegetable Unit, Oughterard, Co. Galway
- Irish Farmers Association (IFA)
- Irish Sugar Ltd
- Leitrim Farmers Co-op
- Macra-na-Feirme
- Maize Growers Association
- Professional Agricultural Contractors Association
Meetings were held with the following:

- Animal and Plant Health Association (APHA)
- An Taisce
- Bord Glas
- Demeter Standards Ltd
- GM-Free Ireland
- Irish Cattle and Sheep Farmers’ Association (ICSA)
- Irish Doctors Environmental Association
- Irish Farmers Association (IFA)
- Irish Grain and Feed Association (IGFA)
- Irish Organic Farmers and Growers Association (IOFGA)
- Irish Seed Saver Association Ltd.
- Irish Seed Trade Association (ISTA)
- Leitrim Farmers Co-op
- Macra-na-Feirme
- Organic Trust Limited
- Teagasc

Stakeholder views specific to coexistence were wide ranging. All aspects were covered, examples of which include the following:

- Implementation strategy (voluntary/legislative basis) and degree of State control
- Crop-specific measures, such as cross-pollination, introgression with wild relatives, volunteer survival, seed admixture, harvesting and transport losses, etc.
- Zones of a single production type (GM-free zones)
- Issues specific to organic producers
- Measures to be developed based on scientific data
- Economic loss and liability
- Responsibilities of both GM and non-GM producers
- Consultation between neighbouring farmers
- Information provision and exchange
- Education and awareness
- Cleaning of machinery and segregation issues
- Issues regarding seed production and distribution
- Consumer choice
- Biodiversity
- Research and economic benefit

The Working Group, in the preparation of this Report, was charged with taking into consideration all the stakeholder issues and views raised during the consultation process with a view to developing the most appropriate coexistence policy that meets the interests of all those affected.

A significant number of the submissions received, from organic and environmental groups in particular, addressed wider issues relating to GMOs. Their concerns focus mainly on the broader issues including; scientific uncertainty in relation to food safety and the environment, concerns in relation to the democratic process, cost/benefit of GM crops, competitiveness and market aspects. These stakeholders are fundamentally opposed to the introduction of GM crops to Ireland and support a total ban on their introduction. While conscious of these concerns, many of the issues raised are outside the remit of the Working Group including issues relating to safety of GM food and environmental safety and, the policy decision of whether to grow GM crops or alternatively keep Ireland free of GM crops.

All stakeholder submissions are included in Appendix 6.
2.6 Research and coexistence

The European Commission has advised that management measures should be based on science and on the characteristics of the crop and the farming system. GM crops are unique not only in their production, but in the way they should be researched. Furthermore, research collected on a GM crop modified for one trait may not relate to the same crop modified for a different trait. For example, a potato variety modified for blight resistance and the same potato variety modified for herbicide tolerance, need to be assessed separately for food safety, environmental and economic impact on an individual basis.

Moreover, a universal system of crop management is not applicable to GM crop cultivation. Results from the UK Farm Scale Evaluation (FSE) trials (Firbank et al. 2003) and the Bright Project (Sweet et al, 2004) would indicate that the husbandry management must be flexible if the potential of the GM crop is to be fully realised, while at the same time minimising any negative impact.

Over the last 6 years, the EU, along with some individual Member States, have invested in GM crop research in order to gauge the short- and long-term impact of the technology. The European Science Foundation supported Assessing the Impact of Genetically Modified Plants (AIGM) programme (www.esf.org) is an example of such investment and demonstrates the potential of inter-disciplinary collaboration in addressing major issues in a transparent manner. The JRC is currently funding research on economic assessment of coexistence measures in the seed and crop production phases. Under the Community Framework Programme, research projects dealing with certain aspects of coexistence include SIGMEA and CO-EXTRA.

In the UK, the Department for Environment, Food and Rural Affairs has been actively funding GM crop research and development, culminating in expenditure of €8.8 million for the three-year FSE trials. Based on the findings from this research, the UK government reaffirmed the scientific opinion that there is no scientific case for a blanket ban of GM crops but that they must be considered on a case-by-case basis. (www.defra.gov.uk/corporate/ministers/statements/mb040309.htm)

From an Irish perspective, trials on herbicide-tolerant GM sugar beet were completed by Teagasc in 1998 (Mitchell, 2000). At present, Teagasc are assessing the potential economic and environmental benefit/risk of GM crop cultivation. This is in collaboration with the National University of Ireland, Maynooth and expands upon previous research completed with Trinity College, Dublin. An information resource (www.gmoinfo.ie) has been established to facilitate the dissemination of information from this work and provide answers to many of the questions frequently asked with regard to GM crops.

Whereas results from studies carried out internationally provided guidance to the Working Group, there are deficiencies in how these results may be applied in an Irish context, as the risk of admixture varies greatly and is dependent on local conditions and practices. Though a number of Irish based research programmes are currently underway, further research must be completed to investigate the coexistence of GM and non-GM crops from an Irish context. During the compilation of this Report, the Working Group highlighted several areas that necessitate further investigation, including research activities that improve our knowledge on how best to ensure coexistence and an examination of the balance between the potential
benefit associated with GM crop cultivation and the cost of adhering to coexistence measures in Irish farming systems.

2.7 Relevant experience of coexistence

The recommendations of the Working Group are primarily based on scientific publications specific to individual crops and the existing knowledge base derived from the multiplication of seed from individual crops through the Seed Certification Scheme.

The segregation of specific crops is a well-known concept in agriculture. The Irish Seed Certification Scheme minimises genetic admixture and maximises varietal purity through statutory measures in the regulation of seeds grown for sale. The DAF is the designated Competent Authority for Seed Certification in Ireland.

The EU Seeds Directives (Appendix 4) on regulations pertaining to seed crop production make provision for the marketing of conventional, GM and organic seed. These directives specify the minimum purity levels to be achieved depending on the species and the generational category. Measures required to attain the specified purity include minimum separation distances and time intervals between different seed crops and any other crop of the same species. Effective segregation during the harvesting, storage and seed assembly processes are also critical to the attainment of the required purity standards. National seed inspection and testing agencies enforce these regulations, and failure to meet the purity standards, results in the exclusion of the seed for certification and marketing and the loss of the seed premium to the grower.

These requirements for certified seed production were considered an appropriate guide for the development of best practices for minimising admixture in non-GM crops grown in proximity to GM crops. However, the specific technical management requirements laid down under Seed Certification would not, of themselves, be an appropriate blueprint for the purposes of maintaining crop purity for the coexistence of GM and non-GM crops for the following reasons:

- In seed certification, the responsibility of protecting the purity of the specific seed crop lies, to the greater extent, with the seed grower. From a coexistence perspective, the purity of the non-GM crops grown adjacent to GM crops are more dependent on the actions of the neighbouring GM crop growers i.e. third party involvement and hence the issue of liability.

- There is considerable variation between seed certification standards for varietal purity and those proposed for GM crop labelling.

- Verification of seed purity for certification is by way of visual field and laboratory inspection of morphological characteristics. The purity of non-GM crops i.e. the presence/content of GMOs, can only be verified by way of laboratory testing of the harvested produce.

In addition to the divergence of technical requirements/objectives between seed certification and that of the coexistence of GM crops with non-GM crops, there are other more general differences, including:
Seed production is a small-scale activity with premia to be gained and not comparable to bulk production of commodity crops.

While the production of seed is generally a high value crop and justifies the various additional inputs and costs, the production of commercial GM crops may not give rise to an economic return that would justify the additional costs associated with operating coexistence measures.

Seed growers are generally selected by seed assemblers for the production of seed of combinable crops. Under the Commission Guidelines for coexistence, all growers are free to produce the crops they choose for the general market.

In considering the above, it is clear that more appropriate safeguards to those prescribed for seed certification would be required for the coexistence of GM and non-GM crops. A number of other Member States have adopted a similar approach in developing their coexistence strategies. Nevertheless, the vast experience gained through the operation of the seed certification scheme has served as a relevant benchmark for referral, in devising crop management measures for coexistence as proposed in this Report.

2.8 Proportionality and financial implications of coexistence

Article 2.1.4 of the Commission Guidelines states that ‘measures for coexistence should be efficient and cost-effective, and proportionate’...and .. ‘they should not go beyond what is necessary in order to ensure that adventitious traces of GMOs stay below the tolerance thresholds set out in community legislation’. Furthermore, Article 2.1.4 goes on to state that ‘they (coexistence measures) should avoid any unnecessary burden for farmers, seed producers, co-operatives and other actors associated with any production type’. Article 2.1.7 states that ‘national strategies for coexistence should ensure an equitable balance between the interests of farmers of all production types’.

Adhering to coexistence measures will have a cost implication for a farmer intending to grow a GM crop. Ultimately, the decision to cultivate GM crops will be determined by cost/benefit, in which the costs of coexistence will be one of the deciding factors. In considering coexistence of GM crops and non-GM crops, there are many factors which have a bearing on cost. Whatever measures are implemented must, therefore, take account of the principle of proportionality and the need to adhere to EU law on competition.

The financial implications associated with the coexistence of GM and non-GM crops are discussed in more detail in Chapter 9.

2.9 Addressing economic loss arising from admixture

GM crops must obtain full regulatory approval and be deemed safe on environmental and human and animal health grounds before they are approved for release in EU Member States. Directive 2001/18/EC puts in place a step-by-step approval process based on a case-by-case assessment of the risks to human health and the environment. The issue of coexistence is therefore not about crop safety, but rather the economic impact of admixture of GM and non-GM crops in their production and marketing.
The primary task of the Working Group is the identification of best-practice with regard to management measures for the minimisation of admixture that best suits Irish crop production systems. However, the Working Group must also consider the potential economic loss i.e. the loss of market value or inaccessibility to certain markets, plus the cost of any remediation measures, arising from admixture as a result of the commercial growing of GM crops whether through the fault of growers or not. This loss may extend beyond the current production year in certain circumstances.

Such potential economic loss gives rise to concerns by conventional non-GM and organic farmers regarding their livelihoods being affected by the adventitious presence of GMOs. Conversely, farmers who wish to grow GM crops may be concerned about their liability for adventitious presence even though there may be no fault on their behalf. Such concerns could prevent the growth of GM crops and could threaten their competitiveness and ability to survive on international markets in the future. As stipulated in the Commission Guidelines, no form of agriculture should be excluded in the EU and farmers should be able to choose the production type they prefer. Consequently, it is necessary to take measures to address economic difficulties to allow the coexistence of conventional, GM and organic crops.

In light of the above, the Working Group considers that GM and non-GM crop growers should not be left to manage coexistence of GM and other crops by local co-operation alone. It is imperative that there be a clear understanding of the position of each party if a problem arises over adventitious presence of GMO. It was therefore necessary for the Working Group to consider and analyse the options for addressing potential economic problems that may arise from any future commercial growing of GM crops in Ireland, with the principal objective of exploring the role of legal liability provisions alongside other ways to provide redress or remediation for any such problems.

Options to cater for the economic impacts of GM crop production on non-GM crop farming are analysed and evaluated and the recommendations for specific arrangements are outlined in Chapter 8.

2.10 Biodiversity implications

The Working Group was aware that the cultivation of GM crops could possibly impact on biodiversity. This potential impact was raised during the stakeholder consultation process, particularly by the organic farming organisations and environmental groups.

While GM crops may have the potential to impact on biodiversity, the Working Group recognised that there are other potential impacts including those from conventional and organic farming practices such as changes in the ratio of crop types cultivated, the method of cultivation (e.g. non-inversion tillage), changes in use of herbicides and insecticides, etc. Changes in cropping patterns – irrespective of production type - may result in alterations to weed and insect populations, which may have a knock-on effect within and outside the cultivated ecosystem.

In relation to the specific issue of implications for biodiversity arising from cultivation of GM crops, EU Directive 2001/18/EC requires that any novel variety must be assessed for risks to human health and the environment before it can be released into the environment or placed on the market. In this context risks to the environment include risks to biodiversity. As part of
the environmental risk assessment, the implications on biodiversity from such a release are required to be comprehensively addressed. Notifiers are also required to carry out monitoring plans under Article 13(2)(e) of Directive 2001/18/EC. This is supplemented by Council Decision 2002/811/EC, which sets out guidelines on the monitoring plan. One of the objectives of the monitoring plan is the identification of any adverse effects of the specific GMO or its use on human health or the environment – either short-term or long-term - which were not anticipated in the environmental risk assessment. It is the responsibility of the notifier to report such results to the Competent Authority and the EU Commission. It should also be noted that Member States are not precluded from carrying out additional monitoring in the form of case-specific monitoring or general surveillance.

There is no specific legislation that prohibits the growing of GM crops in Special Areas of Conservation (SACs) or Special Protection Areas (SPAs). However, under DEHLG legislation, landowners can be notified of specified activities that would require Ministerial consent in these areas in order to protect their habitats and species. The procedures set out in Chapter 7 (see application procedures for growing GM crops) seek to ensure that appropriate arrangements are in place for information sharing in relation to any proposal to grow a GM crop in such sensitive areas.

Finally, while changes to biodiversity are expected to be minimal as a result of the introduction of GM crops, the Working Group considers it prudent that the possibility of such changes are monitored through research which takes account of Irish production practices and topography. Any negative impact arising can then be counteracted by the introduction of appropriate on-farm management measures. The objectives and plans for coexistence monitoring are outlined in Chapter 9.
Chapter 3  The implementation of coexistence

3.1  The objective

The Working Group was charged with making recommendations on the most appropriate strategy for the implementation of best practice to ensure the coexistence of GM crops with non-GM crops in Irish cropping systems. The primary objective of the Working Group was to recommend an implementation strategy that would ensure the coexistence of GM and non-GM crops in the event of growers adopting the new technology but also one that would inspire confidence in all farmers and other stakeholders. It must be noted at this point that the remit of the Working Group in the recommendation of best practice for coexistence applies from pre-sowing of the crop through to the first point of sale of produce. The ‘first point of sale’ is defined as the point where the GM grower surrenders control of the produce, which includes transfer between individual farmers. Subsequent to the first point of sale, the Labelling and Traceability Regulations become operative.

In forming recommendations, the Working Group was conscious that paragraphs 3.4 to 3.8 of the Commission Guidelines advises Member States to carry out certain actions to ensure the successful implementation of coexistence. For example land registers, record keeping, training courses and extension programmes. In addition, Member States are also advised to establish monitoring procedures to guarantee the proper functioning of coexistence measures, monitor and evaluate their effectiveness and, obtain and exchange the information necessary for their improvement over time. To achieve this, the following is required as a minimum:

(i) Establish a database to record information in advance of sowing the crop, including the name and address of the GM crop grower, location and details of the genetic modification of the crop etc. and the provision of information regarding coexistence best practice and confirmation of grower awareness

(ii) Introduce a monitoring programme to verify that the information is accurate, to confirm adherence/non adherence to coexistence best practice and to validate effectiveness.

The Commission Guidelines do not recommend any overall policy for coexistence. Instead, it is up to each Member State to explore the use of different policy instruments e.g. voluntary code of practice, soft-law approaches or mandatory measures backed up by legislation. In the recommendation of a strategy that would be most likely to achieve effective implementation, monitoring, evaluation and control, the Working Group considered three possible options, as follows:

(i) Voluntary code of practice

(ii) Mandatory measures

(iii) Combined voluntary and mandatory arrangement

In deciding on an overall policy, the Working Group was conscious of the diverse range of opinion expressed by stakeholders during the consultation process. In addition, the Working
Group considered it imperative that strategies for coexistence must be formulated in line with international best practice and take cognisance of the position of other EU Member States, particularly with Northern Ireland with whom we share a land border.

The Working Group was also directed by a number of key principles as set out in national policy and the Commission Guidelines. These key principles include requirements that the recommendations:

(i) Be in keeping with the overall positive but precautionary policy expressed by the Government in relation to GMOs.

(ii) Protect the integrity of non-GM crops and be adequate to underpin Ireland’s clean green agricultural production image.

(iii) Meet the obligations placed on Member States from EU Directive 2001/18/EC on the deliberate release of GMOs into the environment and Commission Regulation 1829/2003 on the labelling of food and feed.

(iv) Be efficient, cost-effective, proportionate and ensure an equitable balance between the interests of all production types. Implementation measures should not be unduly onerous and thus prove a deterrent to the managed development of GM crops in Ireland.

(v) Should allow farmers to choose the production type they prefer, without imposing the necessity to change already established production patterns in a neighbourhood.

(vi) During the phase of introduction of a new production type in a region, farmers who introduce the new production type should bear the responsibility of implementing the farm management measures necessary to limit gene flow.

(vii) Inspire confidence in all stakeholders. The Working Group endeavoured to engage with the widest possible constituency by inviting submissions from a broad spectrum of stakeholders representing farming organisations, Teagasc, environmental groups, organic bodies, the seed trade, the animal feed industry, the biotech industry and consumers. The Working Group took all submissions received into consideration in the preparation of the Report.

(viii) Take account of the guidelines issued in Commission Recommendation 2003/556/EC of 23 July 2003 in order to achieve a degree of harmony with the measures proposed by other EU Member States in order to ensure the practical implementation of the measures and meet requirements regarding land registers, education and training, record keeping and post-release monitoring.

3.2 Options for the implementation of coexistence

3.2.1 Voluntary code of practice

Coexistence based on voluntary arrangements would essentially comprise of:
(i) The facility to record, in advance of sowing, details of the GM cultivation such as the name and address of the grower, the location of the proposed cultivation and the name and details of the genetic modification of the variety of the crop being sown.

(ii) Confirmation that the grower is aware of recommended procedures to ensure best practice pertaining to coexistence as detailed in the programme set down for grower education and training (see Chapter 7).

(iii) A facility to elicit and record additional relevant information as it becomes available post sowing of the crop.

(iv) ‘(i)’ and ‘(ii)’ above imply that, as a minimum, a database is established to record the basic information.

(v) A monitoring plan or regime to ensure that the coexistence measures are operating satisfactorily and an inspectorate to ensure information submitted is verified and accurate and to monitor the efficacy of the measures in place.

A voluntary code of practice would be proportionate, efficient, and would offer a high degree of flexibility. Such a system could be introduced in a timely fashion and would not cause any significant delays where a grower wished to cultivate a GM crop. Even though a code of practice would be purely voluntary, there are increasing commercial drivers for growers to comply with procedures to achieve specific standards in the production of crops. The Irish Grain Assurance Scheme (IGAS) is an example of this, where the ultimate aim is to have the production and storage of all grain within the scheme so that all Irish food can be quality assured. Participation in this scheme is also a condition to gain access to certain markets.

Crop coexistence is not a novel concept within Irish agriculture, since it is used extensively for the production of pure seed in the Seed Certification Scheme. It could therefore be argued that a voluntary code of practice would be sufficient to achieve coexistence for at least the ‘lower risk’, less contentious crops e.g. potato. As outlined in Chapter 2, potatoes, and to a lesser extent, beet and cereals, for which there is the potential for GM varieties to be commercialised in Ireland in the short/medium term, have a relatively lower risk for gene dispersal than the out-crossing crops i.e. oilseed rape and maize. There is also evidence across Europe that the separation of high erucic acid oilseed rape works satisfactorily under voluntary arrangements.

However, one of the key drawbacks from a purely voluntary system is that the interests of non-GM crop growers are not adequately protected i.e. there is no financial incentive on the GM crop grower to protect his/her neighbours crops from adventitious contamination. In the event of voluntary arrangements not working satisfactorily, it would be the non-GM crop grower who would suffer economic loss. Such a system would therefore not achieve an acceptable degree of confidence with non-GM crop growers and other stakeholders and would not be in accordance with the principle where ‘national strategies for coexistence should ensure an equitable balance between the interests of all production types’. In addition an entirely voluntary code of practice would not be sufficiently robust to protect Ireland’s clean ‘green marketing image’.

Under purely voluntary arrangements, difficulties also arise for those who wish to cultivate GM crops. Where growers are left to manage coexistence by purely local co-operation, there
is a lack of understanding on their position if a dispute over contamination arises. Consequently, there is the fear of litigation and possible damages even though the GM crop grower may have abided by the required crop management protocols. This could give rise to a lack of clarity in relation to the growing of GM crops and hence would contravene the principle where ‘farmers should be able to choose the production type they prefer without imposing the necessity to change already established production patterns in a neighbourhood’.

For these reasons the Working Group is of the opinion that the coexistence measures should at least in part have a mandatory basis to address the main concerns of all stakeholders. Furthermore, as there is no experience in the cultivation of GM crops in Ireland, the Working Group believe that a reasonable degree of control is necessary. Such an approach would be in keeping with the overall precautionary policy of the Government in relation to GMOs.

3.2.2 Mandatory measures

The establishment of mandatory coexistence measures denotes clear areas of responsibility to which the GM crop grower must abide. The growing of GM crops would not be at the discretion of the individual grower, but would involve obtaining authorisation, on fulfilling certain conditions, to grow the GM crop from the State (or its agent). While much of the practical detail would be similar to that outlined for a voluntary arrangement, adherence to best practice could be enforced and failure to do so would be subject to sanction or penalties.

The major advantage of such a system is that it offers protection to the non-GM crop grower, as there are concrete, actionable guarantees that the protocols are being followed by the GM crop grower. In addition, there is clear understanding of where the GM crop grower would stand if a dispute over contamination arises. Mandatory measures provide the basis for a legitimate assessment of culpability by an independent adjudicator in the event of economic loss (legal or otherwise). In other words, a mandatory system offers some assurance that all parties (both GM and non-GM crop growers) have a specific course of redress in the event of admixture occurring. This, in effect, allows for the development of different agricultural production systems.

Mandatory coexistence measures also offer a high degree of transparency. With an obligatory system for coexistence, not only growers, but also consumers and food companies, are reassured that the strict enforcement of the growing of GM crops would minimise the chances of admixture occurring. This would assist in maintaining Ireland’s ‘clean green image’ reputation as a producer of high quality food.

Mandatory-based measures would also adequately address the obligations placed on the State under Directive 2001/18/EC to draw up effective measures and best practices to allow for coexistence. Furthermore, it would allow the DAF to compile, in a more effective manner, relevant and timely statistics to be used for the following:

- Collating regional information as specified under Article 2.2.6 of the Commission Guidelines i.e. the crop-specific GMO share and the number and type of crop varieties that coexist in a region.
- Developing a Register of GM cultivation.
- Monitoring and evaluating the effectiveness of coexistence measures for fine-tuning over time.

For the above reasons, the Working Group is of the opinion that the principal coexistence measures should have a statutory basis in order to address the main requirements of all stakeholders.

3.2.3 Combined mandatory and voluntary arrangement

The Working Group considered that an entirely mandatory system may be construed as disproportionate and expensive to both growers and the State. It could be argued that such a system would result in a higher level of State intervention in normal day-to-day agricultural activities. Such a system may also be deemed prohibitive to the growing of GM crops and could be construed as a barrier to trade. For these reasons, the Working Group examined a third option i.e. a combined mandatory and voluntary arrangement for specific coexistence measures.

A comprehensive framework for the coexistence of GM crops with non-GM crops will involve many elements. For example, the establishment of appropriate separation distances between neighbouring crops of the same or related species, establishing minimum cropping intervals between GM and non-GM crops (especially seed crops), appropriate transport and storage procedures, putting in place a mechanism(s) to address economic loss and an effective post-monitoring procedure. While the main elements to achieve these objectives should be mandatory, the Working Group believe some elements (measures) could be incorporated into a Code of Good Farming Practice for Coexistence. In any event, some of the crop management measures necessary to ensure coexistence would prove problematic to enforce, difficult to verify and in some cases are applicable to both the GM and non-GM crop grower, e.g. adherence to rotation interval, control of volunteers, etc.

A combined approach of mandatory measures and a code of good farming practice for coexistence measures would allow greater proportionality and improved efficiency and cost-effectiveness. While it may be argued that there may be less incentive for GM crop growers to implement measures under a Code of Good Farming Practice, it is in their interests to do so in order to reduce their risk of liability.

The Working Group recommend that the main elements of coexistence be mandatory, while others, including certain crop management measures should be incorporated into a Code of Good Farming Practice for coexistence.

3.3 A framework for coexistence

In devising an appropriate implementation framework for coexistence, the Working Group was particularly cognisant of the principle, as set out in the Commission Guidelines, that: ‘farmers who introduce the new production type should bear the responsibility of implementing the farm management measures necessary to limit gene flow during the phase of introduction of a new production type in a region’.
A number of the key mandatory measures to be included in a framework for coexistence are set out below. These, and other measures and additional recommendations are discussed in greater detail throughout the remainder of this Report.

- Approval must be obtained from the DAF before cultivation can commence. Approval would be subject to the provision of information e.g. location of crop, variety, nature of genetic modification, etc.

- Confirmation that the GM crop grower has fulfilled the education/training requirements pertaining to coexistence including crop management measures, procedural requirements and liability issues.

- Adherence to the separation distances between GM and non-GM crops as set down.

- Signed agreements with neighbouring farmers in respect of arrangements where use of their land is necessary as part of the separation distance.

- Arrangements to ensure comprehensive record keeping.

Non-compliance with these key measures will trigger the imposition of sanctions. This will serve to strengthen adherence to the coexistence measures and ensure accountability of all GM crop growers.

In order to minimise the level of State intervention and overall cost, it is envisaged, in the medium to long term, inspection and verification for compliance should be based on risk analysis. However, it is envisaged that in the short term, production of GM crops in Ireland is unlikely to be carried out on a significant scale and the State should bear the cost of inspection controls on all GM crops planted in the initial years of GM crop cultivation.

The Working Group recommend that the following important crop management measures be incorporated into the Code of Good Farming Practice with respect to the growing of GM crops:

- Adherence to the recommended crop rotation intervals and control of volunteer plants, bolters, etc.

- Machinery hygiene and other mechanisms in preventing mechanical movement of seed/grain.

- Security and condition of transport equipment.

- Agronomic measures to minimize return of seed to the seedbed.

- Testing of home-saved non-GM seed for confirmation of seed purity.

### 3.4 Policy instrument to implement mandatory measures

The introduction of mandatory measures for coexistence requires that they be given legal force through an appropriate policy instrument.
In considering the most appropriate policy instrument, the Working Group was keen to avoid a significant delay in putting in place a legal arrangement that would facilitate the enactment of coexistence measures. Furthermore, it was considered desirable that any such instrument should have a degree of flexibility to ensure that coexistence measures could be adjusted in the light of new evidence, without undergoing a long and involved process.

In deciding the most appropriate legislative framework, the Working Group considered the following options:

(i) Create a new Act of the Oireachtas
(ii) Create a Statutory Instrument (S.I.) under Article 26a of EU Directive 2001/18/EC.

Both of these options have attractions and limitations as outlined below.

(i) Act of the Oireachtas

The creation of a stand-alone piece of legislation (viz. an Act of the Oireachtas) would give the DAF significant scope to encompass all of the recommendations of the Working Group. It would also minimise the need to revisit the legislation where coexistence measures require adjustment. However, the creation of an Act of the Oireachtas can be a long process and is ultimately dependent on the priority afforded to it by the Oireachtas. Recently, however, the EU Commissioner for Agriculture stated her wish to have proposals formulated for a possible EU-wide legislative framework within which national governments could implement their own coexistence regulations. Consequently there is the possibility that a new EU Regulation could come into law just as the Oireachtas is in the latter stages of preparing the Act for approval.

(ii) Statutory Instrument

The second option is the creation of a Statutory Instrument (S.I.), based on one of the Articles of the EU Directive on Deliberate Release (2001/18/EC), i.e. Article 26a. This would allow the creation of a S.I. within a much shorter timeframe. However, several S.I.s may be required over time as some of the controls proposed may need updating on an ongoing basis (e.g. changes in maximum seed thresholds, organic regulations, etc.) and some new additional controls may need to be introduced as coexistence measures are introduced for other crop species. The process of enacting a S.I. is also less flexible in eliciting public contributions than the process of adopting primary legislation, so a S.I. may not be the most appropriate route in this case.

However, as there is currently no mechanism to impose controls on a grower who wishes to sow a EU-approved GM crop, the Working Group recommend that a S.I. be put in place as an interim measure, thus giving effect to an approval system with the main conditions attached. In parallel with this, and dependent on developments at EU level, work should be undertaken on the development of an Act of the Oireachtas to give the cultivation of GM crops its own stand-alone legislation in relation to the coexistence of GM and non-GM crops.
3.5 Scope of coexistence strategy and its implementation

The scope of the Working Group’s proposed strategy extends from agricultural crop production to the first point of sale. The focus of the remainder of this Report is on the establishment of ‘best practice’ in four main areas. These include:

(i) Technical measures for minimising admixture.

Chapters 4 and 5 evaluate the possible dispersal sources of pollen and seed, estimates the possible extent of crop-specific dispersal and, recommends appropriate crop management protocols.

(ii) Underpinning coexistence - procedural requirements and the provision of information.

The recommendation of the most appropriate measures to underpin coexistence through a series of procedural requirements is outlined in Chapter 7.

(iii) Economic loss, liability and redress.

Chapter 8 evaluates the options and recommends appropriate measures for addressing economic loss.

(iv) Monitoring and review of coexistence measures and future research.

Procedures for the verification and evaluation of the coexistence measures and their review for improvement over time are outlined in Chapter 9.

Recommendations:

I. That a combined mandatory and voluntary arrangement best meets the objective of implementing coexistence measures. Mandatory measures require that they be given legal status, while voluntary measures should be specified in a code of Good Farming Practice.

II. That a Statutory Instrument be put in place initially as an interim measure, thus giving effect to an approval system with the main conditions attached. In parallel with this, and dependent on developments at EU level, work should be undertaken on the development of an Act of the Oireachtas to give the cultivation of GM crops its own stand-alone legislation with regard to the coexistence of GM and non-GM crops.
Chapter 4  Measures for ensuring crop purity

4.1 Introduction

The adventitious presence of GMOs in non-GM crops can arise through various pathways. These include: the use of impure seed, cross-pollination, seed dispersal from volunteers and mechanical transfer at sowing, harvesting, transport and storage operations. For effective prevention of admixture, it is necessary to counteract these pathways through various crop management measures. In addition to crop management measures, there are also additional tools i.e. genetic barriers and regional measures. This chapter discusses the various mechanisms/measures available, applicable in an Irish context, to prevent admixture from GM crops to non-GM crops. In forming recommendations for appropriate measures and best practices, practicality, effectiveness and efficiency (cost) were the priority of the Working Group, as these are central to their success.

4.2 Use of pure seed

Seed is the starting point for the production of most crops. The purity of seed has a considerable influence on the level of impurity of the harvested product. As outlined in Section 2.3, the Commission has proposed that directives on seed should contain limits on GMOs in seed that would take account of possible sources of admixture in the chain from seed to food/feed while still meeting the labelling threshold of 0.9%. The proposed thresholds for seed are 0.3% and 0.5% for cross-pollinating and self pollinating species respectively. However, there has been no agreement from Member States on this issue to date. Currently, independent studies on the economic impact of seed thresholds are being carried out on behalf of the Commission in order to inform this decision and establish the thresholds on a sound scientific basis. It should also be noted that certification procedures in relation to GM seed production, have not as yet been agreed at Member State or International level.

For coexistence to operate effectively, it is critical to get the baseline correct i.e. that GMO content in seed is below the seed threshold limit. Growers may choose between two possible options in sourcing seed for the production of conventional and organic crops i.e. (i) seed purchased as certified and (ii) home-saved seed. These are discussed in further detail below. Recommendations are also made regarding best practice for seed usage.

4.2.1 Certified seed

Under the EU seeds Directive (Appendix 4), seed offered for sale within the EU must be certified to certain quality standards prior to placing on the market. The EU seeds Directive specifies minimum purity levels to be achieved depending on the species and generational category. In addition, seed can only be marketed if that particular variety is registered in Ireland’s ‘National Catalogue of Agricultural Plant Varieties’, or in the EU ‘Common Catalogue of Agricultural Plant Varieties’. Certified seed is multiplied under an approved certification system, administered in Ireland by the DAF as the designated competent authority.
Ireland has a limited plant breeding industry. New varieties of potatoes, grasses and clovers are bred by Teagasc Crops Research Centre at Oak Park, Carlow. Consequently, most seed for multiplication purposes is imported into Ireland i.e. all seed of cereals, peas, beans, lupins and oilseed rape are imported, plus some grass seed (grass seed multiplication has declined dramatically in Ireland in recent years) and some potato (as tubers). There are also significant imports of seed for commercial crop production. All maize and beet seed (it is not possible to produce quality seed of these crops in Ireland), horticultural seed (including ornamentals) as well as the majority of grass seed (95%) and some seed potatoes (15%) are imported. There is a very small proportion of cereal seed imported for commercial crop production, however, the majority of cereal and approximately 85% of potato seed is multiplied in Ireland. If/when GM crops are commercialised in Ireland, GM seed is likely to be acquired from similar sources. There is no commercial certified organic seed production in Ireland at present but this is likely to change in the short-term as demand for organic seed will increase due to changes in EU legislation governing the use of conventional seed for organic production.

Certified seed, whether imported or produced in Ireland, offers an assurance to crop growers of seed purity to a specified standard. Should the growing of GM crops commence in Ireland, the Seed Certification Division within the DAF will be required to certify seed of conventional and organic varieties to the required purity standard i.e. within the specified EU threshold for adventitious presence of GMOs. Verification of GMO admixture below the permitted threshold will require testing which will inevitably lead to additional costs in the supply of conventional and organic seed. It is envisaged that the onus will be on the seed assembler to pay for testing of seed lots in the first instance.

It should be noted that, in view of the fact that specified GMO thresholds apply only to adventitious presence i.e. inadvertent presence, blending of seed lots having an admixture of GMO above the threshold with GM-free seed lots to reduce overall GMO content, is not permitted.

The purity of the seed used for the production of a crop will be a key factor in determining liability for economic loss arising from the labelling limit for food and feed produce being exceeded. It is logical that the potential liable party will demand proof that the admixture has not been the result of the condition of the seed i.e. GMO content above the permitted threshold. Certified seed offers this assurance.

Should seed of GM varieties be multiplied in Ireland, it will be certified under the same certification scheme as presently pertains to conventional and organic seed. It is envisaged that assembly of GM seed will require strict segregation from non-GM seed at all points in the intake and in the processing plant and that additional supervision may be required from the DAF inspectorate.

It is the view of the Working Group that all certified GM seed lots should be easily distinguishable from non-GM seed to avoid, particularly, on-farm accidental mixing. The Working Group suggests that the potential to have GM seed dressed with a distinct coloured dressing and that a distinct coloured symbol be added to the label should be explored with the seed trade. In addition, all certified non-GM seed should be tested by the seed assembler, with check sampling and testing by the DAF.

As outlined in Chapter 2, seed certification as a model for the coexistence of GM and non-GM crops has many shortcomings. However, it is informative to examine the production of
certified seed in Ireland and to describe the operation of the Seed Certification Scheme, as it raises many of the issues that will be dealt with in a coexistence strategy. (see 4.10 below for details of seed certification scheme in Ireland).

4.2.2 Home-saved seed

The right to save seed from one’s own crop is a long established principle internationally – known as ‘farmer privilege’. In general, home-saved seed is not within the scope of the Marketing Directives and therefore, may vary in quality and carries none of the assurances associated with certified seed in terms of traceability, identity preservation, plant health and quality standards. Nevertheless, the use of farm-saved cereal seed (home-saved seed) is widespread on Irish farms. For phytosanitary reasons, it is not permitted to retain farm-saved seed potatoes in Ireland, only certified basic seed may be planted. Maize seed is not suitable for home-saving for a variety of reasons, not least the unacceptable lack of uniformity in the F2 generation from the hybrid F1 currently used to grow commercial crops.

Should GM cereal crops be grown in Ireland, there will be implications for the sowing of own home-saved conventional and organic seed. In contrast to certified seed, the purity of home-saved is not verified, with the result that the crop grower may be exposed to economic risk as a consequence of:

   a) The GMO threshold of 0.9% being exceeded in his/her harvested produce.

   b) The possibility of liability arising in the event of gene dispersal to neighbouring crops. This may occur either by mechanical transfer or by GM pollen transfer to neighbouring crops located within the recommended separation distance. (This situation is unlikely to arise for home-saved cereal seed, as the percentage of GM seeds in the home saved seed is likely to be low and in any event, cereals present a low risk of cross-pollinating with other plants and require a relatively short separation distance).

To offset these risks, it is in the interest of users of home-saved seed to certify that the GMO content of such seed is within the EU permitted seed labelling threshold level.

It is the view of the Working Group that sampling and testing for GMOs in home-saved seed should be carried out by an independent competent body. GMO testing will undoubtedly add to the cost of home-saved seed. A representative sample of the home-saved seed should be retained until after harvest.

The Working Group recommend that users of home-saved seed be encouraged to test for GMO content prior to planting and thus ensure the purity of that seed is adequately preserved.

4.3 Crop separation

Genetic material from crops is spread primarily through either pollen or seed dispersal. GM and non-GM crops of the same type are similar in that if they flower and are fertile, pollen is produced and subsequently, seed is set once fertilisation has occurred. Where pollen from a conventional non-GM crop lands on an adjacent crop, if it is the same crop type and the
variety is receptive to external pollen, cross-pollination will occur and hybrid seeds will be produced.

With regard to coexistence, the propensity for pollen flow between related cross-pollinating crops is an important issue. For, if there is a significant transfer of pollen from a GM crop on to a related non-GM crop that is grown nearby, the relevant threshold (e.g. 0.9% for grain) could be exceeded for that non-GM crop. The likelihood of thresholds being exceeded is greatly influenced by the:

- Amount of pollen produced by the donor plant
- Weight of the pollen and thereby the distance it may be transferred by air currents
- Ability of the pollen to survive over time
- Prevailing climatic conditions and their effect on pollen dispersal and survival
- Insect numbers and activity
- Degree of synchronisation of flowering period between crops
- Degree of compatibility between plants to achieve cross-fertilisation
- Area of pollen source relative to the area of the recipient crop, i.e. relative field sizes.

The characteristics of pollen flow from a crop are wholly dependent on the crop in question, the local geography and the weather conditions over the flowering period. Research has shown that in a normal field environment the distribution of pollen from a crop decreases significantly as the distance increases away from the crop border, until a separation distance is reached where the number of cross-pollination events is practically zero. For coexistence, this raises two key questions:

(i) Can this separation distance be applied to a field situation to minimise cross-pollination between a GM and a non-GM variety? and,

(ii) What is the appropriate separation distance for individual crops?

In the absence of extensive field-scale data, research-derived distances can be employed in a farm scenario to moderate the rate of crossing between a GM crop and a corresponding conventional/organic crop. If adopted, this will minimise admixture and maintain levels of purity within the non-GM crop at less than the specified threshold. However, due to adverse weather patterns and the behaviour of insects, particularly bees (see ‘6.2.5’ under), it is important to note that cross-pollination may not be eliminated outside of the prescribed geographical distance. Though rare, events can still occur and the appearance of unwanted GM-conventional/organic hybrids is a reality. The only means to prevent this from happening is to prohibit GM crop cultivation in the locality, an option that is not currently permitted by EU legislation, except in certain limited circumstances (see section 4.9, under - ‘Zones of a single production type’).

To present Irish farmers with an effective model for coexistence, the Working Group was acutely aware of the importance of ensuring that the separation distances are both realistic and workable but more-importantly, science-based. The Working Group established the separation distances for seed in accordance with the proposed thresholds for adventitious admixture of 0.3% and 0.5% respectively for cross-pollinated and self-pollinated crops and for general produce in keeping with the legislated 0.9% maximum threshold. While the Regulation on organic farming (Council Regulation EEC No. 2092/91/91, Article 13)
provides for the setting of GM thresholds, to date, no thresholds have been set. In the absence of specific thresholds for organic seed, the above levels are taken as applicable.

While significant research has been carried out in Europe and elsewhere into calculating the rate of pollen transfer for several primary crops, little research has been conducted on this subject from an Irish perspective. The seed crop separation standards (Table 4.3) for species multiplication in Ireland under the Seed Certification scheme have been working satisfactorily. These separation standards therefore, were used as a benchmark with which to compare the published scientific research in this area and thus played an important role in establishing the separation distances adopted by the Working Group for each crop species.

While a series of management measures must be adopted throughout the growing season to ensure coexistence, the Working Group realise that separation distances will be an integral part of any GM cropping system to reduce the adventitious presence of GMOs in non-GM crops and should be a mandatory requirement.

4.4 Crop rotation and the control of volunteers

The emergence of volunteer plants in a rotation is a common occurrence and volunteers of certain crops (e.g. oilseed rape and potato) can pose serious problems. Volunteers emerge from post-harvest residual seed left in the field, or through re-growth of vegetative material. This can arise from seed loss during harvesting, from transport spillage or, due to the shedding of seed prior to harvest. Seeds can remain dormant from one to several years depending on species.

Volunteers from GM crops could provide an important source of admixture to non-GM crops, particularly through the production of GM seed in successive non-GM crops. Furthermore, the dispersal of pollen from GM volunteers could compromise the purity of following crops and neighbouring crops of the same species. The prevention of admixture through volunteers is therefore a critical component in crop management for the coexistence of GM and non-GM crops.

Suitable crop rotations i.e. a suitable time interval between the cultivation of a non-GM crop following a GM crop of the same species, is key for the prevention of admixture in following non-GM crops. Volunteers from a GM crop in subsequent non-GM crops of the same species would prove very difficult to identify and cannot be controlled by practical means. However, a suitable rotation allows for the control of volunteers in subsequent non-GM crops of a different species through a variety of methods (see below). At present, in the certification of seed, the rotation requirement varies from one to six years free of the same crop depending on the crop species (Table 4.4). These rotation intervals provided invaluable assistance in the recommendation for rotation intervals for GM and non-GM crops (Chapter 5).

However, the maintenance of the recommended rotation intervals is complicated in Irish farming systems, due to the common practice of short-term land rental agreements. This is particularly the case with crops where volunteers may appear for a number of years and where there is a longer recommended rotation interval e.g. oilseed rape. In many cases, the history of an individual field may only be verified by the provision of detailed records and maps. The process of verification would require the establishment of a comprehensive
database by the DAF. Additional verification could also be provided as part of the ‘post-release’ monitoring programme under Directive 2001/18/EC.

The Working Group propose that adherence to the recommended rotation interval should operate according to the Code of Good Farming Practice for coexistence with respect to rotation intervals, as it is very much in the interest of growers to do so in order to: (a) protect their own non-GM crops from admixture and (b) protect neighbouring crops and prevent possible liability resulting from admixture to neighbouring crops arising from the transfer of pollen from volunteer plants.

Mechanisms to limit volunteer emergence include chemical and mechanical control. The suitability of these control mechanisms will depend on choice of crops in the rotation. In many cases, volunteers from a GM crop can be effectively controlled in crops of a different species by chemical means. However, control of volunteers may be more efficient and cost-effective if carried out prior to sowing the following crop. Leaving the field uncultivated or fallow for a short period after harvest ensures that lost seed will remain on the soil surface and not enter the seed bank. Consequently, seed will germinate and the resulting volunteers can then be effectively controlled through mechanical or chemical means. Shallow cultivation to a depth of 5-10cm post-harvest (a common practice in minimum tillage systems) can significantly increase germination of seed post-harvest, thereby leading to more effective control. Furthermore, where the field is left fallow (with appropriate green cover) over the winter for the sowing of spring crops the following year, severe climatic conditions can reduce the viability of lost seed. While helpful in the control of potato ground-keepers, Ireland’s temperate climatic conditions can render this mechanism inadequate for certain crops.

### 4.5 Weed control

An issue that is raised in the debate on GM crops, is the possible hybridisation of GM crops with related weed populations in field margins, roadside ditches, etc. This concern centres around the escape and possible establishment of the GM trait in a weed population, thereby leading to a ‘superweed’ that may prove difficult to control through traditional practice. The appearance of GM crop-wild hybrids could have an indirect effect on coexistence if indeed a novel weed materialised and developed into a serious pest after successive years of GM cultivation. It would also become an issue if these hybrids established themselves amongst a conventional/organic crop. Furthermore, the establishment of feral populations in non-cultivated areas, arising from poor volunteer control could also pose a similar problem.

The formation of crop-wild hybrids of maize, barley, wheat and potato is not considered a potential problem in Ireland. In the case of maize, no wild relative exists. With barley, wheat and potato, even if cross-pollination with wild relatives were to occur, they would not be sufficiently viable or aggressive to establish significant populations (see Chapter 5). However, weedy relatives of oats, oilseed rape and beet are common across the country and hybrids could be formed with pollen originating from a cultivated crop. It is a reasonable assumption that GM crops will be no different to conventional crops in their potential to form hybrids and viable progeny with weedy relatives.

However, vigilance should be exercised on behalf of both the GM and non-GM crop growers to ensure control of any such weedy relatives to prevent their build-up and possible
hybridisation with related non-GM crops. The ability to recognise and eliminate the weedy relatives through either chemical or mechanical means before they set seed will ensure a reduction in the number of hybrid seeds entering the seed bank.

The Working Group was also conscious that GM weeds or ‘unwanted GM plants’ could arise through seed dispersal, both within and between farms, during the transport of GM crop straw and where seeds remain viable in organic waste derived from GM crop straw i.e. slurry and farmyard manure. Considerable amounts of straw are transferred between farms, principally for the bedding of livestock, but can also be used for feeding purposes. Again, vigilance and monitoring on behalf of all farmers should be exercised to ensure control of GM plants that arise from the dispersal of seed through this pathway.

4.6 Prevention of physical and mechanical seed dispersal

The many years experience gained in the certification of seed would indicate that the primary source of admixture in seed is not caused from cross-pollination, but rather by mechanical means i.e. machinery dispersal of seed and improper segregation during assembly, transport and storage. Mechanical movement of seed would be one of the most critical points of concern with regard to the coexistence of GM and non-GM crops.

Seed admixture can occur during mechanical operations involving sowing, harvesting, on-farm transport, on-farm storage, transport off-farm and at merchants premises. Movement can occasionally occur also via other routes e.g. animals, water transport following flooding, etc. For the prevention of admixture through these routes, the Working Group recommends that growers, contractors and all operatives involved in the transport and storage of GM seed must adhere to the Code of Good Farming Practice for coexistence with respect to: (a) the use of machinery and equipment and (b) the transport and storage of GM produce.

The code of Good Farming Practice for coexistence in the prevention of physical and mechanical dispersal of seed from GM crops should include:

(i) Use of dedicated equipment and storage for GM produce.

(ii) Thorough cleaning of cultivation, sowing and harvesting equipment between operations on GM and non-GM crops.

(iii) Cleaning and sealing of transport equipment, avoidance of over-filling and covering to prevent spillage during transport.

(iv) Thorough cleaning of drying and cleaning equipment between operations on GM and non-GM produce.

(v) The maintenance of stores and care in segregation during store filling and emptying.
Adherence to the code of practice will prove more problematic with certain crops. For example, due to the small size and spherical shape of oilseed rape seeds, cleaning of machinery, sealing of trailers etc, will be more difficult and time-consuming than that for other crops. Growers could consider the use of dedicated machinery and storage lines for GM and non-GM crops. This may be essential in the case of oilseed rape. Input from contractors in this respect would be particularly valuable.

4.7 Buffer zones

Buffer zones are areas of a non-GM crop grown around the perimeter of a field that has been cultivated with a GM crop. Buffer zones are normally sown to the same species, or in the case of insect-pollinated plants, may be sown to other flowering species. The buffer zone/margin acts by ‘absorbing’ the GM-derived pollen as it is released from the GM crop. By trapping the pollen in this manner, the quantity of pollen that is available to cross-pollinate with an adjacent, related non-GM crop is substantially reduced. The appropriate width of the buffer zone is dependent on a number of variables including the crops’ ability to outcross and the size of the pollen source. The establishment of buffer zones is standard practice in seed multiplication and GM crop research trials.

The harvested produce from the buffer zone can be combined with that of the GM crop or may be harvested separately but treated in the same manner as produce from a GM crop.

4.8 Genetic out-crossing barriers

Mechanisms to limit gene transfer between plants are generally based on physical barriers such as separation distances, destruction of volunteer plants, controlled rotations and buffer zones.

While these barriers have proven effective in maintaining varietal seed purity over many years, additional ‘genetic barriers’ can also be employed to reduce the unintentional mixture of GM and non-GM material. The potential of certain genetic barriers suggests that their adoption may reduce the requirement in relation to restrictive separation distances. This would be the case if the barrier prevented pollen production or removed the GM trait from the pollen. For example;

- Crops genetically modified to produce sterile pollen (male sterility), pollen lacking GMO or not producing pollen at all, would restrict the spread of the GMO into organic/conventional crops.

- A GM variety with an altered flowering period to that of the non-GM equivalent through either delayed or premature flowering would eliminate the overlap in flowering period, therefore decreasing the potential for gene dispersal to the non-GM crop.

- A crop engineered with a GM trait via chloroplast transformation (as opposed to nuclear transformation) will significantly reduce the impact of pollen dispersal. This is because chloroplasts are predominantly maternally inherited, which implies the
pollen should not possess the GM trait. As with the two previous examples, this would require verification at the risk assessment stage to ensure stability of the trait.

Genetic out-crossing barriers have possibilities for the future, although these are limited in their application at present.

4.9 Zones of a single production type

Zones of a single production type are geographical regions where GM or non-GM crops are grown exclusively. However, they are generally understood to be regions where GM crops are not grown i.e. GM-free Zones.

It is considered that zones of a single production type (conventional, organic or GM) could reduce the costs and the regulatory control measures associated with coexistence. However, such zones have received greatest attention with regard to specific areas or regions where the coexistence of GM crops and non-GM crops would prove to be extremely difficult. This has led to strong public local concern regarding the economic implications if GM crops were introduced into these areas.

Article 2.1.5. of the Commission Guidelines sets out a clear position regarding measures of a regional dimension. It states: ‘measures of a regional dimension should apply only to specific crops whose cultivation would be incompatible with ensuring coexistence, and their geographical scale should be as limited as possible. Such region-wide measures require to be justified for each crop and for each product type separately’. Consequently, there are no legislative procedures in place to give legal standing to the establishment of zones where the cultivation of all GM crops are prohibited. Furthermore, a declaration of a crop-specific GM-free zone that would eliminate the choice of farmers to cultivate a particular GM crop, is not legal under present EU legislation without justification that the GM crop cannot successfully coexist with its non-GM equivalent.

The on-going debate in the EU over regions that wish to declare themselves free from GM crops was re-visited by the Commission at a recent meeting of COPA/COGECA. Their position was clear in that a blanket ban on the cultivation of GM crops was not permissible because it was disproportionate to the objective of the successful separation of GM and non-GM crops. However, a ban might be considered on a crop specific basis in a given region (see reference to Article 2.1.5. above), on the proviso that the Commission deemed it ‘proportionate’ to the risk that non-GM crops or seeds would suffer accidental admixture with GM material above the EU thresholds for such admixture.

The EU Commission has also pointed out that Article 19.3 (c) of Directive 2001/18/EC may not be used as a basis for justifying a GM-free zone ‘unless the conditions referred to for the protection of particular ecosystems/environments and/or geographical areas have been explicitly specified in the written consent given to grow that particular GM crop’. In addition, Article 22 of Directive 2001/18/EC does not allow for a Member State to prohibit the growing of any GM crop which complies with the requirements of this Directive. The Commission Guidelines reiterate this view stating that ‘in principle, farmers should be able to cultivate the type of crops they choose – be it GM crops, conventional or organic crops. None of these forms of agriculture should be excluded in the EU’.
At present, no proposals have been submitted to establish a GM free zone in respect of an individual crop in a region in Ireland. However, this may change in the future depending on the extent and type of GM crops cultivated. In the event of a significant increase in the area of organically produced crops in Ireland, or a change in the EU regulations pertaining to GMOs in organic crops, the organic sector may feel that the only way to protect their interests would be a blanket ban on a particular GM crop(s) in a particular region(s). In this situation, an analysis of the risks of admixture by GM crops would have to be undertaken and if the findings reached the conclusion that a GM crop(s) could not coexist with its organic equivalents within the thresholds pertaining under normal coexistence management measures, an application to establish a GM free zone on such specific crops at regional level could be taken up by the State with the EU Commission.

An alternative to obtaining legal status, by way of scientific justification, for a regional ban on GM crops is by way of voluntary agreement between farmers. GM-free zones may be established by groups of farmers deciding to regionally segregate the growing of various crop types i.e. GM and non-GM, and coordinating their production practices. This can only work effectively if all farmers in that particular region agree and work together regarding the type of crops they wish to cultivate, be it GM or non-GM.

4.10 Certified seed production in Ireland

4.10.1 Background

The certified seed sector is an important component of agricultural production in Ireland, particularly with respect to cereals and potatoes. In 2004, 1,100 producers grew 10,000 ha of cereals for seed use, while 400 producers grew 3,500 ha of seed potatoes. 24 companies operating 30 seed assembly plants handled the intake of cereals.

Table 4.1 shows the complexity of seed production of even a relatively small number of species. Seed of each combination of variety and category must be segregated at all stages of the production process and traceability must be maintained at all stages.

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>No. of Varieties</th>
<th>Number of categories</th>
<th>Varieties x Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>50</td>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>Grasses</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Beans</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Potatoes</td>
<td>22</td>
<td>7</td>
<td>154</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>16</td>
<td>362</td>
</tr>
</tbody>
</table>

The EU Seeds Directives (see Appendix 4) make provision for the production and marketing of certified seed. These Directives have been transposed into national legislation (although specific operational rules for GM seed and organic seed have not yet been agreed).

The seed certification system is based on a number of different generational categories of seed, so seed production involves, not only the segregation of varieties but also the segregation of different categories of the same variety. The system is ultimately based on
ensuring the segregation and traceability of the seed. The entire system from planting to marketing is supervised, monitored and controlled by the DAF inspectorate.

Under current regulations, certified seed produced for placing on the market is subject to certain quality and control standards implemented by the DAF. These standards cover crop production to ensure species and varietal identity and also seed assembly, packing, labelling and traceability. Thus, seed certification is an example of seed being produced to required purity standards, by observing rules designed to prevent admixture of the seed crops by commercial crops during production, assembly and storage.

Each variety has a unique official description (recorded at the DUS testing), based on characteristics defined by the International Union for the Protection of New Varieties of Plants (UPOV) and the Community Plant Variety Office (CPVO). This description is the basis for confirmation of varietal identity. A variety will only be registered and placed on the market if it is phenotypically distinct from all other varieties and satisfies the relevant National and EU legislation.

The purity standards for crops certified in Ireland are summarised in Table 4.2 below.

**Table 4.2** Seed certification purity standards (for species multiplied or cultivated in Ireland)

<table>
<thead>
<tr>
<th>Species</th>
<th>Seed Certification - field standards for varietal purity (maximum impurities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perennial Ryegrass</td>
<td>Not specified</td>
</tr>
<tr>
<td>Field Beans</td>
<td>0.3%, 1.0%, 2.0% (depending on category) *</td>
</tr>
<tr>
<td>Field Pea</td>
<td>0.3%, 1.0%, 2.0% (depending on category)</td>
</tr>
<tr>
<td>Maize</td>
<td>0.1%, 0.2%, 0.5%, 1.0% (depending on category)</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>0.1%, 0.3% (depending on category)</td>
</tr>
<tr>
<td>Potatoes</td>
<td>0.1%, 0.25% (depending on category)</td>
</tr>
<tr>
<td>Sugar &amp; Fodder Beet</td>
<td>Not specified</td>
</tr>
<tr>
<td>Wheat, Barley, Oats</td>
<td>0.1%, 0.3%, 1.0% (depending on category)</td>
</tr>
</tbody>
</table>

* Certified seed is classified by category of purity. For example, in the case of potatoes, 100% purity is required for Pre-basic and Foundation seed, 99.95% for Super Elite and Elite and 99.9% for Class H.

**4.10.2 Crop management measures**

**Crop separation distances** are specified for each crop species in order to prevent admixture of the seed crop. These requirements are summarised in Table 4.3. For cross-pollinating species these separation distances are expressed as the distance from the nearest potentially pollinating crop, based on pollen viability and flow capacity.

For all species under the Irish Seed Certification Scheme there are minimum separation distances to prevent mechanical admixture of the seed crop at harvest. The onus is on the seed grower to ensure that the required separation distance is observed with regard to adjoining and neighbouring crops. The DAF inspectorate monitors these distances and, to
date, has found that the operation of these separation distances have not presented a problem in ensuring seed meets the certification standards.

Table 4.3  Seed crop separation distances (for species multiplied or cultivated in Ireland)

<table>
<thead>
<tr>
<th>Species</th>
<th>Minimum seed crop separation distances (metres)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Beans</td>
<td>50 m to 200 m (depending on category)*</td>
</tr>
<tr>
<td>Field Pea</td>
<td>2 m</td>
</tr>
<tr>
<td>Maize</td>
<td>200 m</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>100 m to 500 m (depending on category)</td>
</tr>
<tr>
<td>Perennial Ryegrass</td>
<td>50 m to 200 m (depending on category)</td>
</tr>
<tr>
<td>Potatoes</td>
<td>2 m</td>
</tr>
<tr>
<td>Sugar &amp; Fodder Beet</td>
<td>300 m to 1,000 m (depending on category)</td>
</tr>
<tr>
<td>Wheat, Barley, Oats</td>
<td>2 m</td>
</tr>
<tr>
<td>Triticale</td>
<td>20 m to 50 m (depending on category)</td>
</tr>
</tbody>
</table>

* These distances can be disregarded if there is sufficient protection from any undesirable foreign pollination.

Crop rotation requirements are set down for each species to ensure that there is no carry-over of plants arising from volunteers from previous crops of the same species. Dependent on species, this requirement varies from one to six years. (Table 4.4).

While the inspectorate staff are locally based and generally deal with the same seed growers from year to year, they are largely dependent on the seed grower to accurately declare the rotation history of the field. However, it is fully in the interest of the seed grower to observe the correct rotation in order to ensure the purity of the seed. The process of verification of crop rotation is aided by the provision of detailed maps, which are kept on individual grower files.

For seed potatoes there are also additional specific phytosanitary requirements with regard to the land used for tuber multiplication in order to ensure freedom from certain pests and diseases.

Table 4.4  Comparison of seed crop rotation requirements (for species multiplied or cultivated in Ireland)

<table>
<thead>
<tr>
<th>Species</th>
<th>Irish seed certification crop rotation standard (interval since previous crop of same species)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Beans</td>
<td>2 years</td>
</tr>
<tr>
<td>Field Peas</td>
<td>2 years</td>
</tr>
<tr>
<td>Maize</td>
<td>n/a</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>6 years</td>
</tr>
<tr>
<td>Perennial Ryegrass</td>
<td>1 year</td>
</tr>
<tr>
<td>Potatoes</td>
<td>3 to 6 years (depending on category)</td>
</tr>
<tr>
<td>Sugar Beet &amp; Fodder Beet</td>
<td>n/a</td>
</tr>
<tr>
<td>Wheat, Barley, Oats</td>
<td>1 year</td>
</tr>
<tr>
<td>Triticale</td>
<td>1 year</td>
</tr>
</tbody>
</table>
Mechanical admixture is minimised by adherence to prescribed machinery hygiene practice with respect to planting, husbandry, harvesting and transport operations.

4.10.3 Seed assembly

The process of seed assembly, from harvesting, transport, storage and processing is subject to ‘conditions of certification’ and good operational practice. These requirements are detailed in species-specific operational manuals.

An assembler must have adequate intake, drying, cleaning, and storage facilities to handle the number of categories and volume of seed intended for certification. An assembler may be restricted to a smaller number of categories and volumes of seed by the DAF, where facilities are not deemed adequate. On receipt of the seed, the assembler should ensure that:

- There is reconciliation of the volume delivered with the certified production area through a ‘passport system’.
- The intake areas are clean and clearly identified.
- A sample from each load is taken at the intake point.
- Categories and quantities of all varieties delivered are recorded and records on their storage location retained.

Following intake, seed is dried, pre-cleaned and stored pending further cleaning, sampling, and laboratory testing. In addition, most seed is dressed with chemical pesticides to control seed-borne pests and diseases prior to distribution. Detailed records are maintained of all quantities certified and labels issued allowing for traceability between farmers and merchants if required.

Most seed plants are compliant with relevant ISO standards and the businesses are registered as members of IGAS.

4.10.4 Official controls

The entire process from farm to final seed marketing is subject to spot-checks, tests and inspections by the DAF crop inspectorate. Verification of varietal identity, purity and plant health is based on both visual inspection of the seed crop in the field and laboratory testing.

At sowing, strict procedures are in place to ensure that the variety and category of seed sown are correct. Seed labels retained by the grower are inspected to reconcile the area planted with the amount of seed supplied.

The seed crop is systematically inspected at specific crop growth stages. Certain characteristics are visible only at very specific growth stages, thus timeliness of crop inspections is of the utmost importance. Where necessary, impurities may have to be removed from the crop during the growing season (rogueing), to ensure that the crop reaches the minimum purity standards. In some cases, this is not practical or economically possible and the crop is rejected for seed use.
If all crop inspection requirements are met, the crop is provisionally accepted (depending on laboratory testing for cereal seed) for certification and the assembler and grower are notified. The assembler is also given a written crop inspection report.

All seed processors, importers, blenders and packers must be registered with the DAF. Certified seed potato growers and packers must also be registered. Seed assembly plants are inspected before registration to ensure that their plant and equipment is adequate for the production of certified seed.

To ensure that seed meets the required certification standards, samples are taken from each seed-lot and undergo official tests, including germination, purity and the presence of certain seed borne diseases. If all requirements are met, the seed is labelled and certified for marketing by the DAF.

In addition, field ‘post-control plots’ of each seed lot are grown by the DAF and inspected during the year to assess compliance with varietal purity standards. Certified seed standards in each Member State are monitored through EU comparative trials and the operations of the designated certifying authority are subject to EU audit.

Current controls relating specifically to purity of seed with respect to the presence of GMOs are applied under the EU ‘Interim Plan of Action’ (July 2000). Under this plan six species were deemed to be ‘at risk’ of the adventitious presence of GMO – beet, maize, oilseed rape, soyabean, cotton and tomato. While all of these crops, except soyabean and cotton, have been cultivated in Ireland, only oilseed rape has had seed produced here in the recent past (2000).

For seed of the above species, importers of seed are required to provide a certificate from an approved laboratory indicating that each seed lot has been tested and found to be free of EU unauthorised GM content, or be within the threshold for approved GM events. The DAF carries out check-sampling and testing on a proportion of imported seed lots. Tests conducted since the introduction of the plan has found no presence of unauthorised events, or authorised events in excess of the permitted threshold.

While the procedures outlined above with regard to seed certification do not, in themselves, provide a blueprint for the controls necessary to manage the growing of GM crops, they are a valuable knowledge base for the development of coexistence measures and a source of experience for inspectorate staff for the operation of measures that will be required for the production of GM crops in the future.

Recommendations

I. The recommended separation distances between GM crops and non-GM crops as set down in this Report should be a mandatory requirement.

II. Growers, contractors and all operatives involved in the transport and storage of GM seed should adhere to the Code of Good Farming practice for coexistence with respect to: (a) the use of machinery and equipment and (b) the transport and storage of GM produce.
III. The Code of Good Farming Practice for coexistence should address the following:

a. rotation intervals after the cultivation of a GM crop
b. control of volunteer plants and related weed species
c. control of bolters in beet
d. use and cleaning of machinery and equipment
e. transport and storage of GM produce
f. testing of home-saved seed for GMO content

IV. Where independent scientific analysis suggests that a GM crop(s) could not coexist with its non-GM equivalents, within the thresholds pertaining under normal coexistence management measures, the State should consider an application to the EU Commission to establish a GM free zone on such specific crops at regional level.

V. Users of home-saved seed are encouraged to test for GMO content prior to planting and ensure the identity of that seed is adequately preserved.

VI. GM seed should be easily distinguishable from non-GM seed and should be labelled accordingly.
Chapter 5  Crops review

5.1  Maize

5.1.1  Production and distribution

Maize (\textit{Zea mays}) is a member of the grass family (\textit{Poaceae}) and originates from the Mexican region. Worldwide, maize is an important crop and is grown for:

(i)  Dried grain – which is processed as animal feed or human food. Flour, starch and oil obtained from maize grain are important base materials in the production of a range of foods. A large proportion of the maize starch is converted into syrups or ethanol for industrial use.

(ii) Sweet corn – where immature grain is harvested from the cobs of suitable varieties and used for human food.

(iii) Animal forage – where the whole crop is harvested and fed to animals, either directly or after preservation in the form of silage.

Globally, 21\% of total maize grain production is consumed as food. Maize forms a higher proportion of the staple diet in developing countries, while there is an increasing level of consumption of sweetcorn and popcorn in the developed regions.

Maize is widely grown in the European Union and represents a significant proportion of global maize production. Significant areas of maize production in Europe include the Danube basin from southwest Germany to the Black Sea together with Spain, southern France and northern Italy. In 2001, total production in the fifteen countries then comprising the EU was estimated at 38.86 million tonnes, the largest producers being France and Italy.

Maize has only recently become a significant crop in Ireland where it is produced and ensiled for animal forage. The entire plant is harvested and processed into animal feed in the form of silage. There is no commercial production of sweetcorn, maize grain or maize seed in Ireland. Distribution of maize grown in Ireland is outlined in Figure 5.1. The most recent CSO full Census of Agriculture taken in June 2000 gave a total area of production in Ireland of 13,978 hectares of forage maize, grown on 1,881 farms, giving a mean area of 7.431 hectares per farm. There was a significant increase in the total area of forage maize grown in Ireland in 2001 (19,700 ha) and 2002 (19,300 ha) while the area planted in 2003 decreased to 15,600 ha. (CSO, 2004). The crop has proven attractive to beef and dairy farmers and the area planted may also increase if more suitable varieties for Irish conditions become available.

Currently most maize production in Ireland is concentrated in the east, south-east and south of the country. Data from Area Aid Applications in 2004 listing the counties growing in excess of 200 ha is presented in Figure 5.2. These give an indication of the main maize growing regions in the country, however, a number of maize growers would not be included in the list of area aid applicants as they would not all have applied for area aid.
Maize is planted at about 100-110,000 seeds/ha and requires soil temperatures in excess of 8 °C to commence growth. The crop is planted in April-May and harvested in September-October. Yield of forage maize varies considerably depending on the climatic conditions during the growing season but is estimated at 13 – 14 tonnes dry matter per hectare. There has been an increasing trend to plant the crop under plastic film cover to allow earlier sowing and more rapid establishment. The use of film can increase dry matter yield by approximately 3 tonnes/ha and ensures consistency in yield and quality from year to year.

There is no maize seed produced in Ireland, as climatic conditions do not favour such production. The crop is planted with imported hybrid seed, mainly imported from continental Europe. Although maize is primarily cross-pollinating, breeder- or foundation-seed is produced from self-pollinated seed after several generations of inbreeding. A high degree of self-pollination (99.9%) is assured by planting in blocks that are separated by distances of at least 200m from other sources of pollen (Ingram, 2000). Hybrid seed production is accomplished by inter-planting rows of the male and female inbred parents (e.g. one row of pollinator to four female rows). Self-pollination of the female parent is prevented through detasseling prior to pollen shed or by the use of male-sterile females. Hybrid seed production requires similar separation distances to that employed for foundation seed (Eastham & Sweet, 2002).
5.1.2 Mechanisms of gene dispersal and survival

5.1.2.1 Pollen dispersal and hybridisation with wild relatives

Maize is a cross-pollinating plant and depends mainly on wind dispersal of pollen for fertilisation. It is an open pollinating crop with the male (tassel) and female (silk) flowers borne on separate plant organs. Pollen is produced in the male inflorescence and is released from the tassels in large quantities. In most varieties, pollen is produced before the female flowers, although there is usually some overlap of pollen shedding and silk emergence on the same plant that can account for up to 5% self-pollination.

Maize is primarily wind-pollinated although a small proportion of self-pollination (5%) does occur. Insect pollination (mainly bees) may also occur but it is deemed to be very limited, as the female flowers on a maize plant do not possess nectar. The survival time for pollen can vary from a few hours in hot dry conditions to several days in more temperate humid conditions.

The distance maize pollen can disperse depends on prevailing wind patterns, humidity and temperature. Pollen falling on the silks of the same maize variety or on a different variety will germinate almost immediately and complete fertilisation within 24 hours.

The maize plant is a prolific producer of pollen and it has been estimated that it can yield between 4.5 and 25 million pollen grains (Paterniani & Stort, 1974). Maize pollen measures approximately 0.1mm in diameter and is the largest of any pollen normally distributed by wind. Under normal climatic conditions, in excess of 90% of maize pollen is deposited within 5 metres from the source (Sears & Stanley-Horn, 2000).

There are no wild relatives of maize in Western Europe with which maize can hybridise. Hence, there is no risk that a trait from a GM maize variety will transfer into an interfertile wild species.

5.1.2.2 Seed dispersal and volunteer plants

Maize is an annual crop and seeds are the only survival structures. Natural regeneration from vegetative tissue is not known to occur and maize is not an invasive plant as it is a weak competitor outside cultivation. For this reason maize is not found in non-crop situations, such as hedgerows, ditches or roadsides. Survival of maize plants in succeeding rotation crops is rare and any volunteers that do occur are killed by frost or herbicide programmes.

The maize ear is borne on a central spike (cob) enclosed in modified leaves (husks). Seed dispersal does not occur naturally as individual kernels remain attached to the central spike and are not released to the soil surface prior to harvest. Small amounts of seed and whole cob dispersal may arise however during the mechanical operations of sowing, harvesting and transport and to a lesser extent from wind or pest damage.

5.1.3 Genetic modification of maize

Current genetic modifications to maize primarily relate to agronomic properties such as herbicide tolerance and resistance to certain lepidopteran insect pests (European Corn Borer
and Mediterranean Corn Borer). The donor genes have been obtained from bacterial sources such as *Bacillus thuringiensis*, to confer pesticidal properties to the modified maize plant. A *Streptomyces* bacterial gene has been used to express tolerance to the non-selective glufosinate-ammonium herbicide in maize. As a result, it is possible to control weeds in the field during the growth phase of the maize crop, and also control specific insect pests through the pesticidal properties incorporated in the plant.

Maize is subject to damage from a number of organisms including insects, birds and mammals. It is also susceptible to a range of fungal diseases and nematode, insect and mite pests. The European Corn Borer (ECB) (*Ostrinia nubilalis*) and the Mediterranean Corn Borer (MCB) (*Sesemia nonagrioides*) are considered the most damaging insect pests in the main maize producing countries in Europe. The ECB occurs mainly in France, Spain and Italy, while the MCB is most prevalent around the Mediterranean Sea, including Morocco. Both the ECB and the MCB can produce up to four generations per annum but two generations are more common.

As both the ECB and the MCB feed internally in the maize plant, they are difficult pests to control using conventional organo-phosphate and synthetic pyrethroid insecticides and for this reason GM varieties containing inherent resistance (*Bt* corn) have been developed to minimise losses. As neither the ECB nor the MCB are significant pests of maize in Ireland at present, there would be no economic advantage in planting the currently available varieties of *Bt* corn here.

Herbicide-tolerant maize varieties may prove attractive to Irish growers, as at present, control of certain weeds can be problematic in maize crops. Also, the withdrawal of approval for the use of atrazine, the most commonly used herbicide available to maize growers for the past number of years, will make weed control more difficult. The use of herbicide tolerant maize would simplify and improve the control of weeds. Some savings could result in the cost of weed control and, in addition, the environmental and toxicity profile of the herbicides currently used on GM crops would be more benign than the herbicide range used on non-GM crops at present.

### 5.1.4 The coexistence of GM and conventional maize

The conditions for the coexistence of GM and non-GM forage maize in Ireland are favourable. This is underlined by the fact that there is no seed production, maize volunteers are not a crop management issue and no wild relatives exist. In addition, GM content in non-GM crops following cross-fertilisation from GM crops is confined to the grain. As only forage maize is cultivated in Ireland, the overall GM content would be diluted in the animal feed i.e. the proportion of dry matter content of cob to vegetative material in the plant is approximately 1:1 thereby reducing the GM content of the whole crop forage by 50%.

**Coexistence measures**

**Certified seed:** Use of certified seed will ensure seed purity i.e. GMO content conforms to the labelling thresholds. Use of home-saved seed does not arise with maize.
Crop separation: The separation distance required to prevent the level of out-crossing exceeding the maximum threshold of 0.9% in a non-GM maize crop can be influenced by a number of factors including wind speed, wind direction, relative humidity, plant buffer zones between crops, pollen barriers, field size of both donor and recipient crops, flowering synchronisation, etc.

In 2001, the Advisory Committee on Releases to the Environment (ACRE, 2001) concluded that separation distances of 80, 130 and 290 m were adequate to ensure an upper limit of 1%, 0.5% and 0.1% respectively, of adventitious presence as a result of introgression via pollination in feed maize. These were employed for the Farm Scale Evaluation (FSE) trials in the UK (Henry et al., 2003) and comply with the recommended separation distances from the UK Supply Chain Initiative on Modified Agricultural Crops (SCIMAC). While maize pollen has been shown to travel distances of up to 800m (Treu and Emberger, 2000), a review of the literature (Eastham and Sweet, 2002) concluded that a separation distance of 200 m would maintain crop purity at 99% in grain maize in most cases. Standards laid down by the EU for the Seed Certification of Maize indicates that a separation distance of 200m is sufficient to maintain a crop purity level of 99.8%. Though such a distance has been suggested as a measure for the coexistence of GM and non-GM maize in Denmark (Tolstrup et al, 2003), some reports would suggest a 200m separation distance as excessive.

A study of seven Bt maize fields in Canada reported that between 96% to 99% of pollen remained within a 25m-50m radius of the maize fields and that 100% of pollen was deposited by 100m (Sears and Stanley-Horn, 2000). As part of the Farm Scale Evaluation study, Henry et al, 2003, concluded that the 0.9% threshold would be achieved at a separation distance of 25m and that the SCIMAC distance of 80m would, in most cases, be sufficient to ensure that levels of admixture were kept below a threshold of 0.3%. Further support for a minimal distance (6-12m) is provided by an examination of the coexistence of GM and non-GM maize in Spain where the commercial cultivation of GM maize exceeded 32,000 ha in 2003 and was estimated at 58,000 ha for 2004 (Brookes et al., 2004).

While there is significant variation in research findings with regard to the separation distance for maintaining purity in maize crops, it is concluded that a separation distance of 50 m should be adequate to comply with the maximum labelling threshold of 0.9% under Irish conditions. This is based on the fact that maize production in Ireland is for animal forage, with a dilution factor of 50% where the grain and vegetative material is ensiled as animal forage.

Rotation and control of volunteers: As maize does not give rise to volunteer plants and there are no wild relatives in Ireland, it is not deemed necessary to introduce a cropping interval prior to the planting of a following non-GM crop.

Cleaning of machinery and equipment: For growers of GM maize crops, all equipment, especially that used for sowing, harvesting and transport operations should be thoroughly cleaned between operations on GM and non-GM crops to ensure there is no inadvertent dispersal of GM seed. Transport equipment should be maintained to a high standard and all necessary precautions taken to ensure there is no loss of seed during transport, either on-farm or to other external premises.

(See Appendix 5 for summary table of crop management measures).
Crop management recommendations for the coexistence of GM and non-GM maize

I. The coexistence of GM and non-GM maize crops is feasible with a minimal impact to non-GM maize production.

II. A separation distance of 50 metres is recommended between conventional and GM forage maize crops.

III. Machinery should be thoroughly cleaned between operations on GM and non-GM crops.

IV. As the maize crop does not give rise to volunteers or wild relatives, it is not deemed necessary to introduce a cropping interval prior to the planting of a following non-GM crop.
5.2 Beet

5.2.1 Production and distribution

Beets (*Beta vulgaris ssp. vulgaris*) are members of the *Chenopodiaceae* family and comprise several cultivated forms, the most common of which grown in Ireland being, sugar beet, fodder beet, mangolds and red or garden beet. These beets are biennial plants growing vegetatively in their first year after which they are harvested for use in the food and feed industries. They exist in diploid, triploid, and tetraploid forms and are grown in Ireland as annual crops for the production of sugar for food and food additives, as a salad crop (red/garden beet) and as animal feed (fodder beet and mangolds). Beet production in Ireland is mainly in the form of sugar beet for the production of sugar. By-products include beet leaves, beet pulp and molasses, which are used for animal fodder. Sugar beet is distinguished from fodder beet in that the beet is primarily formed by the root, has higher dry matter (in excess of 20%) and the flesh colour is white. Fodder beet is primarily formed by the hypocotyl and is produced mainly above the soil surface.

The beet crops grown in Ireland are purely vegetative and therefore do not depend on a flowering and pollination period for their formation. As commercial varieties of beet are biennial, they do not usually flower within the harvesting regime for root production and a result very little pollen and seed is produced during the normal production cycle. However, some plants (usually less than 1%) have a low vernalisation requirement and will produce seed in their first season (bolters) from which pollen and seed will be produced and possibly dispersed. Some varieties are more prone to bolting than others and also climatic (especially prolonged cold spells early in the growing season) and environmental conditions can induce an increased level of bolting. Very early sowing in spring can give rise to an increased level of bolting. Modern varieties have, however, been bred to minimise the incidence of bolting. Beet crops are planted in March-April and harvested in late September-October. Sugar beet production is concentrated in the south and south-east of the country and is delivered to the factory on a phased basis from September to December. It is normally stored on-farm post harvest, usually in open-air clamps, until the date of delivery specified by the factory. It is grown under contract and processed during autumn/winter for the production of sugar. Sugar beet leaves are usually deposited on the soil surface at harvest and grazed *in situ* as animal feed. The extract from the processed sugar beet crop may also be used for animal feed as beet-pulp.

Fodder beet is grown for animal feed, although the acreage of fodder beet produced in Ireland is relatively small and has decreased in recent years. A small amount of red beet or ‘beetroot’, spinach, spinach beet and chard are grown as salad and vegetable crops for human consumption.

For the prevention of disease and pest carry-over between crops, a cropping interval of at least three years is operated for conventional cropping.

Both sugar beet and fodder beet production are concentrated in the east and southeast of the country (Figures 5.3 and 5.4). As sugar beet is grown under contract there is little deviation in the total area planted or the location of crop production from year to year.
A breakdown of sugar beet production and relative farm size in the year 2000 is outlined in Table 5.1. Beet production was spread across all farm sizes, with the mean area planted per farm of 6.9 ha.

Figures 5.5 and 5.6 outline the counties from which the majority of Area Aid Applications were submitted for sugar and fodder beet respectively for the year 2004.

- Sugar Beet: 26,691 ha grown on 2,965 farms with a mean area of 9.0 ha/farm. (DAF, Area Aid Applications, 2004).
- Fodder Beet: 4,049 ha grown on 1,122 farms giving a mean area of 3.6 ha/farm (DAF, Area Aid Applications, 2004).

The number of growers from area aid data is less than that recorded for the CSO, as not all beet growers would submit an area aid application.
Table 5.1  Number of farms with some or all of the area under sugar beet in 2000

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>&lt; 5</th>
<th>5-&lt; 10</th>
<th>10-&lt; 20</th>
<th>20-&lt; 30</th>
<th>30-&lt; 50</th>
<th>50-&lt; 100</th>
<th>≥ 100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of farms</td>
<td>104</td>
<td>238</td>
<td>512</td>
<td>606</td>
<td>1,205</td>
<td>1,385</td>
<td>600</td>
<td>4,650</td>
</tr>
<tr>
<td>Total area under sugar beet (ha)</td>
<td>209</td>
<td>674</td>
<td>1,771</td>
<td>2,271</td>
<td>6,084</td>
<td>10,638</td>
<td>10,554</td>
<td>32,201</td>
</tr>
<tr>
<td>Average under sugar beet (ha)</td>
<td>2.0</td>
<td>2.8</td>
<td>3.5</td>
<td>3.7</td>
<td>5.0</td>
<td>7.7</td>
<td>17.6</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

Figure 5.5  Sugar beet production area and number of farms in counties with area in excess of 800 ha.

Source: DAF, Area aid, 2004

Figure 5.6  Fodder beet production area and number of farms (to nearest 10) in counties with area in excess of 150 ha.

Source: DAF, Area aid, 2004

There is no seed production of beet in Ireland. The entire Irish seed requirement is imported. Sugar beet seed is mainly produced in southern Europe, while beet production in the more temperate regions of northern Europe is mainly vegetative for the production of sugar. Most of the potential for hybridisation and introgression is likely to occur in these seed producing areas. Thus, the main risk of the adventitious introduction of GM seed into conventional and organic beet crops in Ireland is from imported seed. Under the EU Interim Plan of Action, beet seed imports must be sampled, tested and found to be GM-free in order to be marketed. The DAF carries out administrative controls and check-sampling and testing to ensure compliance with this regulation.
5.2.2  Mechanisms of gene dispersal and survival

5.2.2.1  Pollen dispersal and hybridisation with wild relatives

Beet pollen is mainly dispersed by wind and to a minor extent by insects. In research (Dark, 1971) that used red beet as a pollinator source for a crop of sugar beet, the maximum cross-pollination recorded in the immediate downwind portion of the sugar beet crop was 5%. This fell to 0.3% at 90 m and 0.1% at 180 m. A second experiment by Dark (1971) gave similar results with 73% cross-fertilisation occurring in the adjacent 4 metres.

Wind speed and direction during flowering have a direct impact on pollen dispersal and strong correlations have been established between pollen dispersal and the direction of the prevailing wind. Beet is a prolific producer of pollen and the period of survival can be considerable (up to 50 days) given optimal conditions. However, under normal conditions pollen does not survive more than 24 hours when subject to wetting by dew.

Cross-pollination in root crops is not considered to be significant since the crop is harvested before flowering. However, a small proportion of plants in a crop will produce seed in the first year (‘bolters’) and this could facilitate the movement of a GM trait to non-GM crops/interfertile wild species. Therefore, the main risk relates to cross-fertilisation of weed beets and to the production of seed generated volunteer beet in the following crop. Cross-pollination between GM plants and non-GM plants will not result in harvested roots containing genetically modified material in the same year, i.e. the root is produced vegetatively and only the seed will be GM.

Hybridisation and introgression between cultivated beet and wild beets has been shown to occur. Wild sea beet (Beta vulgaris ssp. maritima) can be a significant problem in cultivated crops and is more frequently found in mild coastal regions. The wild beet is a hardy annual plant with thin multi-stemmed roots and low-lying stalks arranged in the form of a rosette. Weed beets contain a gene that allows them to reproduce as annual plants without the requirement for vernalisation. Wild sea beet occurs naturally in the seed-producing areas of Mediterranean Europe. This has facilitated the spread of sea beet in seed lots imported into the temperate north and western European regions and its establishment as a weed beet in cultivated crops. Seed from wild beet will survive in the seed bank, in some cases over the rotation interval between beet crops. These plants maintain their annual growth habit thus facilitating the production of seed in subsequent generations. Cultivated beets and wild sea beets are cross-compatible and there is a high risk of gene transfer where they are grown in close proximity and allowed to produce seed. There is a risk of pollen transfer to wild beet species where bolters and volunteer plants are not adequately controlled.

5.2.2.2  Seed dispersal and volunteer plants

Beet seed shed from bolters may give rise to a limited number of volunteer plants but these are usually controlled in the normal rotation and weed control programmes in following crops. Bolters and annual beet cannot be controlled by selective herbicides in the beet crop – they have to be removed by hand-rogueing or with the application of herbicide to individual plants.
Admixture of GM and non-GM beet is most likely to occur during distribution of GM seed or, as a result of failure to adequately clean planting drills and from spillages of seed in-store or on-farm. In addition, there is a considerable amount of within-farm and farm to factory transport involved in beet production. This can result in some dispersal of beet plants, which may develop as volunteers in subsequent crops or as feral populations in the precincts of storage clamps – beet roots or parts of roots containing growing points have the potential to survive over winter, especially in Ireland where winters can remain relatively mild. The control of such plants is essential to prevent these plants completing their biennial life-cycle and thus producing pollen and seed. Beet plants and remnants of the root may also remain in or on the soil post harvesting and these can give rise to volunteer plants in the following year.

5.2.3 Genetic modification of beet

Beet is a broadleaved crop that establishes slowly and thus has poor initial tolerance of weed competition. It is also sensitive to many herbicides, so that repeated low dose rates are often applied to give effective weed control. Weed control is therefore relatively expensive and poor weather conditions often reduce the effectiveness of the herbicide treatment. Beet is also sensitive to phytotoxicity from some herbicides, especially if the crop is under climatic stress. The high cost of conventional herbicides and the additional cost of making repeated applications to the crop, make the possibility of a more simplified weed control programme in GM crops more attractive to Irish growers. Some trials were conducted in Ireland to test for herbicide efficacy and crop tolerance to Round Up (Mitchell, 2000).

The two primary agronomic benefits that have been associated with the adoption of herbicide tolerant GM beet include: (i) increased flexibility for herbicide application and, (ii) an improved ability to control weed beet (Sweet et al., 2004). Compared to conventional programmes of weed control, either glyphosate or glufosinate ammonium provide the farmer with an extended ‘spray window’; the duration of which is dependent on the end of weed emergence and also crop vigour (Sweet et al., 2004).

Increases in yield of beet/sugar from GM varieties can vary significantly. The cultivation of herbicide tolerant beet has been shown to provide the grower with an average 6% yield increase (May, 2003; Moll, 1997; Tenning, 1998; Richard-Molard, 2001). Genetic modification offers the potential to increase overall beet yield and also improved sugar content per unit produced. In addition to the increased yield, savings would be expected as a result of the reduced pesticide applications.

As beet is susceptible to a number of viral diseases, international research has also focussed on the development of virus resistance. For Ireland, the most economically important diseases are: Rhizomania, which is a soil-borne disease caused by Beet Necrotic Yellow Veined Virus (BNYVV) and, Virus Yellows caused by two viruses – Beet Yellows Virus and Beet Mild Mosaic Virus, both of which are transmitted by aphids.

5.2.4 The coexistence of GM and non-GM beet

The coexistence of GM beet with non-GM beet will require existing management practices plus some additional precautions, mainly in the control of bolters and the destruction of
volunteer plants.

**Measures**

**Certified seed:** Use of certified seed will ensure seed purity i.e. GMO content conforms to the labelling thresholds. Use of home-saved seed does not arise for beet production in Ireland.

**Crop separation:** As beet is a biennial plant and is only grown vegetatively in the first year of its life cycle, there is a limited requirement for separation of GM and non-GM crops. The separation distance is dependent on the level of control of bolters, volunteers and weed beet plants in the adjacent beet crops. Assuming adequate control of bolters is maintained, the Working Group suggest that a separation distance of 6 metres between the border of the GM crop and the nearest non-GM beet crop to prevent mechanical gene dispersal. This separation distance is accompanied with a strict requirement that all bolters in the GM crop are removed and destroyed prior to flowering and setting of seed.

**Rotation and volunteer plants:** The main focus in preventing gene transfer is to maintain strict control of bolters and volunteer and weed beets that may survive in following crops or in beet clamps. The incidence of bolters arising from the sown seed is recorded annually in the DAF sugar beet Recommended List Variety trials and is approximately 0.1%. However, a small number of beet seeds may survive from one beet crop to another.

There is a strict enforcement of a one in three year rotation interval for sugar beet production in Ireland. Beet plants that survive in the following crops can be controlled with the normal herbicide programmes. The 3-year rotation interval as currently practiced should give good control of volunteer plants and of weed beet seed germinating in non-beet crops.

**Cleaning of machinery and equipment:** Admixture with GM and non-GM beet is most likely to occur during distribution of GM seed or, as a result of failure to adequately clean planting drills and from spillages of seed in-store or on-farm. For growers of GM beet crops, all equipment, especially that used for sowing, harvesting and transport operations should be thoroughly cleaned before and after use in order to ensure there is no inadvertent dispersal of GM seed. Transport equipment should be maintained to a high standard and all necessary precautions taken to ensure there is no loss of seed during transport, either on-farm or to other external premises.

Appropriate segregation of GM and non-GM harvested produce is essential to prevent the adventitious presence of GM plants in conventional/organic batches post-harvest. This can be achieved with proper storage measures and accurate record keeping and labelling, the latter of which is now required under EU legislation.

**Crop management recommendations for the coexistence of GM and non-GM beet**

**I.** A separation distance of 6 metres should be maintained between the border of a GM beet crop and the nearest non-GM beet crop to prevent mechanical admixture.

**II.** Bolters and annual beet should be rigorously controlled in GM crops to prevent pollen dissemination to wild relatives and to bolters of non-GM crops.
III. A cropping interval of three years should be maintained to effectively control volunteer plants and to reduce the number of annual beet seeds in the soil.

IV. Machinery should be thoroughly cleaned between operations on non-GM and GM crops.
5.3 Potato

5.3.1 Production and distribution

Potato (Solanum tuberosum) is cultivated for its tubers and is an annual, herbaceous plant that grows rapidly under the mild moist Irish climatic conditions. Potato leaves are alternate in order and the floral inflorescence consists of several flowers that can be pink, white, purple, or blue in colour. If the cultivar is fertile and the flowers are pollinated, berries will form that can contain up to several hundred true potato seed (TPS). TPS is primarily used in breeding programmes.

Commercial potatoes are all propagated vegetatively from "seed tubers" - references to "seed potatoes" generally refer to seed tubers, and not to true potato seed. Propagation from true seed only occurs at the breeding stage. Following the identification of commercially promising new varieties, the varieties are propagated by meristem tip culture. This system allows the production of virus-free clone stocks, which are then multiplied as minitubers in glasshouses, and for a further two years under strict field conditions, before commercial release of stocks.

Production may be categorised into the ‘first’ and ‘second’ early, ‘maincrop’ and ‘processing’ categories, with seed production of each category. Potato seed tubers are sown in drills, not only to facilitate harvesting but also to protect the tuber from light, which stimulates the production of the toxic alkaloid, solanine. Shoots emerge from the ‘eye’ of each tuber and subsequently, tubers develop from the root system of the plant. Dependent on the variety, between 8-25 tubers per plant can be produced.

Usually included in a 4-year rotation, seed tubers are sown in March/April and harvesting is carried out between June and September. ‘First’ and ‘second’ early potatoes are harvested between June and August and provide the consumer with the smaller, less starchy but popular ‘new potatoes’. Maincrop, processing and seed potato crops are harvested in September/October and are mostly processed by the food industry. Seventy percent of Irish potato production can be attributed to just three varieties: Rooster, Kerr’s Pink and British Queen. Rooster now accounts for 54% of the maincrop production area. Other varieties of significance include Lady Claire, Record and Lady Rosetta.

Potato is susceptible to several bacterial, fungal and viral diseases both during the growing season and post-harvest. As a result, significant quantities and frequent applications of crop protection products are applied. Late blight (caused by Phytophthora infestans) is one of the more destructive potato diseases and imposes upon the sector an annual cost of over €10 million. Other pests and diseases include ‘common scab’ (Streptomyces scabies), ‘gangrene’ (Phoma exigua), ‘black leg’ (Erwinia caratovora), potato cyst nematode (Globodera pallida) and potato virus X and Y (PVX and PVY respectively).

The Bord Glas National Potato Census 2004 showed that there were 732 commercial potato growers in the country, producing a harvest of over 300,000 tonnes of potatoes annually. Commercial potato production utilises approximately 12,600 ha of land, with the organic sector producing upwards of 114 ha (DAF, Organic Census, 2002).

Production is dominated by a small number of large-scale growers and the trend towards larger holdings is continuing with a 23% decrease in the number of growers between the
years 2000 and 2004. The largest 150 growers now account for 76% of the production area. In 2000, the average area per grower was 13.8 ha, whereas in 2004, the average holding was 17.2 ha. There is considerable concentration of potato production in the Northeast, with Meath, Dublin and Louth accounting for 58% of national production area. However, these three counties only account for 23% of the total number of growers. The highest numbers of growers are located in Donegal (132 growers with 1,237 ha), Cork (101 growers with 1,180 ha) and Wexford (89 growers with 848 ha). The location and main potato growing counties are outlined in Figures 5.7 and 5.8 while the distribution of potato farming across the various farm size categories are listed in Table 5.2.

**Figure 5.7**  Potato distribution by county

![Map showing potato distribution by county](image)

<table>
<thead>
<tr>
<th>Percentage of the Agricultural Area Used (AAU)</th>
<th>Meath</th>
<th>Dublin</th>
<th>Louth</th>
<th>Donegal</th>
<th>Cork</th>
<th>Wexford</th>
<th>Kilkenny</th>
<th>Tipperary</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 – 6%</td>
<td>3563</td>
<td>45</td>
<td>49</td>
<td>67</td>
<td>57</td>
<td>132</td>
<td>101</td>
<td>89</td>
</tr>
<tr>
<td>1 – 5%</td>
<td>2082</td>
<td>67</td>
<td>57</td>
<td>132</td>
<td>101</td>
<td>98</td>
<td>84</td>
<td>50</td>
</tr>
<tr>
<td>0.5 – 1%</td>
<td>1237</td>
<td>57</td>
<td>132</td>
<td>101</td>
<td>89</td>
<td>337</td>
<td>437</td>
<td>110</td>
</tr>
<tr>
<td>0.1 - 0.5%</td>
<td>180</td>
<td>84</td>
<td>180</td>
<td>84</td>
<td>437</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>0 – 0.1%</td>
<td>310</td>
<td>50</td>
<td>50</td>
<td>84</td>
<td>50</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

**Figure 5.8**  Number of potato growers and total area in counties with more than 300 ha.

![Chart showing number of growers and area](image)

Source: DAF/Bord Bia, National Potato Census, 2004
Table 5.2  Number of farms with some or all of the area under potatoes in 2000

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>&lt;5</th>
<th>5-&lt;10</th>
<th>10-&lt;20</th>
<th>20-&lt;30</th>
<th>30-&lt;50</th>
<th>50-&lt;100</th>
<th>≥100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of farms</td>
<td>547</td>
<td>701</td>
<td>966</td>
<td>743</td>
<td>961</td>
<td>748</td>
<td>253</td>
<td>4,919</td>
</tr>
<tr>
<td>Total area under potatoes (ha)</td>
<td>105</td>
<td>154</td>
<td>622</td>
<td>740</td>
<td>1,492</td>
<td>2,667</td>
<td>7,755</td>
<td>13,535</td>
</tr>
<tr>
<td>Average under potatoes (ha)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.6</td>
<td>1.0</td>
<td>1.6</td>
<td>3.6</td>
<td>30.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

In 2003, 9,200 tonnes of certified seed potatoes were produced in Ireland. Certified seed production in Ireland is restricted to certified ‘basic’ seed. The proposed labelling threshold for the presence of adventitious GM content in seed potatoes is 0.5%. As potatoes are vegetatively propagated, there is no risk of cross-pollination leading to impurities in the current-year seed crop. The long-established crop rotation requirements have proved adequate for volunteer control purposes. As with all seed crops, care must be taken at all stages of seed production to ensure the segregation of the seed.

It is estimated that in the region of 15 to 20% of the Irish seed requirement is imported. Under the Interim Plan of Action, potato is not considered to be an “at risk” species, and there is currently no GMO testing regime for imports. Under current legislation, home saving of GM tubers for seed may only be carried out under the seed potato certification scheme and thus under strict control measures which would maintain full segregation and traceability from non-GM tubers.

5.3.2  Mechanisms of gene dispersal and survival

5.3.2.1 Pollen dispersal and hybridisation with wild relatives

The potato plant is primarily self-pollinating. As a consequence, the potential impact of pollen dispersing from a GM potato is limited. Estimates for cross-pollination range from 0-20% (Plaisted, 1980), with pollen primarily dispersed by wind. Field trials with a GM potato crop have recorded maximum pollen dispersal distances of between 5-10m (Tynan et al., 1990). Pollen from a GM potato crop is unlikely to affect the receiving crop (conventional/organic), as fertilisation of the flower and subsequent seed production has no influence on tuber production (Treu and Emberlin, 2000; Eastham and Sweet, 2002). Therefore, if tubers taken from a crop that had been exposed to GM pollen were used as seed for the next crop, there would be no transmission of the GM material (Bock et al., 2002). Insect pollination can occur but it is not considered a significant mechanism for pollen transfer in potato (Eastham and Sweet, 2002).

Two related weed species (*woody nightshade* Solanum dulcamara and ‘deadly nightshade’ Solanum nigrum) of potato can be found in Ireland. However, research has concluded that cultivated potato cannot cross naturally with either of these weeds (Dale et al., 1992; McPartlan and Dale, 1994). As such, potato is considered to be a naturally contained species within Europe (Eijlander and Stiekema, 1994) and there is virtually no risk of a GM trait escaping from a GM potato crop into a related weed species.
5.3.2.2 Seed dispersal and volunteer plants

A continuous problem associated with potato cultivation is the significant number of tubers that remain in/on the ground post-harvest. These volunteer tubers or ‘groundkeepers’, emerge in the next season, thereby causing a weed problem for the following crop(s). If not adequately managed, they in turn will produce tubers and if not controlled, the problem will persist for several years. The issue can be compounded further if the crop is sorted and graded in the field immediately after harvesting, which adds to the number of tubers over-wintering in the soil seed bank. Estimates in Denmark put the number of residual tubers at anywhere between several hundred to several thousand per hectare (Tolstrup et al., 2003). Though this level of variation can be attributed to local farming conditions and cannot be directly applied to Irish potato systems, it underlines the importance of appropriate post-harvest control.

Adequate groundkeeper control in the following non-potato crops can be achieved through the application of an appropriate herbicide. Post-harvest cultivation can be delayed, thereby exposing tubers to winter frosts and bird feeding leading to a significant reduction in tuber viability. While it is possible for tubers to be lost during transportation, they have negligible capacity to establish outside the controlled environment of the field. Therefore, feral potato plants present minimal to zero risk of acting as a viable pollen source or recipient (Treu and Emberlin, 2000).

Many years' Irish experience in potato breeding programmes would indicate that it is extremely unlikely that volunteers arising from true potato seed would cause a problem. There is no record of new potato varieties being found in Irish land, as would be the case if plants originating from cross-pollinated true seed persisted. In almost ninety years of official inspections under the Seed Potato Certification Scheme, no new or unidentifiable variety has been found as a volunteer.

Admixture of GM and non-GM potato crops can occur during mechanical operations involving planting, harvesting, on-farm transport, on-farm storage, transport off-farm and at merchants premises.

5.3.3 Genetic modification of potato

To date, no GM potato has been approved for placing on the European market. However, potato is amenable to GM technology and a total of 232 applications have been made to the EU for the deliberate release of GM potato into the environment for research purposes (EU/JRC, 2005). It should be noted that a GM potato variety modified for starch is currently going through the regulatory procedure for the placing on the market under Directive 2001/18/EC.

From an agricultural perspective, the primary genetic modifications made to potato confer herbicide tolerance, insect, nematode and fungal resistance, and to a lesser extent, alterations in starch content. A potato variety designed to resist late blight (Phytophthora infestans) disease has already been created (Song et al., 2003). It has been estimated that the potential impact of introducing blight resistant GM potato onto the Irish market, all other factors being equal, would increase the annual income of the potato sector by approximately €4.5million. The reduction/elimination of associated fungicide control would account for over 80% of this
financial impact (Gianessi et al., 2003). Other disease traits that could be potential targets for GM include tolerance to PVX and PVY.

Whereas no application has been submitted directly to the EPA to approve GM potato cultivation in Ireland for field trial purposes (Part B notification), this may change if a GM blight-resistant potato variety became commercially available. The use of potato for alternative purposes (synthesis of industrial, medicinal products) is an additional factor that could also accelerate the appearance of GM potato in Ireland. GM potato varieties with modified starch content have been developed for the purpose of supplying the starch industry. Many research papers have already reported the successful synthesis of vaccines, antibodies etc. in GM potato. Produced in the tuber, these compounds have been extracted and purified and subsequent efficacy testing has highlighted this technique as a potentially novel system for the production of therapeutics.

5.3.4 The coexistence of GM and non-GM potato

Based on the reproductive characteristics of the crop, the coexistence of GM and non-GM potato crops will not pose a significant challenge to the Irish potato growers. To ensure that the 0.9% / 0.5% thresholds are not exceeded in crops adjacent to a GM crop, some additional management measures will be required, and in particular, the prevention and control of ‘groundkeepers’.

Measures

Certified seed: Under Irish legislation, all seed potatoes intended for planting, whether for own-use or for marketing, must be officially certified under the seed potato certification scheme. Such certification provides the assurance of identity, varietal purity and traceability of seed.

Home-saved seed: Home-saved seed potatoes are subject to certification by the DAF and unofficial home-saving of seed is illegal.

Crop separation: While research studies have indicated that potato pollen can travel distances of up to 20m from its source in certain circumstances, the current distance for traditional potato breeding purposes is only 4m. In light of this, a 20m separation distance should prove adequate for either a 0.5% or 0.9% threshold requirement. While cross-pollination and fertilisation can give rise to potato ‘berries’, these will not generally give rise to viable potato plants and any that do arise are easily controlled in a normal tillage rotation.

Rotation and volunteers: The management of groundkeepers is essential for coexistence. In addition to existing mechanical and chemical control measures, vigilance should be exercised during harvesting to minimise the number of tubers returning to the seed bank. During the grading process, waste tubers should be disposed of appropriately to ensure they do not give rise to volunteer plants.

As with conventional potato systems, GM potato should preferably be followed by cereals in the rotation, which would permit the application of cereal herbicides to control emerging groundkeepers. Similarly, it is recommended that GM potato should be included in a one in four year rotation for commercial production, with a 4-6 year rotation (depending on
generation category) applying before being followed by a seed crop. The intervening rotation crops should also be monitored closely for groundkeepers.

**Cleaning of machinery and equipment:** All farm machinery and equipment should be thoroughly cleaned prior to, and after, sowing and harvesting. All vehicles should be checked to prevent spillage during transport to storage facilities. If necessary this should include covering the tubers during transfer from the field.

The appropriate segregation of GM and non-GM harvested tubers is essential to prevent the adventitious presence of GM tubers in conventional/organic batches post-harvest. This can be achieved with proper storage measures and accurate record keeping and labelling, the latter of which is now required under EU legislation.

**Crop management recommendations for the coexistence of GM and non-GM potato**

I. A separation distance of 20m is recommended to limit gene dispersal, primarily, mechanical admixture.

II. Effective monitoring and control of groundkeepers is necessary to prevent the development of volunteer plants. Measures include a one in four-year crop rotation or up to six years for early generation seed crops.

III. Machinery, transport and storage equipment etc., used in GM crop production, should be thoroughly cleaned between operations on GM and non-GM potato crops.
5.4 Cereals - Wheat, Barley, Oats and Triticale

5.4.1 Production and distribution

Cereals are members of the *Gramineae* (grass) family. Most cereal grains produced on Irish farms are used for food and animal feed for the home market, although there is a small level of trade in seed and whole grains, especially to Northern Ireland. In total, 43,000 tonnes of cereal *seed* was produced in Ireland in 2003, while total cereal production for food and feed is in the region of two million tonnes annually.

According to the Area Aid Applications for 2004, a total of 15,043 producers planted 311,702 ha of cereals with a mean area per farm of 20.7 ha. The main production regions are in the south and east (Figure 5.9).

**Figure 5.9** Distribution of cereals in Ireland

Source: Central Statistics Office, Census of Agriculture, 2000

Counties with the highest production areas are outlined in Figure 5.10

**Figure 5.10** Counties with cereal area in excess of 10,000 ha

Source: DAF, Area aid, 2004
**Wheat**

Wheat is believed to have originated in the Middle-East and is thought to be the result of an accidental hybridisation between the diploid einkorn Triticum species with a wild grass-like Aegilops species. Common wheat (*Triticum aestivum L.*) is a hexaploid and is the world’s most cultivated crop, with production based primarily in the more temperate areas of the Northern hemisphere. There are several wheat species and up to 20,000 cultivars.

Wheat is primarily a self-pollinating plant, though a limited amount of cross-pollination can occur, mainly via wind-dispersal. Cross-pollination under field conditions normally involves less than 2% of all florets (Wiese, 1991). Cross fertilisation is reduced under conditions of high humidity and increased in warm dry weather.

Anthesis starts several days after the spike emerges, with the main culm flowering first and the tillers later. Flowering begins in the middle third of the ear and proceeds upwards and downwards. Winter sown wheat varieties flower in early June, while spring-sown crops will flower 2-3 weeks later. Flowering will usually be completed in the plant within one week, although this can extend to two weeks in cold, dull weather conditions.

The quantity of pollen produced is regarded as relatively low, estimated at 2,700 grains per pollen sac, and these mature 1-3 days before fertilisation occurs. Under favourable weather conditions a floret will complete the flowering cycle in a matter of minutes, although an unfertilised spikelet may remain open for a number of hours or even days, thus increasing the potential for cross fertilisation.

Wheat grown in Ireland is used either for seed, animal feed (feed wheat), or for bread and biscuit flour production. Wheat germ may also be extracted and used as a food supplement. There is an increasing utilisation of the whole-wheat crop, harvested prior to being fully ripe and used as animal forage. Wheat straw is used for animal bedding, animal feed, organic matter for soil, as a substrate for mushroom compost or occasionally for fuel.

The mean area of conventionally grown wheat in Ireland for the years 2001 to 2003 was 94,400 ha, of which 63,500 ha was sown in autumn and 31,000 ha sown in spring (Figure 5.11). The relative area of winter versus spring sowings varies from year to year depending on the sowing conditions prevailing during autumn, with a corresponding increase in spring sowing following difficult autumn conditions.

**Figure 5.11  Spring & winter wheat area 2001-2003**

Source: Central Statistics Office, 2004
Mean yield of winter wheat was 9.1 t/ha in the years 2001-2003 and mean yield of spring wheat was 7.6 t/ha. A total of 3,347 farms had wheat crops in 2000 with an average area of 23.3 ha/farm (Table 5.3).

Table 5.3  Number of farms with some or all of the area under wheat in 2000

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>&lt; 5</th>
<th>5-&lt; 10</th>
<th>10-&lt; 20</th>
<th>20-&lt; 30</th>
<th>30-&lt; 50</th>
<th>50-&lt; 100</th>
<th>= / &gt; 100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of farms</td>
<td>34</td>
<td>62</td>
<td>207</td>
<td>211</td>
<td>563</td>
<td>1,226</td>
<td>1,044</td>
<td>3,347</td>
</tr>
<tr>
<td>Total area under wheat (ha)</td>
<td>63</td>
<td>320</td>
<td>1,476</td>
<td>1,640</td>
<td>6,172</td>
<td>18,667</td>
<td>49,628</td>
<td>77,966</td>
</tr>
<tr>
<td>Average area under wheat (ha)</td>
<td>1.9</td>
<td>5.2</td>
<td>7.1</td>
<td>7.8</td>
<td>11.0</td>
<td>15.2</td>
<td>47.5</td>
<td>23.3</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

Most wheat crops receive at least two applications of foliar fungicide, with some winter crops receiving three and in some cases four applications to control diseases, the most common of which are powdery mildew (Erysiphe graminis f. sp. tritici), glume blotch (Septoria nodorum) and leaf blotch (S. tritici). Take-all (Gaeumannomyces graminis) root disease and eyespot stem disease (Pseudocercosporella herpotrichoides) can also lead to major yield and quality reductions and render the wheat plant susceptible to lodging. Fusarium ear disease can also result in a significant reduction in yield and quality, especially in warm moist summers. A plant growth regulator to minimise lodging risk, is also normally applied in spring. Seed for conventional crops is chemically treated prior to planting to control a range of seed-borne diseases.

Barley

Barley (Hordeum vulgare L.) is one of the major cereal crops in the world, ranking fourth behind wheat, maize and rice. The basic chromosome number is seven and all cultivated forms are diploid (2n = 14). It is self-pollinating, though cross-pollination can occur to a limited extent. Cross-pollination between barley cultivars is generally low, recorded at less than 2% at short separation distances of 1–2m, even where the recipient plants are male sterile (Tammisola, 1998).

Most pollen is shed within the spikelet and consequently self-fertilisation is usual in barley. Pollination may occasionally occur while the head is in the boot but usually occurs 3–4 days after it has emerged, with pollen grains germinating within minutes of landing on the stigma. Flowering begins in the middle third of the ear and proceeds upwards and downwards, taking between 1-4 days to complete. Winter sown varieties flower in late May/early June, while spring-sown crops will flower 2-3 weeks later. Flowering will usually be completed in the plant within one week, although this can extend to two weeks in cold, dull weather conditions.

Cultivated barley is an annual crop and is planted in Ireland as winter-sown (usually September) or as a spring-sown crop (February – April) and harvested in late July (winter-sown) and mid to late August (spring-sown).

Barley cultivars exist as two types - two-row and six-row. Two-row types dominate the barley crop in Ireland with all of the spring-sown crop and over 95% of the winter crop sown to two-row cultivars. Six-row types contain 25-60 kernels per ear, while two-row cultivars
contain an average of 15-30 kernels per ear. Although the six-row types are generally higher yielding, grain quality is inferior to the two-row cultivars.

The barley crop in Ireland is used for animal feed and as a raw material in the malting and brewing industry. Occasionally barley crops may be harvested for whole-crop forage. Barley is normally planted in rotation with wheat, sugar beet or potatoes. Loss of grain during harvest can lead to the build-up of reservoirs of seed in the soil seed-bank and the subsequent production of volunteers. However, these can be controlled with conventional herbicides during the normal rotation and will generally not survive in the seed-bank for more than 1-2 years.

The mean acreage of conventionally grown barley in Ireland for the years 2001 to 2003 was 180,400 hectares, of which 20,900 ha was sown in autumn and 159,500 ha sown in spring. (Figure 5.12).

**Figure 5.12** Spring & winter barley area 2001-2003

![Barley Area '000 ha](chart)

Source: Central Statistics Office, 2004

Mean yield of winter barley was 7.4 t/ha in the years 2001-2003 and mean yield of spring barley was 6.2 t/ha. A total of 12,980 farms had barley crops in 2000 growing an average area of 14.0 ha/farm (Table 5.4).

**Table 5.4** Number of farms with some or all of the area under barley in 2000

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>0-5</th>
<th>5-10</th>
<th>10-20</th>
<th>20-30</th>
<th>30-50</th>
<th>50-100</th>
<th>&gt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of farms</td>
<td>227</td>
<td>410</td>
<td>1,367</td>
<td>1,585</td>
<td>3,407</td>
<td>4,338</td>
<td>1,646</td>
<td>12,980</td>
</tr>
<tr>
<td>Total barley</td>
<td>450</td>
<td>1,908</td>
<td>9,718</td>
<td>12,743</td>
<td>35,546</td>
<td>62,621</td>
<td>59,321</td>
<td>182,307</td>
</tr>
<tr>
<td>Average under</td>
<td>2.0</td>
<td>4.7</td>
<td>7.1</td>
<td>8.0</td>
<td>10.4</td>
<td>14.4</td>
<td>36.0</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

Most barley crops receive two applications of foliar fungicide to control diseases, the most common of which are powdery mildew (*Erysiphe graminis* f. *sp. hordeum*), leaf blotch (*Rhynchosporium secalis*) and net blotch (*Drechslera teres*). Seed for conventional crops is also chemically treated prior to planting to control a range of seed-borne diseases. Winter barley is generally treated with an insecticide in October/November to control aphid populations and prevent the spread of barley yellow dwarf virus, while some spring crops may also receive an insecticide application.
Oats

Oat production in Ireland ranks third behind barley and wheat in scale of production. It is used mainly for animal feed, particularly in the horse and sheep industries, but it is also used for food in breakfast cereals and in recent years there has been some growth in the export market. World production is relatively small compared to wheat and barley and, to date, there has been little interest in the development of genetically modified oats.

The cultivated oat (*Avena sativa L.*) is a member of the *Gramineae* family and, like wheat and barley, is self-pollinating with a limited degree of cross-pollination. The basic chromosome number of *Avena* is seven (2n = 14). With a ploidy series similar to wheat it exists as diploids, tetraploids and hexaploids. Cultivated oats in Ireland (*Avena sativa*) and the naked oat (*Avena nuda*) are hexaploids, as is the weed form *Avena fatua* (wild oats).

Oats is grown as an annual crop and sown in either autumn (September-October) as winter oats, or in spring (February – March) as spring oats. The mature stem terminates in a loose open panicle with branched, pendulous, 2-3 flowered spikelets. The oat plant grows to a height of 90-120 cm and is normally treated with plant growth regulator to reduce risk of lodging. The main foliar diseases are powdery mildew (*Erysiphe graminis f. sp. avenae*) and crown rust (*Puccinia coronata*), control of which requires at least one and possibly two (winter sown) applications of fungicide in conventional crops. Unlike barley and wheat, oats will grow on soils that are sandy, low in fertility and slightly acidic.

The mean area of oats grown for the years 2001-2003 was 18,900 ha, of which 9,900 ha was spring-sown and 9,000 ha winter-sown (Central Statistics Office, 2004) (Figure 5.13).

![Figure 5.13](image)

**Figure 5.13** Spring & winter oat area 2001-2003

The ratio of winter to spring sown oats can vary considerably depending on the suitability of sowing conditions in the autumn. The mean oat area grown per farm was 7.4 ha, sown on a total of 2,277 farms (Table 5.5). Spring oats is sown in February/March and harvested in mid to late August and gave a mean yield of 6.4 t/ha for the three years 2001 – 2003. Winter oats is sown in September-October and harvested in early August and gave a mean yield of 8.0 t/ha for the years 2001-2003.
Table 5.5  Number of farms with some or all of the area under oats in 2000

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>&lt; 5</th>
<th>5-&lt; 10</th>
<th>10-&lt; 20</th>
<th>20-&lt; 30</th>
<th>30-&lt; 50</th>
<th>50-&lt; 100</th>
<th>= / &gt; 100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of farms</td>
<td>38</td>
<td>74</td>
<td>247</td>
<td>261</td>
<td>497</td>
<td>707</td>
<td>453</td>
<td>2,277</td>
</tr>
<tr>
<td>Total area under oats (ha)</td>
<td>67</td>
<td>161</td>
<td>807</td>
<td>859</td>
<td>2,286</td>
<td>4,581</td>
<td>8,054</td>
<td>16,815</td>
</tr>
<tr>
<td>Average under oats (ha)</td>
<td>1.8</td>
<td>2.2</td>
<td>3.3</td>
<td>3.3</td>
<td>4.6</td>
<td>6.5</td>
<td>17.8</td>
<td>7.4</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

Triticale

Triticale (*Tritice secale*) is a ‘man-made’ cereal from the crossing of wheat and rye. It is regarded as having a higher cross-pollination potential than wheat, barley or oats. Triticale is normally sown in October and to a lesser extent in February/March and harvested in August. It is tall-strawed and late maturing but requires lower inputs than wheat or barley. It can be susceptible to ergot disease (*Claviceps purpurea*) and is also prone to sprouting pre-harvest. The crop has good foliar disease resistance especially to *Septoria tritici* and has good resistance to lodging, despite its tall straw.

There has been very little triticale production in Ireland in recent years. However, there is some renewed interest recently, as a low-input crop for whole-crop forage, and in particular, is of interest to organic cereal producers due to its higher level of disease resistance and superior nutritional content relative to wheat. Production methods are similar to those for wheat and while the grain yield is lower than wheat, the cost of production is also lower as it can be grown with a reduced level of inputs.

Triticale’s nutritional quality is similar to, and in some respects, surpasses that of wheat. In particular, triticale’s higher lysine content, better protein digestibility and mineral balance make it suitable for inclusion in certain human and animal feeds. Triticale has been developed for production in more difficult soil and environmental conditions and performs better than wheat in acid soils.

5.4.2 Mechanisms of gene dispersal and survival

5.4.2.1 Pollen dispersal and hybridisation with wild relatives

Wheat pollen is described as relatively heavy (de Vries, 1971) and has characteristics favourable for self-pollination. Pollen is produced in relatively small amounts, will generally only remain viable for a number of minutes. Out-crossing levels are likely, therefore, to be low (Treu & Emberlin, 2000). A study by de Vries (1974), recorded that after a distance of 1m from the pollen source the rate of out-crossing was below 10% and that no cross-pollination events were recorded beyond 20 m from the source.

Wagner & Allard (1991) measured cross-pollination in barley plants at 0.23% for plants set 0.3m apart and concluded that, while barley pollen was recorded to travel up to 60m from source, a separation distance of one metre would be adequate to maintain a minimal level of cross-fertilisation.
Oats is self-pollinating with a limited degree of cross-pollination, while triticale is regarded as having a higher cross-pollination potential than wheat, barley or oats.

In general wheat and barley do not inter-cross. Any hybrid seed produced would be either sterile or, if fertile, would not survive. Insects are not considered significant vectors for cross-pollination in cereals, as nectar is not produced in the flowers. Also, the prevalence of self-pollination means that any visiting insects are unlikely to contribute significantly to cross-pollination (Treu & Emberlin, 2000).

Wheat and barley can cross with wild barley species such as *Hordeum jubatum*, *H. marinum*, *H. murinum*, *H. bulbosum* and others. Given the propensity for barley to self-pollinate and the lack of success in achieving hybridisation with other *Hordeum* species, even with manual intervention, it is considered unlikely that any cross-fertilisation will occur with wild relatives. The ability of any such hybrids to survive has been shown to be extremely limited and they are unlikely to establish as feral populations or become invasive in conventional crops.

Wheat may also cross with wild *Aegilops* species (e.g. *A. cylinrdrica*), which grows wild in parts of Europe (Feil & Schmid, 2002). However, all naturally occurring wheat hybrids are highly sterile and appear to be restricted to the first cross with little evidence for subsequent introgression (Ellstrand et al, 1999).

Cultivated oats has the greatest potential to hybridise with its wild relative – wild oats (*Avena fatua*) which is widespread in Irish tillage fields. Wild oat is difficult to control as it has a very high propensity to propagate and also to survive in the soil seed bank over a number of years.

Cultivated cereals do not generate feral populations that are sufficiently vigorous to establish significant populations and in any case are easily controlled by mechanical or chemical methods.

### 5.4.2.2 Seed dispersal and volunteer plants

Plant breeding methods over many years have developed cultivars that ripen uniformly over a short timescale. Breeding has also minimised the degree of seed shedding at harvest to reduce losses and minimise subsequent volunteer populations. Such breeding has reduced the ability of the cultivar to spread and survive over time.

Cereal seeds have a short survival period (1 – 3 years) in the soil seed-bank. However, they may survive for a longer period if they are ploughed-in following harvest. Reduced cultivation helps to minimise the return of seeds to the seed bank and the survival rate of seeds on a year-to-year basis. The longer seeds remain on the soil surface after harvest, the greater the possibility that they will germinate. Shallow tilling of the soil surface several days post-harvest will also encourage the germination of seeds and the resulting volunteer plants can then be destroyed, either by mechanical or chemical treatment.

Barley seed has the potential to survive longer than wheat, oats or triticale in the soil. In a continuous monocropping rotation, conventional cultivation techniques have the potential to generate a significant population of volunteers over time.
In general, volunteer cereals can be readily controlled by using a varied crop rotation in combination with the use of herbicides or through mechanical means. However, volunteers of the same species as the host crop are more difficult to control and would require particular management and rotation practices where GM crops are part of the cropping rotation.

Cereal seeds can also be dispersed via:

- **Farm Machinery** used during sowing and harvesting. Cereal seeds can be distributed in sowing equipment and in soil attached to machinery used for sowing (although the degree of distribution through the latter would be negligible). It is generally accepted that it is possible to adequately clean cereal sowing equipment where sufficient care is exercised.

A certain degree of seed loss is inevitable both before (seed shedding) and during harvest. At harvest, lighter seeds may be blown from the harvester, escape through the sieves or be carried in the harvester between crops. Proper cleaning of the harvester is essential to prevent carryover between crops – harvesting equipment can be difficult to clean to an acceptable standard.

Seed may also become embedded in the straw, while seeds from plants less than fully ripe may be returned to the soil surface attached to the straw. Most of these seeds will remain on the soil surface but a small proportion may be dispersed to neighbouring fields by birds or attached to humans, animals, rodents or farm machinery. Barley seed is more prone to such dispersal where part of the awn remains attached, as will occur if the crop is harvested prior to full maturity.

- **Straw** used for animal bedding and occasionally as an animal feed. Seeds may be embedded in the straw or attached to the rachis (especially if the crop is harvested prematurely). Such distribution may be within the farm or to other farms where straw is traded between farms. Straw is frequently traded out of the arable east and southern areas of the country to the non-arable livestock rearing western and northern areas. This is particularly true of barley straw.

- **Fresh animal manure** can contain a small number of viable seeds. Most grains will however, be de-natured in passing through the digestive tract of an animal so the number of viable seeds will be relatively small.

- **Transport** equipment. A large potential exists for seed distribution and loss associated with the transfer of seed from the harvester to grain trailers and the subsequent transport within the farm, between farms and from the farm to merchant’s premises. Losses can be significant if the harvesting equipment and transport equipment are not adequately sealed.

- **Assembly and Storage** There is potential for significant admixture of seed during assembly and storage, either on-farm or at merchants’ premises.
5.4.3 Genetic modification of cereals

Wheat is at the most advanced stage in GM cereal development particularly in terms of fungi resistance and herbicide tolerance. However, it is not expected that any application to grow GM wheat will be made in Ireland for the next 5-7 years.

There has been less research devoted to the development of GM barley, oats or triticale. However, in the medium term, research may concentrate on improving the malting and brewing characteristics of barley, while oats has certain nutritional and health attributes, which may attract GM research in future.

5.4.4 The coexistence of GM and non-GM cereals

The Working Group considers it possible to cultivate GM cereals in coexistence with non-GM cereals in Ireland. This is provided that the measures below are undertaken:

Measures

Certified seed: Use of certified seed will ensure seed purity i.e. GMO content conforms to the labelling threshold. As with all seed crops, the utmost care must be taken at all stages of seed production to ensure the segregation of the seed, both before and after propagation.

Home-saved seed: Growers using home-saved seed should have tests carried out to ensure the GMO content is below the seed labelling threshold. A sample should be retained for confirmation if required.

Crop separation: A separation distance of 6m should be maintained between both commercial and seed crops of non-GM and GM wheat, barley and oat crops to prevent cross-pollination and mechanical admixture at sowing and harvesting.

Due to its greater capacity for cross-pollination, the separation distance between commercial GM and non-GM triticale should be set at 20m. For seed crops of triticale, a separation distance of 50m should be adhered to.

Rotation and control of volunteers: The growing of GM cereals requires careful management for the prevention of seed loss at harvest and the control of volunteer plants post-harvest. Suitable rotations will allow for control of volunteer plants in following crops. A rotation interval of two years and three years is recommended for commercial and seed production of wheat, barley, oats and triticale respectively. If cultivation of GM oat varieties commences, stringent control of wild oats will be required to minimise the transfer of GM traits into the wild oat population.

Cleaning of machinery and equipment: All sowing, husbandry, harvesting and transport equipment should be thoroughly cleaned between operations on GM and non-GM cereals. Transport equipment should be adequately sealed to prevent loss of seed during transport, either on-farm or to other external premises. In addition, it is advised that straw from GM cereals should be retained on the host farm to prevent seed dispersal between farms.
Crop management recommendations for the coexistence of GM and non-GM cereals

I. A minimum separation distance of 6 metre should be maintained between GM and conventional wheat, barley and oat crops in order minimise cross-fertilisation and to avoid mechanical admixture. This should apply to both seed and grain crops.

For triticale, a separation distance of 20m is recommended between GM and conventional crops. This should be extended to 50m for seed production of triticale.

II. Non-GM crop growers should test and retain a representative sample of home-saved seed for the confirmation of seed purity.

III. A two-year non-cereal break should apply in the rotation between a GM cereal crop and a succeeding non-GM cereal grain crop.

IV. A three-year non-cereal break should apply in the rotation between a GM cereal crop and a succeeding non-GM cereal seed crop.

V. All machinery, transport and storage equipment used in GM crop production should be thoroughly cleaned between operations on GM and non-GM crops.

VI. All seed spillages should be thoroughly cleaned and disposed of appropriately.

VII. Volunteer plants should be effectively controlled through either mechanical or chemical means.

VIII. Where there is GM oat production, wild oats should be stringently controlled.
5.5 Oilseed rape

5.5.1 Production and distribution

Oilseed rape (Brassica napus) (or ‘canola’) is the world’s third most important oil-producing crop. Primarily a self-pollinator [outcrossing rates of 12-47% (Becker et al., 1992)], the crop is characterised by its bright yellow flowers that appear in April/May/June. The oil extracted from the harvested seed, is suitable for both animal and human consumption. Additionally, the oil can also be used as a biological fuel to power diesel engines that only require a simple modification to ensure compatibility. The oilseed rape cultivated for this purpose possesses high levels of the toxic glucosinolate, erucic acid. This is in contrast to the low erucic acid varieties, the oil from which is used to synthesise human/animal products. The residue that remains following the oil extraction process is high in protein and, when modified into a ‘cake’, is a beneficial supplement in animal feed.

Between 1996 and 2002, the global area of GM oilseed rape increased from 0.1 million ha to 3.0 million ha. In 2004, 4.3 million ha of GM oilseed rape was cultivated, up from 3.6 million ha in 2003 (James, 2004). The uptake of GM oilseed rape (or ‘canola’) has been most prominent in Canada where more than 75% of the commercial crop is genetically modified.

Oilseed rape is a relatively minor crop in Ireland and cultivation has decreased significantly since 1998, when over 5,500 ha were planted. The total area planted to oilseed rape in 2003 was in the region of 2,300 ha (CSO, 2004) and most of the crop was grown in the east and south-east of the country (Figure 5.14). According to Area Aid Applications to the DAF in 2004, there were 127 oilseed rape growers applying for area aid on a total of 2001 ha, giving a mean area 15.8 ha per grower. Oilseed rape was grown in 14 of the 26 counties, with Wexford, Meath, Louth and Westmeath growing in excess of 100 ha per county. Wexford had the highest number of growers (42) followed by Louth (26) and Meath (22). The remaining counties each had seven growers or less reflecting the higher concentration in just three counties. (Table 5.6)

Figure 5.14  Distribution of oilseed rape per county

![Distribution of oilseed rape per county](image)

Source: Central Statistics Office, Census of Agriculture, 2000
Table 5.6 Number of oilseed rape area aid applicants 2004

<table>
<thead>
<tr>
<th>County</th>
<th>No. of Applicants</th>
<th>Area (ha)</th>
<th>Mean Area / Applicant</th>
<th>County</th>
<th>No. of Applicants</th>
<th>Area (ha)</th>
<th>Mean Area / Applicant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlow</td>
<td>4</td>
<td>53.2</td>
<td>13.3</td>
<td>Meath</td>
<td>22</td>
<td>422.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Cork</td>
<td>7</td>
<td>26.5</td>
<td>3.8</td>
<td>Offaly</td>
<td>1</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Dublin</td>
<td>2</td>
<td>53.9</td>
<td>26.9</td>
<td>Tipperary</td>
<td>2</td>
<td>44.5</td>
<td>22.3</td>
</tr>
<tr>
<td>Kildare</td>
<td>5</td>
<td>61.7</td>
<td>12.3</td>
<td>Waterford</td>
<td>1</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Kilkenny</td>
<td>4</td>
<td>83.5</td>
<td>20.8</td>
<td>Westmeath</td>
<td>7</td>
<td>117.6</td>
<td>16.8</td>
</tr>
<tr>
<td>Laois</td>
<td>1</td>
<td>29.3</td>
<td>29.3</td>
<td>Wexford</td>
<td>42</td>
<td>644.5</td>
<td>15.3</td>
</tr>
<tr>
<td>Louth</td>
<td>26</td>
<td>396.6</td>
<td>15.3</td>
<td>Wicklow</td>
<td>3</td>
<td>45.1</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>127</strong></td>
<td><strong>2001.1</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>15.8</strong></td>
</tr>
</tbody>
</table>

Source: DAF, Area Aid, 2004

There has been no certification of oilseed rape seed in Ireland since the year 2000. The Irish seed requirement for this crop is therefore all imported. Under the Interim Plan of Action, oilseed rape seed imports must be sampled, tested and found to be GMO-free in order to be freely marketed. The DAF carries out administrative controls and check-sampling and testing to ensure compliance with this regulation.

Recently there has been an increased interest in growing oilseed rape for the production of biofuel and this is reflected in the increase in the number of growers in the Wexford area (up from 27 in 2003 to 42 in 2004) where a crushing plant is located. It is estimated that there are over 5,000 ha of oilseed rape planted in 2005 and this is expected to increase in the coming years. Approximately three tonnes of rapeseed is required to produce one tonne of rape oil.

Though both spring and winter varieties are available, winter varieties predominate in Ireland and serve as a convenient break crop in a cereal rotation. Sown in early autumn, these varieties flower the following April/May with harvesting occurring 10 - 12 weeks thereafter. The mean yield of oilseed rape in Ireland for the period 2001 – 2003 was 3.1 tonnes/ha.

As with all crops cultivated in Ireland, oilseed rape is susceptible to several fungal diseases. Blackleg (Leptosphaeria maculans), light leaf spot (Cylindrosporium concentricum) and stem rot (Sclerotinia sclerotiorum) can all impact significantly on crop yield while the crop can also require chemical treatment to control several pests. In addition to disease and pest control, oilseed rape suffers from competition with weeds, especially grasses, which are significant nutrient competitors. Herbicide treatments are therefore essential prior to seedling emergence and in the early stages of crop development.

5.5.2 Mechanisms of gene dispersal

5.5.2.1 Pollen dispersal and hybridisation with wild relatives

Pollen-mediated gene flow is a subject that has been researched intensively over the last 10 years. Notably, the rate of outcrossing will vary according to variety, local topography and environmental conditions (Salisbury, 2002). Furthermore, the level of outcrossing between two fields is dependent on the respective size of the two fields in question (Eastham and Sweet, 2002) and whether flowering in both fields is synchronous.
Oilseed rape is predominantly self-pollinating. However, pollen from oilseed rape plants can be readily dispersed via wind and insects. For insect-mediated pollen dispersal, the contribution of honeybees and bumblebees can be significant with pollen transfer occurring up to distances of 5km (Ramsay et al., 2003). Collaborative research, carried out by Teagasc and Trinity College Dublin (Flannery, 2004), has examined this issue but further work is required to gauge the implications of the research for coexistence in an Irish context.

Wind-derived pollen movement in oilseed rape has received significant attention. GENESYS, a modelling system designed to calculate the probability of gene flow from a GM to non-GM winter oilseed rape has been developed by INRA (Institut National de la Recherche Agronomique) in France and utilised in several studies (Bock et al., 2002; Tolstrup et al., 2003). In addition, multiple field trials have been completed on plots varying in size from several metres to several hectares. From an analysis of the collective data, it is clear that caution is required before results acquired from undersized field trials are used to predict an outcome for commercial scale production (Wilkinson et al., 1995). Recently, the importance of completing field trials on an agricultural scale has been further highlighted (Eastham and Sweet, 2002; Salisbury, 2002).

The conflicting issue in many of the research studies has been the separation distance required between the GM and non-GM crop. In the UK, Canada, France, Belgium and Sweden, varying separation distances (50m-400m) have been employed in research trials (Salisbury, 2002). The farm scale evaluations completed in the UK from 2000-2002, adopted a successful separation distance of 50m to attain a 1% threshold. Earlier work in the UK, for GM oilseed rape fields greater than two ha in size, recommended distances greater than 1.5m, 10m and 100m in order to maintain thresholds of <1%, <0.5% and <0.1% respectively (Ingram, 2000). Though alternative field surveys in France have suggested distances greater than 30m, 120m and 400m to obtain the same thresholds (CETIOM, 2000), the possibility that the studied crop could have contained traces of adventitious GM seed contamination was not addressed (Salisbury, 2002). As with all crop systems, the complete containment of GM oilseed rape pollen is impractical and while the majority of oilseed rape pollen is deposited within 10m, a review of several studies (Salisbury, 2002) has indicated that a 50m separation distance could ensure the rate of outcrossing does not exceed 0.9% (Table 5.7). However, the extent to which this is influenced by local climatic and topographic conditions is unclear and further research would be required to establish relevant data for Irish conditions.
Table 5.7  Rate of outcrossing between large *B. napus* fields as described in published research studies. Modified from (Salisbury, 2002)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Separation distance</th>
<th>Rate of outcrossing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Beckie et al., 2001)</td>
<td>0m</td>
<td>1.1</td>
</tr>
<tr>
<td>(Beckie et al., 2001)</td>
<td>50m</td>
<td>0.2</td>
</tr>
<tr>
<td>(CETIOM, 2000)</td>
<td>30m</td>
<td>&lt;1</td>
</tr>
<tr>
<td>(CETIOM, 2000)</td>
<td>120m</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>(Champolivier et al., 1999b)</td>
<td>1m</td>
<td>2</td>
</tr>
<tr>
<td>(Champolivier et al., 1999b)</td>
<td>20m</td>
<td>0.2</td>
</tr>
<tr>
<td>(Messean, 1997)</td>
<td>65m</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>(Downey, 1999)</td>
<td>20m (Field 1)</td>
<td>1.5</td>
</tr>
<tr>
<td>(Downey, 1999)</td>
<td>50m (Field 1)</td>
<td>0.4</td>
</tr>
<tr>
<td>(Downey, 1999)</td>
<td>20m (Field 2)</td>
<td>0.01</td>
</tr>
<tr>
<td>(Downey, 1999)</td>
<td>50m (Field 2)</td>
<td>0</td>
</tr>
<tr>
<td>(Norris and Sweet, 2002)</td>
<td>25m (Field 1)</td>
<td>0.25</td>
</tr>
<tr>
<td>(Norris and Sweet, 2002)</td>
<td>50m (Field 1)</td>
<td>0.10</td>
</tr>
<tr>
<td>(Norris and Sweet, 2002)</td>
<td>25m (Field 2)</td>
<td>0.7</td>
</tr>
<tr>
<td>(Norris and Sweet, 2002)</td>
<td>50m (Field 2)</td>
<td>0.4</td>
</tr>
<tr>
<td>Simpson unpublished</td>
<td>26.5m</td>
<td>0.15</td>
</tr>
<tr>
<td>(Eastham and Sweet, 2002)</td>
<td>51.5m</td>
<td>0.1</td>
</tr>
<tr>
<td>(Wilkinson et al., 1995)</td>
<td>&gt; 32m</td>
<td>0.03-0.05</td>
</tr>
</tbody>
</table>

The issue can be complicated however. If, for example, a non-GM oilseed rape field has been sown with a variety that possesses a high level of male sterility, this crop is more sensitive to external pollen than a typical fertile variety and its cultivation adjacent to a GM crop would result in a higher level of outcrossing. Consequently, larger separation distances could be required if the 0.9% threshold is not to be exceeded (Eastham and Sweet, 2002; Ramsay et al., 2003).

As well as originating from the crop of oilseed rape, sources of pollen can also originate from oilseed rape volunteers that appear in rotation, related *Brassica* species and as feral populations that have established along a roadside, some of which can persist for over 12 years (Ramsay et al., 2003). Several wild relatives of oilseed rape exist in Ireland, the most widespread being wild turnip (*Brassica rapa*), which commonly flowers along hedgerows in the summer months. Due to its self-incompatibility, the possibility of a GM trait establishing in a wild *B. rapa* population does exist, (Snow and R., 1999) though it is dependent on multiple genetic and environmental factors. Similarly, hybridisation between *B. napus* and *B. juncea* (Indian mustard) is also possible (Jorgensen et al., 1996). Hybridisation is also possible with *Sinapis arvensis* (Charlock) a common weed in agricultural systems. Natural hybridisation between *B. napus* and *Raphanus raphanistrum* (wild radish) has not been observed (Sweet and Shepperson, 1996; Jorgensen, 1999). Hybridisation between *B. napus* and *B. oleracea* (wild cabbage) is theoretically possible but no known hybrids have been reported through open-pollination (Scheffler and Dale, 1994).

5.5.2.2 Seed dispersal and volunteer plants

As oilseed rape is harvested when the pods are at low moisture content, premature pod shatter can be a serious problem both prior to and during harvesting. Between 10 and 50% of the seeds can be lost due to the fragile pods opening before harvest, which can translate to 400-2000kg of seed deposited per hectare. Failure to harvest crops as soon as they are ripe can lead to significant loss of seed and this can be exacerbated if weather conditions are
unfavourable. In wet, windy weather conditions where harvesting is not possible, major seed losses can result leading to the establishment of very significant volunteer populations in succeeding crops. The small seed size and spherical shape of the seed can also lead to significant losses during harvesting and post-harvest transport. If left on the soil surface, much of this seed will germinate in the weeks following harvest, especially when adequate soil moisture is present. Young volunteer plants are relatively easy to control by either mechanical or chemical means and in general are easily controlled by conventional herbicides in following cereal crops. However, if soil inversion occurs immediately after harvest, very significant seed populations are returned to the soil seed bank where they may lay dormant for several years and produce high populations of volunteer plants for a number of years in following crops.

Even with ideal harvesting conditions and with careful management practices, a certain percentage of seed will be lost at harvest. Seed-shed, arising from premature pod shatter and harvesting is a significant issue in the cultivation of oilseed rape, where an average of over 3500 seeds /m² can be lost at harvest and remain on the soil surface (Sweet, 2004). In some harvests, pod shatter and seed loss can be especially severe in oilseed rape crops grown in Ireland due to unfavourable weather conditions at harvest. While this characteristic of oilseed rape will ensure the consistent emergence of oilseed volunteers, it is essential to employ best management practices to ensure a minimal return of oilseed rape seed to the soil seed bed and to effectively control the persistence of volunteers in other crops through herbicidal and mechanical treatment.

5.5.3 Genetic modification of oilseed rape

Since the first GM oilseed rape was developed (Moloney et al., 1989) significant research has been undertaken in GM oilseed rape, which is evident in the high number of notifications that have been lodged to the EU under Directive 2001/18/EC (http://biotech.jrc.it/deliberate/dbplants.asp).

The primary traits that have been incorporated into GM oilseed rape include herbicide tolerance, male sterility, insect resistance and the modification of seed oil composition. Future traits that could be introduced into oilseed rape include improved crop hardiness and further oil modifications. Oil content and composition are high on the list of targets as oilseed rape is the world’s third most important source of vegetable oil. The development of GM oilseed rape varieties with a higher percentage oil content and extraction rate may become an attractive prospect should the economics of rape oil for fuel or ‘biodiesel’ production become more favourable in the future.

Potentially, the most attractive modifications for GM oilseed rape for agricultural use for Irish farmers will be in disease and insect resistance. The incorporation of delayed pod shatter would be particularly advantageous to Irish growers, as currently loss of yield due to pod shatter is an annual problem in oilseed rape crops. Modification to generate higher oil content and improved oil extraction rate for biofuel production will also attract research interest.

There is very little oilseed rape seed produced in Ireland at present, however, should GM oilseed rape production become prevalent in other Member States, Ireland could prove an attractive location for the production of GM seed crops, should the overall level of oilseed rape production remain at its current low level.
5.5.4 The coexistence of GM and non-GM oilseed rape.

Based on the reproductive biology of the crop and the particular climatic conditions prevailing in Ireland, the coexistence of GM oilseed rape with non-GM oilseed could prove a major challenge. This is because of the mobility of oilseed rape pollen, the prolific emergence of oilseed volunteers in a rotation following oilseed rape cultivation and the presence of interfertile wild relatives. Therefore to ensure that the 0.9% / 0.3% GM labelling thresholds are not exceeded, existing management practices will require modifications and further research to establish appropriate separation distances for Irish conditions.

Measures

Certified seed: Use of certified seed will ensure seed purity i.e. the GMO content conforms to the labelling threshold. As with all seed crops, the utmost care must be taken at all stages of seed production to ensure the segregation of the seed, both before and after propagation.

Home-saved seed: Growers using home-saved seed should have tests carried out to ensure the GM content is below the GMO seed labelling threshold.

Crop separation: The establishment of a standard separation distance is complex because of the range of research findings and the influence of local conditions on pollen and seed dispersal and the survival and multiplication of volunteer and feral populations.

This is further complicated by:

- relatively high wind speeds leading to high rates of pollen dispersal over long distances
- lack of research data on the impact on beekeeping and honey production
- significant loss of seed pre-harvest and during harvesting operations due to unfavourable weather conditions
- high propensity of seed to establish feral populations under Irish temperate climatic conditions
- high return to and long-term survival rate of oilseed rape seed in the seed-bank.

The degree to which a trait originating from GM oilseed rape will disperse is difficult to assess in a field situation and the Working Group recommends that a comprehensive research programme be undertaken to establish appropriate separation distances and management measures for field-scale production of GM oilseed rape under Irish conditions.

Additional coexistence measures, as outlined below, would also need to be adopted and strictly enforced to prevent admixture of GM and non-GM crops.

A buffer crop of 10m of non-GM oilseed rape should be sown along the perimeters of each GM field. In addition to the separation distances this will further confine the spread of GM pollen and assist in reducing the potential for seed admixture at either sowing or harvesting. This buffer zone should to be sown and harvested after the GM crop and produce should be labelled as GM.

Rotation and control of volunteers: Seed loss during harvesting is unavoidable with oilseed rape and, in addition to losses in transport, the appearance of volunteers in the rotation is
inevitable under Irish conditions. Substantial control of GM originating volunteers can be achieved by allowing lost seed to germinate post-harvest, upon which the volunteers can then be controlled with target herbicides or by mechanical means. It is critical that volunteers are not allowed to develop in the rotation to the point where they discharge pollen and viable seed as this would increase the burden for subsequent crops and the potential for enhanced gene flow with non-GM crops.

GM oilseed rape should be included in a minimum four-year rotation, with a cereal crop following the GM oilseed rape to facilitate the control of volunteers. The cropping interval between the cultivation of GM oilseed rape and growing a non-GM oilseed rape seed crop in the same field should be eight years to prevent the carryover of volunteers.

The flowering period of many wild relatives of oilseed rape overlaps significantly with that of current winter oilseed rape varieties. As this could provide a mechanism for gene flow, it may prove problematic if herbicide tolerance is the trait introduced into the GM population. To minimise this risk, interfertile material should be removed from the perimeters of the field prior to flowering of the GM oilseed rape crop.

Cleaning of machinery and equipment: All sowing, harvesting, transport and storage machinery and equipment must be thoroughly cleaned after each use. This is critical to curtail the emergence of feral GM oilseed rape populations. Contractors have a particular responsibility in this regard as the size and spherical shape of oilseed rape seed make thorough cleaning difficult and seed deposits in combines and other equipment can give rise to transfer between farms.

Crop management recommendations for the coexistence of GM and non-GM oilseed rape

I. The setting of specific separation distances for seed and commercial crops should be postponed until further research data becomes available, preferably data relevant to Irish growing conditions.

II. A 10m buffer zone of non-GM oilseed rape should be sown (after planting the GM crop) around the perimeter of a GM oilseed rape crop and harvested with the GM crop.

III. Growers using non-GM home-saved oilseed rape seed should test and retain a representative sample of the seed to ensure it complies with the GMO labelling thresholds.

IV. A four-year non-oilseed rape arable break should be adhered to in the rotation between a GM oilseed rape crop and a succeeding non-GM oilseed rape crop.

V. An eight-year non-oilseed rape arable break should be adhered to in the rotation between a GM oilseed rape crop and a succeeding non-GM oilseed rape crop for seed.
VI. Volunteer plants must be effectively controlled to prevent the build-up of GM populations over time.

VII. Feral oilseed rape and wild relative populations in the vicinity of the GM oilseed crop should be controlled before flowering.

VIII. All machinery used in GM crop production should be thoroughly cleaned between operations on GM and non-GM crops.

IX. It would be desirable that GM oilseed rape should have dedicated equipment and processing lines in seed assembly premises.
Chapter 6  Review of organic and horticultural crop production

6.1 Organic crop production

6.1.1 EU Regulations pertaining to GMOs and organic production

While the EU Action Plan on Organic Farming specifies ‘that genetically modified organisms and/or any product derived from such organisms must not be used in organic farming (with the exception of veterinary medicinal products’)\(^3\), it is accepted at EU level that the presence of GMOs in non-GM farming systems cannot be completely excluded during cultivation, harvest, transport, storage and processing and that a certain level of adventitious presence will occur if GM and non-GM crops are grown in open agricultural systems.

Under current EU legislation, even though GMOs have not been directly used in the organic production system, the possibility is not excluded that organic products may contain some GMOs resulting from adventitious admixture. While it is proposed to introduce a provision in Regulation (EEC) No 2092/91/EC on organic farming, that products that are labelled as containing GMOs cannot be sold as organic, an amendment to Regulation (EEC) No 2092/91/EC is necessary to clarify the legal situation regarding the use of input products (feed, additives, etc.) which could contain GMOs, or, have been produced by a GMO.

Concerning seed for organic production, point 2.2.3 of Regulation (EEC) No 2092/91, states "The organic farming regulation establishes that no GMOs shall be used in production. Thus, materials, including seeds, which are labelled as containing GMOs cannot be used. However, seed lots containing GM seeds below the seed thresholds (which would not need to be labelled for this GMO presence) could be used. The organic farming regulation does allow for the setting of a specific threshold for the unavoidable presence of GMOs, but no threshold has been set. In the absence of such a specific threshold, the general thresholds apply."

As the general thresholds for seed have still not been established, the question of deciding whether specific thresholds for seed used in organic farming need to be set, and at what level, is still under consideration by the Commission and Member States.

The alternative to setting specific thresholds for GMOs for organic farming, is to operate a voluntary process-based system, where organic farmers would ensure, through their own protocols, that the use of GM inputs in their production system is avoided.

6.1.2 Organic crop production in Ireland

Baseline requirements for organic production are set at EU level. The DAF, as the competent authority, has approved three private organic certifying bodies\(^4\) to licence organic operators in Ireland. The labelling of a product as “organic“ implies that the product has been produced in compliance with the current regulations and agreed production standards.

\(^3\) Article 6 of Council Regulation (EEC) No 2092/91 on organic farming.
\(^4\) Demeter Standards Ltd.; Irish Organic Farmers and Growers Association and Organic Trust Ltd.
A census of organic operators taken by the DAF in 2002 identified that there were 923 organic producers registered with the DAF in Ireland (the figure has not significantly changed since then). The sector is concentrated in the south and west of the country, with Munster and Connacht accounting for three-quarters of all organic producers (Figures 6.1 and 6.2).

**Figure 6.1** Number of organic producers (all enterprises) by county 2002

![Organic Producers/County](source: DAF, Census of Irish Organic Production, 2002)

The total area of land devoted to organic production is c. 30,000 ha which represents 0.7% of the farmed area of the country (UAA). This is considerably lower than the former EU (15) average of 3.5% in 2002. The vast majority of organic farmers are livestock producers with beef and sheep as the major enterprises.

**Figure 6.2** Number of producers and total area in organic production (all enterprises) 2002

![Number & area in organic production](source: DAF, Census of Irish Organic Production, 2002)

There were 139 growers of organic crops in 2002 (some growing more than one crop), widely dispersed throughout the country: 77 producers growing vegetables, 40 growing cereals, 30 potatoes and 22 producing fruit (Figure 6.3). The total area devoted to organic crop production was 618 ha.
The average crop area for cereals was 10.4 ha; for potatoes 3.8 ha, vegetables 1.5 ha and fruit 0.4 ha (Figure 6.4). There were c. 3.6 ha of protected cropping (polytunnels and glasshouses) of salad crops and fruit.

The main counties for organic cereal production were Wexford (18% of all cereal producers), Kildare (13%) and Tipperary (13%) (Figure 6.5).
The main counties for organic vegetable production were Cork (16% of all vegetable producers), Galway (12%), Wicklow (9%) and Clare (9%) (Figure 6.6).

**Figure 6.6** Number of organic vegetable producers by county 2002

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cork</td>
<td>12</td>
</tr>
<tr>
<td>Clare</td>
<td>9</td>
</tr>
<tr>
<td>Galway</td>
<td>7</td>
</tr>
<tr>
<td>Wicklow</td>
<td>7</td>
</tr>
<tr>
<td>Leitrim</td>
<td>5</td>
</tr>
<tr>
<td>Tipperary</td>
<td>4</td>
</tr>
<tr>
<td>Offaly</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: DAF, Census of Irish Organic Production, 2002

### 6.1.3 Coexistence of GM crops and organic crops in Ireland

Given the present level of organic crop production, a limited introduction of GM crops should not pose a significant risk to organic crop production in the short-term. In addition, the range of GM crops currently available for commercialisation (oilseed rape and maize) are not grown to any significant extent by the organic sector in Ireland.

Implications for the organic sector from the introduction of GM crops in the longer-term will depend on the degree of expansion in the number of organic farming units, the extent of production and number of growers of GM cereals, potatoes and other horticultural crops. Other factors are changes in current organic production practices where organic production of oilseed rape, beet and maize may develop and where there is also cultivation of GM varieties of these species.

Where GM beet, maize, cereals and potato crops are grown in proximity to their organic equivalents, similar adjustments in current farming practice, as those outlined for coexistence with conventional production, will be necessary e.g. adherence to a code of good farming practice in relation to use of pure seed, control of volunteers, machinery hygiene, etc.

To provide additional reassurance to organic producers, the Working Group recommend that the separation distances outlined for conventional crops of these species be increased by 50% to allay strong organic stakeholder concern and cater for the relatively smaller unit size of recipient organic fields. As an additional insurance measure, the separation distances with respect to organic seed production should be increased by 100% relative to the distances proposed for conventional seed production.

The issue of the coexistence of GM and organic oilseed rape is similar to that of conventional crops in relation to use of pure seed, control of volunteers, machinery hygiene etc. However,
it has not been possible to set down separation distances for organic and GM oilseed rape due to insufficient research data on this subject, and in particular, data relevant to Irish conditions. Currently, the area of organic oilseed rape constitutes a very small proportion of organic crop production. However, this may change in the future and would, inevitably, have implications for coexistence. Recently, there has been increased interest in the production of oilseed rape as a biofuel source, and should this market continue to expand, there is a real possibility that the acreage of oilseed rape could expand significantly. The possibility that, in the longer term, some of these oilseed rape varieties may be genetically modified is also more plausible as the produce would be principally for a non-food market.

Coexistence of GM and organic crops - recommendations

I. Similar farm management measures, as those outlined for the coexistence of GM and conventional non-GM crops, are necessary for the coexistence of GM and organic crops.

II. Separation distances should be increased by 50% over conventional crops for commercial organic crops and by 100% for organic seed crops.

III. Coexistence measures should be reviewed for organic crops if/when specific thresholds for organic seed and produce are established.
6.2 Horticulture crops

Horticulture has been defined as: ‘that branch of agriculture that deals with the cultivation of plants used for food or for the production of food or ornament, including the technical procedures necessary for the production and preparation for market of flowers, decorative foliage, fruit, honey, mushrooms, nursery stock, vegetable crops (including potatoes and seed potatoes) and hops, and including the cultivation of woody and herbaceous plants and sports turf’ [Bord Glas Act, 1990].

The Irish horticultural industry makes a very significant contribution to the Irish gross agricultural output, positioned third after cattle and milk. At retail level, Irish consumers spending on fresh fruit, vegetables and potatoes, is second only to dairy produce. This section (6.2) itemises those horticultural crops of relevance to the Irish economy and their geographical distribution. It is not anticipated that there will be any production of GM horticultural food crops in Ireland in the short to medium term, although production of GM non-food amenity crops may develop over a shorter timescale. Coexistence measures for horticultural crops are not discussed in this Report and the Working Group suggest that such measures should be prepared in consultation with stakeholders on a case-by-case basis as the need arises.

There are a number of distinct sectors within the horticultural industry, as outlined below.

6.2.1 Field vegetables

The field vegetable sector includes all vegetable crops grown outdoors (excluding potatoes) and is comprised of about 20 main fresh produce lines, which can be categorised in order of area grown in Ireland: brassicas (66%), root crops (20%), bulb crops (6%) and outdoor lettuce (4%).

Most vegetables are either grown directly from seeds or transplants, with practically all breeding and seed production taking place overseas.

The main field vegetable crops grown in Ireland include:

- Brassicas – cabbage, broccoli, cauliflowers, swedes, brussels sprouts, kale and turnips
- Root crops – loose and bunched carrots, parsnips, beetroot
- Salad crops/leafy vegetables – lettuce, spinach
- Alliums – brown/white/red onions, scallions, leeks, shallots, garlic
- Stalk crops – celery
- Squashes – courgettes, marrows, pumpkins
- Rhubarb
- Legumes – peas, beans, mange tout
- Other minor crops – e.g. sweetcorn
- Herbs – parsley, sage, thyme, basil, chives, coriander, dill, mint

The total area of field vegetables produced in the year 2000 was estimated at 5,286 ha. A breakdown of the crop type and area produced is outlined in Table 6.1 and Figure 6.7.
Table 6.1 Field vegetable crop area grown in Ireland 2001

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>ha</th>
<th>Crop Type</th>
<th>ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>2.4</td>
<td>Lettuce (Other)</td>
<td>31.9</td>
</tr>
<tr>
<td>Broccoli/Calabrese</td>
<td>470.3</td>
<td>Onions</td>
<td>162.3</td>
</tr>
<tr>
<td>Brussels Sprouts</td>
<td>238.8</td>
<td>Parsley</td>
<td>27.1</td>
</tr>
<tr>
<td>Cabbage (Storage)</td>
<td>175.2</td>
<td>Parsnips</td>
<td>273.2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>902.1</td>
<td>Rhubarb</td>
<td>53.8</td>
</tr>
<tr>
<td>Carrots</td>
<td>640.6</td>
<td>Scallions &amp; Shallots</td>
<td>78.9</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>641.4</td>
<td>Swedes</td>
<td>559.3</td>
</tr>
<tr>
<td>Celery</td>
<td>41.7</td>
<td>Spinach &amp; Kale</td>
<td>21.8</td>
</tr>
<tr>
<td>Courgettes</td>
<td>7.7</td>
<td>Organic Vegetables</td>
<td>183.3</td>
</tr>
<tr>
<td>Leeks</td>
<td>63.9</td>
<td>Other Fresh/Processed</td>
<td>566.9</td>
</tr>
<tr>
<td>Lettuce (Butterhead)</td>
<td>6.1</td>
<td>Other Herbs</td>
<td>4.5</td>
</tr>
<tr>
<td>Lettuce (Iceberg)</td>
<td>130.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,286.2</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: DAFRD/Bord Glas Census, 2001

Figure 6.7 Field vegetable area (%) 2001

Field vegetable production is concentrated in the eastern and southern regions and in particular close to the large urban areas around Dublin and Cork and in counties Wexford, Meath and Louth (Table 6.2).

Table 6.2 Production area (ha) of main field vegetable crops by county 2001

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Dublin</th>
<th>Meath</th>
<th>Wexford</th>
<th>Cork</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>450</td>
<td>105</td>
<td>61</td>
<td>91</td>
<td>211</td>
<td>918</td>
</tr>
<tr>
<td>Carrots</td>
<td>15</td>
<td>111</td>
<td>255</td>
<td>11</td>
<td>303</td>
<td>694</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>236</td>
<td>23</td>
<td>81</td>
<td>76</td>
<td>89</td>
<td>505</td>
</tr>
<tr>
<td>Swedes</td>
<td>177</td>
<td>34</td>
<td>27</td>
<td>114</td>
<td>125</td>
<td>475</td>
</tr>
<tr>
<td>Broccoli</td>
<td>132</td>
<td>80</td>
<td>45</td>
<td>40</td>
<td>124</td>
<td>420</td>
</tr>
<tr>
<td>Parsnips</td>
<td>240</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>295</td>
</tr>
<tr>
<td>Brussels Sprouts</td>
<td>124</td>
<td>102</td>
<td>5</td>
<td>31</td>
<td>14</td>
<td>276</td>
</tr>
<tr>
<td>Lettuce</td>
<td>106</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>43</td>
<td>153</td>
</tr>
</tbody>
</table>

Source: DAFRD/Bord Glas Census, 2001

Production of most field vegetable crops is dominated by a small number of growers with the total production area of parsnips (91%), outdoor lettuce (90%) and brussels sprouts (88%)
accounted for by the top ten growers (Figure 6.8). Production is also concentrated in specific geographic areas (Figure 6.9):

- Approximately two-thirds of all carrots grown are accounted for by the top ten growers.
- Cabbage (which has the largest production area and the most growers) has the lowest percentage of total production area accounted for by the top ten growers with 27% of the total production area.
- Across all field vegetables, the top ten growers (in terms of area) accounted for 23% of the total production area.
- Dublin is a relatively large producer of cabbage (450 ha, 49% of total cabbage production), parsnips (240 ha, 81% of total parsnip production), cauliflowers (236 ha, 47% of total cauliflower production), and lettuce (106 ha, 69% of total lettuce production).
- Wexford (255 ha), Laois (134 ha), Meath (111 ha) and Waterford (46 ha) account for 79% of total carrot production.
- Dublin (177 ha) and Cork (114 ha) account for over 60% of all swede production.
- Onion production is concentrated in counties Meath, Wexford and Cork which account for 96% of total production.

**Figure 6.8** Field vegetable percentage of total area produced by the top ten growers

Source: DAFRD/Bord Glas Census, 2001
Figure 6.9  Percentage of Agricultural Area Used for vegetable production in each county

<table>
<thead>
<tr>
<th>Percentage of the Agricultural Area Used (AAU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 – 3.5%</td>
</tr>
<tr>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td>0.05 – 0.1%</td>
</tr>
<tr>
<td>0.01 – 0.05%</td>
</tr>
<tr>
<td>0.005 – 0.01%</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office, Census of Agriculture, 2000

The main vegetable areas are located in counties Dublin, Meath, Louth and Wexford.

Seed Production - With the exception of rhubarb and a few other perennial crops most vegetables are produced from imported seed.

6.2.2  Fruit (top, soft, bush, and cane fruit)

There are two main types of fruit crops grown in Ireland, namely ‘top’ and ‘soft’ fruit. A breakdown of the areas and main locations of each type grown in Ireland is outlined in Figures 6.10, 6.11 and 6.12. ‘Top’ fruit refers to orchard crops grown ‘above the ground’ (e.g. apples, pears, plums, etc.), whereas ‘soft’ fruit is a generic description for fruit and berries grown at or near ground level with a characteristic soft fleshy texture and outer skin (e.g. strawberries, raspberries, blueberries, etc.).

Figure 6.10  Fruit area grown in Ireland (2001)

Source: DAFRD/Bord Glas Census 2001
Figure 6.11  Main commercial top fruit production areas 2001

Top fruit production largely relates to orchard production in Ireland, and in particular, the cultivation of apples. Soft fruit crops are grown either in the field or, as is increasingly the case, under protective cover. The use of protective glass and/or polytunnels allows for full season soft fruit production, however, glass houses are mainly employed for early or late season crop production. Much of the soft fruit, in particular strawberries, is grown out of season in glasshouses and polytunnels. These fruit crops are mostly insect pollinated and many have wild relatives commonly encountered in the countryside e.g. brambles, wild rubus etc.

Figure 6.12  Commercial soft fruit production 2001

6.2.3 Protected crops

Protected crops are those grown under the protection of glass or polytunnels. The main crops include tomato, lettuce, cucumbers, celery and peppers. Most of these crops are grown from F1 hybrid seed and are open pollinated varieties. The areas and main locations of production are outlined in Table 6.3 and Figures 6.13 and 6.14.

In 2001, there were 153 growers engaged in protected food crop production, producing a total of 237 ha (some growers produce a number of crops). Lettuce is the most widely planted...
food crop, followed by strawberries and tomatoes. However, the production area of lettuce and tomatoes has fallen since 1998 while that of strawberries has almost trebled.

Protected crop production is concentrated in Leinster, and in particular in county Dublin. Of the 158 ha of greenhouse area devoted to protected crops in Ireland, 59% is located in Dublin. Other major counties for protected crop production include Meath, Louth and Wexford, with 9%, 8% and 6%, respectively, of the total greenhouse area.

Table 6.3  Protected crop production by county

<table>
<thead>
<tr>
<th>County</th>
<th>Growers</th>
<th>ha</th>
<th>Growers</th>
<th>ha</th>
</tr>
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<tr>
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<td>23</td>
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<td>9</td>
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<td>Offaly</td>
<td>2</td>
</tr>
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<td>Wexford</td>
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<td>10</td>
<td>Waterford</td>
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</tr>
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<td>9</td>
<td>Monaghan</td>
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<tr>
<td>Galway</td>
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<td>6</td>
<td>Leitrim</td>
<td>2</td>
</tr>
<tr>
<td>Cork</td>
<td>7</td>
<td>5</td>
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</tr>
<tr>
<td>Wicklow</td>
<td>9</td>
<td>3</td>
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</tr>
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</table>

Source:  DAFRD/Bord Glas 2001 Census

Figure 6.13  Protected crop production – main crops

Source:  DAFRD/Bord Glas 2001 Census

Figure 6.14  Greenhouse area (%) by county 2001

Source:  DAFRD/Bord Glas Census 2001
While many serious pests occur in the protected cropping sector, entomologists have successfully concentrated on using biological control methods and Integrated Pest Management techniques for their control.

6.2.4 Amenity crops

The sector includes protected amenity crops, bedding and pot plants, bulbs and cut flowers and hardy nursery stock.

6.2.4.1 Protected amenity crops

In the protected amenity crop sector, 100 growers produced a total of 62 ha of amenity crops in 2001 (Figure 6.15).

**Figure 6.15**  Protected amenity area (ha) and number of growers 2001

![Protected amenity growers & area 2001](chart)

Source: DAFRD/Bord Glas Census 2001

6.2.4.2 Bedding and pot plants

There were a total of 75 bedding and pot plant growers in 2001. Cork had the highest number of growers with 16, while most other growers were based in Leinster. Growers produce a wide variety of bedding plants with pansies, *Impatiens* F1 hybrids and *Petunias* being the most commonly planted species. Most growers also produce a wide variety of patio and basket species, with *Surfinia* being rated the most commonly planted. Primroses are the most widely grown pot plant.

The production of bedding plants has increased in importance in recent years with eleven new growers bringing the production area to 33 ha. There are now more growers producing bedding plants than in any other amenity or food crop in the protected crops sector.

6.2.4.3 Bulbs and cut flowers

The sector consists of 23 growers producing 184 ha of bulbs for the wholesale market and also 51 ha of flowers. Growing cycles result in only half of the bulb area being harvestable in
a given year. Seventy-two percent of the sector's output is exported. Bulb production is dominated by *Narcissi* (i.e. daffodils), with ‘Golden Harvest’ as the single most widely produced *Narcissus* variety. However, 50 different *Narcissi* varieties were recorded among the 23 growers. Tulip production is accounted for by only two growers.

Flower production takes place both in the open and under protection of glass or polythene tunnels. The level of flower production in Ireland is quite modest, with most of the product imported. The majority of flowers are grown from seed or propagated vegetatively from cuttings.

### 6.2.4.4 Hardy nursery stock

Hardy nursery stock includes shrubs, trees and foliage for decoration, all of which flower and set fruit in prolific quantities. They are propagated both by seed and vegetatively – as cuttings and grafts and many have wild relatives common throughout the countryside.

The DAFRD/Bord Glas census of 2001 recorded a total of 222 hardy nursery stock growers. Co. Tipperary had the largest production area with 145 ha, however, Co. Kildare contributes the most to overall sector sales, due largely to its having the highest area of containerised plants (which typically have a higher value than field plants). Containerised shrubs for retail sale was the single biggest category in value terms – estimated to be €11.6 million in 2001, representing over one-third (38%) of the sector value.

### 6.2.5 Bees and honey production

While wind dispersal is the most common form of pollen transfer in agricultural crops, there are many important crops that depend on the intervention of insects to successfully pollinate. These crops include a wide variety of fruits commonly grown in Ireland (e.g. apple, pear, plum, strawberry, raspberry, etc.) and also tomato, clover and oil seed rape. Bees, (honey and bumble bees) play an important role in the distribution of pollen and particularly so in the case of honey bees (*Aphis mellifera*). They also provide honey and other hive products (wax, pollen, propolis etc.). Bumble bees (*Bombus terrestris*) are often artificially bred and introduced into protected cropping situations (glasshouses etc) to facilitate pollination. Honeybees will generally forage up to 2 kilometres from the hive and occasionally over longer distances. In Ireland, bees depend particularly on hawthorn, blackberry, other fruit and ornamental flowering trees, shrubs, clover, heather and ivy as sources of nectar and pollen. Members of the brassica (Cabbage) family also produce nectar that is attractive to bees. In particular, honeybees will visit flowering brassica crops, and hives are often transported to oilseed rape fields to assist in the pollination of the crop.

Council Directive 2001/110/EC of 20th December 2001 defines and lays down compositional and labelling requirements for honey. With some modifications the general food labelling rules outlined in Directive 2000/13/EC apply to honey. The EU Commission has specified that pollen is a constituent particular to honey and, as bees forage over several kilometers visiting both cultivated and wild plants, the possible presence of GM pollen in honey is beyond the control of the beekeeper. The presence of GM pollen in honey should therefore be considered as adventitious and unavoidable and does not need to be labelled GM (provided...
that the bees themselves have not been genetically modified) and that the proportion of GM pollen in the honey is below the general labelling threshold – i.e. 0.9%.

It is estimated that there are approximately 2,200 beekeepers and 20,000 to 22,000 colonies in Ireland. The Federation of Irish Beekeepers Associations (FIBKA) has 1,500 members and estimate that there are another 700 beekeepers who are not in the Association. Of the combined total, there is one commercial beekeeper and approximately another seventy are described as semi-commercial, i.e. owning fifty or more colonies. The majority (1,600 beekeepers) own less than 10 colonies each. FIBKA has 46 county beekeeping associations affiliated to the Federation, which would suggest wide national distribution.

Total honey production is estimated at about 200 tonnes annually, of which, 10-15% is sold directly to consumers, 35-40% is sold directly to retailers and the remainder is sold to packers. The total value of the honey produced in Ireland in the year 2,000 was estimated at €1.275m.

6.2.6 Genetic modification in horticulture

GM horticultural crops, which have been developed in the USA and are in the commercial pipeline, include herbicide tolerant amenity grasses, lettuce and tomato. Genetically modified virus resistant papayas and potatoes are commercially available but uptake has been limited due to consumer resistance. Research is on-going into higher yielding strawberries, raspberries, virus resistant potatoes and melons, insect resistance in fruit and vegetables, enhanced flower colour and shelf life in floriculture. One of the original GM crops was a tomato ‘Flavor Savr’ in which the shelf life of the tomato was increased to weeks rather than days. Carnations in particular, and chrysanthemums have had their colours altered and vase life extended using GM technology.

There is a significant level of R&D taking place internationally in horticulture and especially in the non-food amenity sector. Genetically modified ornamental grass, selected for disease resistance and dwarfing characteristics for amenity use in recreational areas such as football pitches, golf courses etc, is being developed.

6.2.7 Coexistence of GM and non-GM horticultural crops

Field vegetable crops: Most field vegetables do not flower in the normal production rotation. In the case of cauliflower, broccoli etc., it is usually the immature inflorescence that is harvested. Pollen production is not significant as most are grown as annual crops and harvested before flowering. Some brassica volunteers are occasionally recorded but their incidence is low and they are usually destroyed in vegetable rotations where they are ploughed-in soon after harvest to facilitate a follow-on crop.

There is little likelihood in the medium term of the introduction of GM vegetable production in Ireland. The issue of coexistence would be similar to that of general agricultural crops in the same botanical families. If GM vegetable crops are cultivated, special coexistence measures would, however, need to be put in place, particularly in regions where high concentrations of field vegetable crops are produced. Of particular relevance would be
brassica vegetable crops grown in proximity to oilseed rape crops, with counties Dublin, Meath, Louth and Wexford having significant areas of both crop types.

**Fruit crops:** While there is the potential to introduce, via GM technology, disease resistance into apples, it is not anticipated that GM top fruit varieties will be introduced into this country in the short to medium term. Many of the top fruit genera grown commercially in Ireland have wild relatives, in particular apple and plum. Hawthorn and blackthorn are also members of the same Rosaceae family. All these fruit plants produce large amounts of pollen, which is normally carried from plant to plant by insects, in particular bees. In the event of the introduction of GM top fruit varieties, specific coexistence measures specifying appropriate separation distances to account for bee movement would need to be put in place.

**Protected crops:** The contained nature of protected cropping will greatly reduce the spread of pollen, but it will still be necessary to establish appropriate coexistence measures to prevent cross-fertilisation of adjacent crops. For example, sweet corn for human consumption is grown on a very limited scale under protection, and the issue of cross-fertilisation by neighbouring maize crops should be considered if GM maize was grown in the immediate vicinity.

**Amenity grass:** The introduction of genetically modified ornamental grass would be of particular relevance to Ireland as, if introduced, would pose a high risk for transfer to forage grasses. Grasses are prolific producers of pollen which is freely dispersed by wind over long distances. As grass is generally grown as a permanent crop, it would be extremely difficult to prevent introgression of GMOs into conventional and organic grass crops. While research is on-going internationally on amenity grasses for golf courses, football pitches etc, it is not anticipated that GM amenity grass varieties will be introduced into Ireland in the short to medium term. Given the importance of grass production to Irish agriculture, significant research will be required to examine the feasibility of the coexistence of GM and non-GM grasses.

**Honey production:** An essential element of coexistence measures for beekeepers is that the location of GM crops be made publicly available via a website at the earliest possible date and prior to flowering of the crop. This is especially true for oilseed rape crops in which bees commonly forage.

In summary, horticulture crops pose specific challenges for each crop type for coexistence. If such crops were to be grown in Ireland, crop specific separation distances, cropping intervals, temporal separation of flowering times etc. and other measures would need to be developed. It is likely that non-food amenity crops will be the targets of genetic modification in the short to medium term. It is not anticipated that any GM horticultural crops will be produced in Ireland in the short to medium term and appropriate measures for crop production should be designed on a case-by-case basis as applications for such crops are submitted.
Recommendations on growing horticultural crops

I. The Working Group recommend that specific coexistence measures are developed for horticultural crops on a case-by-case basis as the necessity arises.

II. The grid reference location of GM crops should be publicly available well in advance of crop flowering to inform beekeepers of the presence of GM pollen in their locality.
Chapter 7 Underpinning coexistence – procedural requirements and the provision of information

7.1 Introduction

Following analysis of the issues on the cultivation of GM crops, the Working Group has recommended that certain measures for coexistence should be given statutory backing while others, including certain crop management practices, should be incorporated into a Code of Good Farming Practice (see Chapter 3). A key objective of the Working Group was to develop a framework to underpin coexistence which would be structured, reliable, comprehensive and practical and which would take into account the interests of all concerned.

The framework for the implementation of coexistence has the primary objective of underpinning the crop management practices as recommended in Chapters 4, 5 and 6. The key components for effective implementation can be broadly divided into:

(i) Education and training
(ii) Provision and exchange of information through a series of procedural requirements.

To achieve this, both the industry and the State have certain responsibilities. This chapter sets out the approach to effectively underpin coexistence through a series of procedural/implementation measures. The responsibilities of both the industry, and in particular, the GM crop grower, and also that of the State, are outlined.

7.2 Requirements for approval to grow a GM crop

The implementation strategy as recommended in Chapter 3 is based on an approach whereby, a grower of a GM crop must make an application and be formally approved by the DAF. It also requires adherence to a comprehensive series of technical and procedural measures that are supported by sanctions in the event of non-compliance.

An application for approval to cultivate a GM crop should be assessed by suitably qualified personnel based within the DAF. Assessment for approval will be completed within a specific time frame. The applicant will be required to satisfy specific criteria before approval is granted to grow a GM crop, including aspects relating to education, notification to the DAF and notification of neighbouring farmers, as set out below.

7.2.1 Education and training

In accordance with Section 3.7 of the Commission Guidelines, a fundamental requirement in the future operation of conventional, GM and organic cropping systems is the development of suitable training courses for all those involved in ensuring the harmonised coexistence of the different cropping systems.
The Working Group recommend that education and training courses be developed for all operators involved in the growing, contracting, assembling, storage and distribution of GM crops. The DAF should approve the curriculum of such courses. The DAF should maintain a register of all those who attend and complete such courses.

Training should be mandatory for persons wishing to cultivate GM crops. Other operators are strongly encouraged to attend such courses on a voluntary basis. It may be necessary for GM crop growers to attend ‘update courses’ on coexistence depending on developments and/or changes over time.

Two separate training courses are proposed:

7.2.1.1 Grower/interested party training

The training course will be crop and trait-specific and aimed at farmers (both users of the technology and other farmers wishing to gain an appreciation of the technology e.g. applicants’ neighbours). The training will also be applicable and accessible to other interested parties to include farm staff, contractors, store staff and those involved in seed assembly. (Contractors, in particular, involved in the growing of GM crops, are strongly encouraged to attend such a course). The curriculum of the course should be included in the curriculum of the relevant certificate and diploma courses available to farmers. Grower training programmes could be developed and supplied by Teagasc or other suitable, accredited organisations as approved by the DAF.

Training will provide instruction specific to coexistence on:

a) Management measures for minimising admixture
b) Procedural requirements, and
c) Liability issues.

However, the training course should also cover the broader issues relating to GM crop cultivation i.e. principles of coexistence, crop physiology, biotechnology, and good agricultural and environmental practice (GAEP) as it relates to GMOs and as encompassed in the measures for cross-compliance of EU schemes.

7.2.1.2 Advisor/extension worker training

Given the consequences of admixture of GM and non-GM crops, and the evolving nature of the science involved in biotechnology, the Working Group recommend that training should be provided for suitably qualified advisors/extension workers until such time as the curriculum of existing educational programmes incorporates adequate education and training on coexistence. Such a course should cover in some detail aspects of biotechnology, crop husbandry, crop physiology, liability, etc. that would enable the advisor to provide the most suitable and technically up-to-date information on growing a GM crop and the requirements for coexistence. Advisors/extension workers training programmes could be developed and supplied by third level educational institutions, Teagasc or other suitable, accredited organisations as approved by the DAF.
7.2.2 Prior notification to the DAF

The Working Group proposes that notification to the DAF of the intention to grow a GM crop should be mandatory. Planting of a GM crop prior to DAF approval should incur sanctions. Applications for approval to cultivate a GM crop should be lodged with the DAF a minimum of sixty days prior to the planned date of sowing the crop. The period of sixty days is considered the minimum required to process and verify applications.

Applications should be made on an official purposely-designed application form that incorporates details requested from the applicant. The form should be signed by the applicant, agreeing to the conditions of approval and the undertakings entered into, and be accompanied by other relevant documentation. Some of the main details in the application form should include:

- Name and address of the applicant and proposed location of GM crop
- Name and address of landowner for rented/leased land
- Species and variety(ies) being sown
- Land Parcel Identification System (LPIS) numbers of the field(s) in which it is proposed to grow the crop
- Information on rotation history of the land
- Certificate of confirmation of completion of training
- Written agreements with neighbouring farmers, where relevant (see section 7.2.3).
- Any additional information in support of the application (voluntary notifications, additional safeguards etc.)

7.2.3 Notification/consultation with neighbouring farmers

Commission Recommendation (2003/556/EC) recommends that prior notification be given to neighbouring farmers before GM crops are planted …‘farmers who plan to introduce GM crops for cultivation on their farms should inform neighbouring farmers about their intention’. (Article 2.1.7) and ‘notification to farms located within the relevant perimeter of the planting plans for the next growing season should be made before the seeds for the next growing season are purchased’ (Article 3.3.1).

Notification of neighbouring farmers is important for a number of reasons as outlined in earlier sections of this Report. Adequate separation of a GM crop from a neighbouring non-GM crop of the same or related species, is a critical management measure for minimising admixture, particularly in the case of cross-pollinating plant species.

In the case of a GM crop grower who requires part of his/her neighbour’s land to satisfy the necessary separation distance, it is recommended by the Working Group that signed, written consent must be obtained from neighbouring farmers and submitted as part of the approval procedure as described in section 7.2.2 above. This is essential to minimise disputes and to help determine liability at a later date in the event of economic loss arising from the adventitious presence of GMOs. Furthermore, this should preferably be in place before the GM crop grower purchases his/her seed in order to prevent incurring a loss where an agreement cannot be reached and the required separation distance cannot be achieved. Where written agreement with neighbours is not possible, GM crop producers must meet the
recommended crop separation distance within the boundary/perimeter of his/her own farm. Written agreements should be by way of a specific document issued by the DAF.

Growers of GM crops should also notify contiguous neighbouring farmers, located outside of the required separation distance, of their intention to sow a particular GM crop. This will allow neighbouring non-GM growers to implement their own additional control (voluntary) measures to minimise adventitious presence if they so wish. While such notification is optional, it is highly recommended that GM crop growers adopt the practice of notification (in writing) to all contiguous neighbouring farmers, in line with a code of good farming practice.

7.3 Record keeping

Record keeping is specified within Article 3.6 of the Commission Guidelines, which states that records should be kept with respect to the implementation of management practices for coexistence i.e. farm cultivation, storage, handling, transport and marketing of the GM crop. Article 3.6 also specifies that record keeping is required in order to meet the requirements of the EU Traceability and Labelling legislation. In addition, record keeping would also assist in the fulfilment of Article 3.4 of the Commission Guidelines, which includes the need for ‘notification systems that encourage farmers to report problems or unexpected occurrences in the implementation of the coexistence measures’.

Consequently the maintenance of records should be an obligatory requirement for growers of GM crops. Such records should be subject to access by DAF officials upon request.

All details on the GM crop should be recorded and should include items such as the following:

(i) Written agreements/notifications with neighbouring farmers where relevant.
(ii) Premises where the GM seed was purchased.
(iii) Date of sowing.
(iv) All labels/documentation detailing seed quantity purchased and GM trait/content.
(v) Cultivation, treatments, harvesting, transport and storage management measures undertaken.
(vi) Documentation regarding the disposal or sale of produce.
(vii) Information on additional coexistence measures put in place.
(viii) Records of any problems or unexpected occurrences.

7.4 Compliance inspections

Crop management and procedural measures should be subject to inspection for compliance. It is anticipated that in the initial years of GM crop cultivation, compliance inspection for coexistence measures could be carried out for all GM crops, both to ensure compliance and also for the validation of coexistence measures (see Chapter 9, Monitoring and Review). Specific details regarding inspections should be developed by the DAF. In the longer term, it is envisaged that compliance inspection could be based on risk analysis subject to the satisfactory demonstration of the proper functioning of the coexistence measures set down herein.
A programme of compliance inspections should ensure that GM crop growers are sufficiently aware of their responsibilities in implementing coexistence measures and allow the DAF to take action where measures are not implemented as required. Also, compliance inspections could be relevant in any liability cases, where economic loss results from admixture.

A protocol for addressing non-compliance should be drawn up, included in which would be the following elements:

(i) What constitutes non-compliance?
(ii) The remedial actions to be taken, if required.
(iii) The sanctions that can be imposed.
(iv) The circumstances in which those sanctions/penalties should apply.

A mechanism should be established to allow for appeals on decisions taken by the DAF with respect to approvals for GM crop cultivation and sanctions imposed.

7.5 Establishment of a database

The Commission Guidelines specify that a ‘Land Register’ be established in accordance with Article 31(3)(b) of Directive 2001/18/EC. This can be used to monitor developments of GM crops and to help farmers coordinate local production patterns.

A database should be established and maintained by the DAF to record all relevant information and records in relation to applications, approvals, field data, crops grown, etc. for individual land parcels over a period of years. This will provide a reference as to what GM crops were planted in particular years in the event of a change of ownership of the land and also a reference source for farmers renting land parcels where rotation history may not be readily available.

The database will also serve to facilitate monitoring and inspection and will also facilitate the identification of problems that may arise in the longer term. Access to detailed information will also be essential where liability issues arise.

A database will also be required to supply statistical information on the nature and extent of GM cropping, both from a national perspective (see 7.6 below) and in accordance with the requirements of the Commission Guidelines.

7.6 Information to the public

It is the view of the Working Group that, for transparency and information reasons, the public should be kept informed of the nature and extent of GM crop cultivation. Consequently, the Working Group recommend that a register of the GM crop species, area planted and reference location (as described through the land parcel identification system) should be made available through a dedicated website immediately after the granting of approval to plant the crop.
7.7 Access to further information

As coexistence of GM crops with non-GM crops is a new concept in Irish agriculture and, given that information on coexistence is constantly evolving, the Working Group recommend that information is readily available to farmers and other operators on technical, commercial and legal questions relating to coexistence and GMOs in general. This will augment information disseminated through the formal grower/interested party educational courses. This can be achieved through the setting-up of a website providing information on all aspects of GM crops and coexistence. Teagasc are currently developing such a website (www.gmoInfo.ie).

Recommendations

I. Education and training courses should be developed for all operators involved in the growing, contracting, assembling, storage and distribution of GM crops. Two separate training courses should be established – one for grower/interested party training and a second for extension/advisory workers.

II. Training should be mandatory for persons who cultivate GM crops. All other interested parties, e.g. neighbouring non-GM crop growers, seed suppliers, machinery and transport operators, contractors, advisers/extension workers etc., should attend education and training courses on GM crop production and coexistence.

III. It should be mandatory for a grower to obtain prior approval from the DAF before planting a GM crop. Applications for approval to cultivate a GM crop should be lodged with the DAF a minimum of sixty days prior to the planned date of sowing.

IV. Where a GM crop grower requires part of his/her neighbour’s farm to satisfy the necessary separation distance, it should be mandatory to obtain signed, written consent to that effect, prior to submitting an application for approval. Signed written agreements with neighbouring farmers should be completed on a specific official document issued by the DAF.

V. Where written agreement with neighbours is not possible, GM crop growers must meet the recommended crop separation distance within the boundary/perimeter of his/her own farm.

VI. It is strongly advised that contiguous neighbouring farmers should also receive written notification of the grower’s intention to plant a GM crop prior to the date of sowing.

VII. Record keeping should be a mandatory requirement for growers of GM crops. Such records should be kept for a minimum of five years and be subject to inspection by the relevant authority.
VIII. Crop management and procedural measures should be subject to inspection for compliance. Inspection should extend to all GM crops initially but may be based on risk analysis in the longer term, subject to the satisfactory demonstration of the proper functioning of coexistence measures.

IX. Non-adherence to mandatory coexistence measures should incur sanctions.

X. A mechanism should be established to allow for appeals on decisions taken by the DAF with respect to approvals for GM crop cultivation and sanctions imposed.

XI. A register of those approved to grow GM crops, showing the GM crop species, area and the location (using the Land Parcel Identification System - LPIS), should be accessible to the public through a dedicated website.

XII. Information relating to all aspects of coexistence should be available through an independent website (e.g. Teagasc).

XIII. A database should be established by the DAF with respect to all applicants to grow GM crops, wherein all necessary details of the applicant, the crop and the management of the crop should be recorded for analysis, records and coexistence management purposes.
Chapter 8  Economic loss, liability and redress

8.1  Introduction

In accordance with the Commission Guidelines the issue of coexistence concerns the potential economic loss and impact of the admixture of non-GM and GM crops, and the most appropriate measures that can be taken to minimise admixture. It is important to differentiate between the costs associated with implementing the coexistence measures in order to minimise admixture and the economic loss arising through reduced market value or market accessibility following the admixture of GM and non-GM crops.

Coexistence measures to minimise admixture are discussed earlier at Chapters 4 to 7 and include crop management measures, administrative and procedural requirements. The measures recommended in this Report take cognisance of the principle that ‘those who introduce a new production type should bear the responsibility of implementing the farm management measures necessary to limit gene flow’. The new production type is defined according to what is already most commonly practiced in the region.

Coexistence may also have other cost implications for non-GM crop growers e.g.

- Taking of voluntary or additional measures to minimise admixture e.g. testing of home-saved seed.

- Testing of crops for verification of GMO content might be regarded under civil law as a cost of operating a competitive business.

- Where non-GM crop growers voluntarily choose to impose additional or stricter requirements on their production systems over and above the legal minimum, in order to gain market or price advantage, then non-GM crop growers are responsible for ensuring those requirements are met and for meeting their associated costs, if any.

8.2  Economic loss

In the context of liability, the term economic loss, resulting from the admixture of GM and non-GM crops, applies when a non-GM crop grower incurs a loss as a result of the actions of a third party. The extent of this loss will depend on the:

(i) Difference in the market value or, inaccessibility to certain markets, arising from having to label non-GM crops as GM when thresholds, as set out in Community legislation, have been exceeded. The economic loss is potentially greater for higher value crops such as organic produce.

(ii) Remediation measures for ensuring purity in subsequent crops and the associated costs. These costs may potentially be greater for organic crop production.
(iii) Duration of loss in market value and the period over which remedial action is required. This may extend beyond the current year of production in certain circumstances.

Such issues relating to economic loss necessitate the requirement to determine liability, assess the level of loss incurred and establish possible measures to redress such loss.

8.3 Liability

8.3.1 Background to legal liability in Ireland

There are three categories of liability:

(i) Civil,
(ii) Criminal
(iii) Administrative.

All three are relevant to the coexistence of GM and non-GM crops, although the circumstances under which they apply and the consequences arising may vary.

(i) Civil liability

Civil liability applies when an individual wishes to claim damages against another individual/organisation. The action is taken through the civil Courts. It is the only form of liability that may give rise to the payment of damages, or compensation.

Civil liability is essentially the liability of a defendant to compensate a claimant for personal damage or damage to his/her property:

(a) in so far as this can be quantified in money terms
(b) the damage was reasonably foreseeable and not too ‘remote’,
(c) the burden of proof is on the claimant, and,
(d) the claimant must also be owed a duty of care by the defendant.

(a) Quantification

The principal function of damages is to restore the person whose right has been invaded back to his/her previous position. It follows that there must be a protectable right, i.e. one that is recognised in law. For example, there is no such right that members of the public can invoke to prevent or rectify adverse impacts on public goods, such as the landscape or biodiversity.

Damages are paid based on the harm done and what is required to remediate that harm. What constitutes ‘harm’ is contentious however. For example, the loss of

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Remoteness of damage applies primarily in breach of contract cases, where the defendant will only be held liable for damages as may be fairly and reasonably be considered either arising naturally from the breach of contract, or which was foreseeable as being the result of a breach of contract at the time of agreeing the contract. Remoteness also applies in the tort of negligence, but whether the GM crop farmer is found liable depends on to whom the GM crop farmer owes a duty of care. If the person is outside the class of those to whom he owes a duty of care, even if that damage was entirely foreseeable, then the GM crop farmer may not be liable for it. 5
organic status for crops that are perfectly sound and capable of being sold on the open market may not be actionable harm. However the losses suffered through the inability to obtain the organic premium, or if the farm loses its organic status may be actionable harm. In such circumstances however, ‘harm’ may not be actionable where the damage is adventitious contamination below the threshold levels that determine the status of the crop.

It should be noted that in civil law, once harm has been established the defendant is liable for all financial losses flowing from it providing they are not too remote.

(b) Reasonably foreseeable

The damage must be foreseeable, as well as not too remote. The damage foreseen must also represent a real risk, in that it is justifiable not to take steps to eliminate a risk if it is small and the circumstances are such that a reasonable person, careful not to damage the interests of his/her neighbour, would think it right to neglect it – such as when it may involve considerable and disproportionate expense to eliminate it.

(c) Burden of proof

As the burden of proof rests on the claimant, they must be able to demonstrate that any admixture was not caused by fault on their own behalf. Thus documentary evidence for the use of certified seed, or that home saved seed was tested prior to planting, or records to indicate that shared machinery was properly cleaned prior to use would all assist in this regard.

It should also be noted that responsibility for mitigating the risk of damage also rests with the injured party. Therefore if, for example, the defendant is a GM crop grower, then the responsibility for mitigating risk of damage rests not only on the GM crop grower, but also on his non-GM crop neighbours, providing they have been made aware of his/her intention to cultivate GM crops. Thus, where a person intending to cultivate GM crops actively alerts his/her neighbours to this, those who might be at risk of admixture are advised to take measures to avoid this risk – as, even assuming the GM crop grower might ultimately be liable for any damage caused, the general obligation is to mitigate any possible damage, where it is reasonably practicable to do so, as failure to do so may affect the strength or credibility of any future claim for damages.

This is one of the reasons a formal approval system for the growing of GM crops that requires consultation with farm neighbours, has merit in terms of mitigating potential economic losses associated with the cultivation of GM crops.

(d) Duty of care

Civil liability applies where there is a clear duty of care. Someone who is owed the duty of care can be described as ‘persons who are so closely and directly affected by my act that I ought reasonably to have them in contemplation as being so affected
when I am directing my mind to the acts or omissions that are called into question.
Thus a claimant must establish that the defendant owed him/her a duty of care and in
doing so the Courts will examine whether imposing a duty of care would be fair, just
or reasonable. Within the context of coexistence, the GM crop grower owes a duty of
care to his/her farming neighbours.

Except under very specific circumstances, public bodies are not subject to a duty of
care when they take decisions that are within the ambit of a statutory discretion due to
it. This is to allow statutory bodies to implement regulations without the risk of
litigation, as without such protection statutory bodies may be unwilling to regulate at
all, even if the circumstances require it.

Civil liability is most likely to be in ‘tort’ or fault based, but civil liability in some
circumstances is also ‘strict’, as opposed to fault based. In other words, damages may be
recovered even in the case of no fault. It normally applies where one party is undertaking an
activity that entails a greater risk of loss to others than usual, and when it may be considered
right that he/she accept the consequences if the loss materialises, however hard he/she tries to
avoid this. The ‘polluter pays’ principle is an example of strict liability where the polluter
pays for all the consequences regardless of whether or not he/she was at fault. It may take the
Courts to decide whether strict liability will apply to the growing of GM crops in certain
circumstances.

Contractual liability may also arise – for example under the Sales of Goods Act (1979), or if
the terms of a tenancy agreement have been breached. Thus, contractual liability is relevant
where seed is purchased that does not conform to its description, including any descriptions
relating to its GMO content. Strict liability also applies where the goods are not of
satisfactory quality and in this sense, GMO seed and product is no different from any other.
Contractual liability also applies where a tenancy agreement is breached, for example where a
grower grows a GM crop on rented land where the landowner has forbidden it.

There are a number of defences against liability, even strict liability, which can be invoked. These include:

(i) An ‘Act of God’.
(ii) The intentional acts of third parties provided appropriate measures were in place
     (i.e. vandalism).
(iii) Compliance with a compulsory order from a public authority.

(ii) Criminal liability

Criminal liability applies if the sanction for an unlawful act or omission is penal – i.e. a fine
or imprisonment. Such a sanction is designed to punish the guilty defendant, but not to
provide compensation for anyone who has been injured as a result – therefore damages do not
apply. The proceeds of fines are usually paid to the exchequer, thus a person who has
suffered significant damage would still need to take civil proceedings to obtain full
recompense. The State is the only body that can take a case for criminal liability to Court.
(iii) Administrative liability

Unlike the majority of European countries, Ireland and the UK have what is termed administrative law, which is a system of regulatory powers that have been given by statute to a variety of public and other authorities, whose exercise of them is subject to supervision by the Courts. In the context of coexistence, it is important, as it defines the responsibilities of the State when setting the coexistence measures and its obligations with regard to enforcement when those measures are breached. The powers may include the issue and service of ‘stop’ and ‘enforcement’ notices, coupled with a right of entry onto private property to ensure the notices are acted on.

Administrative law does not usually extend to the levying of fines or other penalties, nor to requiring compensation to be paid to third parties for past actions. Regulatory authorities may impose criminal sanctions if their orders are not complied with, but these are reserve powers to punish non-compliance with the orders and not the original act or omission which gave rise to them.

Regulatory authorities have no legal obligation to act against a person in breach of the applicable rules if they consider it inappropriate or unnecessary. However, a regulatory authority may be considered to be in breach of its duty of care and therefore liable if it fails to take appropriate action, where it has the power to do so and the Courts deem it was appropriate to do so – for example, against breaches of approval conditions to cultivate a GM crop. Under some statutes a person responsible for damage can be required to remediate that damage – such as the liability of a polluter to remediate any pollution he/she may have caused.

8.3.2 Determining liability

Responsibility for redress is linked to determining with whom liability lies. Where admixture occurs from the growing of GM crops, disputes can arise between seed suppliers, landowners and tenants, haulage companies, contractors and growers, etc. in the same way as with conventional crop production. However, additional disputes, may arise between a number of parties that are specific to GM crop production and which would not be normally associated with the production of conventional crops including, for example:

(a) Between GM crop grower and non-GM crop grower:

Where the dispute arises between the GM and non-GM crop grower, two distinct scenarios are possible:

(i) Adventitious contamination occurs despite the fact that the GM crop grower has adhered to the coexistence measures.

(ii) Adventitious contamination occurs where the GM crop grower is considered to have breached one or more of the measures.

(b) Between GM/non-GM crop growers and the State:

Two distinct scenarios arise:
(i) Between the GM crop grower and the State where coexistence measures have been adhered to but where he/she is still held personally liable for damages. The GM grower may choose to seek damages from the State on the grounds of negligence, or the breach of duty of care, or of statutory duty on the basis that the coexistence measures failed to prevent adventitious contamination, for which she/he has been held liable.

(ii) Between the non-GM crop grower and the State where the coexistence measures are adhered to, but where the GM crop grower is not held liable for damages.

It is therefore clear from the above that current law allows for many instances where GM crop growers and the State are possibly subject to liability being established against them. While leaving the determination of liability and redress i.e. payment to be made by the persons held liable for the damage and losses incurred, solely to the Courts is no doubt possible, its practicality may be questioned on a number of grounds. For example,

- In the event of relatively small losses, would using the Court system be a reasonable approach in terms of both cost and timeliness?
- If the growing of GM crops were to become commonplace, could the unknown burden of litigation be handled by the Courts?
- Would a decision to leave recourse purely in the hands of the legal system prove to be a disincentive to farmers wishing to grow GM crops and therefore be construed as an indirect barrier to trade? Most EU countries acknowledge that proving liability for adventitious contamination is difficult and may in some instances be impossible.
- Taking a Court action may result in an injured party failing to receive any compensation, for example, where liability cannot be established.

The Commission Guidelines stipulate that the coexistence measures should be (i) efficient, cost effective and proportionate, (ii) should not go beyond what is necessary in order to ensure that adventitious traces of GMOs stay below the tolerance thresholds and (iii) should avoid any unnecessary burden for growers, seed producers, co-operatives and other actors associated with any production type. Equally, and under competition law, the actions of the State should not prevent the development of a market, including a market for GMOs. This has implications for the legislative environment in which the industry operates and the freedoms or constraints it imposes upon it.

Furthermore, the Commission Guidelines stipulate that ‘no form of agriculture, be it conventional, organic or agriculture using genetically modified organisms (GMOs) should be excluded within the European Union’, and that ‘farmers should be able to cultivate the types of agricultural crops they choose’. In order to allow this, and for the ‘ability to maintain different agricultural production systems that are a prerequisite for consumer choice’, the Commission Guidelines state that Member States should take measures to allow the coexistence of conventional, GM and organic crops.
With respect to the practicality of the Court system in the determination of liability and with the possibility of fear of litigation preventing farmers from choosing the production type they prefer, it is therefore necessary to develop a system where damage to third parties is minimised, that is proportional, not anti-competitive and where the right of the ‘farmer (GM and non-GM) to choose the production type they prefer, without imposing the necessity to change already established production patterns in the neighbourhood’ is respected.

In this regard the Working Group examined other options for redress as outlined in the following section 8.4.

8.4 Alternatives to the Courts for redress of economic loss

8.4.1 Private settlements

Co-operation between growers in resolving disputes that may arise over compensation for economic loss could be successful in many cases where the liable party can be identified. Affected parties should make every effort to reach agreements in this regard.

8.4.2 Insurance

Private insurance is an option that may offer protection and thus a reassurance to GM crop growers and their immediate neighbours, that in the event of a GM crop grower causing loss to a neighbouring farm, the insurance would cover their financial liability for that loss.

Insurance is predicated on establishing, in advance and on an actuarial basis, the likelihood of, and level of loss occurring based on the actual risk involved. However, for GM cropping the level of losses are unpredictable and in many cases the level of loss caused cannot be easily foreseen or indeed quantified in advance.

To date, insurance companies have not been prepared to offer insurance to the growers of GM crops and at present this is not a realistic option. In the future, the insurance industry may decide to offer protection in relation to certain economic aspects associated with GM crop cultivation.

8.4.3 The establishment of a redress fund

In the absence of private insurance to mitigate the liability risks facing both the non-GM and GM crop grower, the Working Group considered the creation of a fund as an alternative to insurance and until such time as the market provides this service. The creation of a fund offers advantages to both the GM and non-GM crop growers, and to a certain extent the State, as follows:

(i) It assists in the creation of a favourable environment whereby it offers protection to those who cultivate GM crops and their neighbours for losses they may incur as a result of the GM crop cultivation.

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6 Article 2.1.7 of the Commission Recommendation 2003/556/EC on Guidelines for Coexistence
Specifically –

(a) It provides a more rapid means of addressing claims for economic loss compared with a Court-based approach.

(b) It provides reassurance to non-GM crop growers who incur economic loss arising from GM crop cultivation that they will not be responsible for meeting those losses, and can have recourse to a non-Court based process to seek redress. It also provides reassurance to the GM crop growers who have caused the economic loss that they are not personally liable for meeting the associated costs [see (iii) below].

(c) It assists the State in meeting its obligations in relation to the Commission Guidelines.

(ii) It provides protection for GM crop growers in the event of the imposition of strict liability in the case of no fault on the part of the GM crop grower.

(iii) It provides redress in the case of adventitious contamination where a grower lacks adequate personal assets to cover the claimant’s losses, and thus reduce any financial loss the claimant may incur as a result.

(iv) By virtue of being a rapid and cost effective process for providing redress, it may reduce the number of subsequent claims made in the Courts for damages. However, this does not preclude the individual from pursuing a subsequent Court case if he/she so chooses.

(v) It reduces the State’s exposure in cases where economic loss arises even though coexistence measures have been adhered to i.e. the provision of redress through a fund means the GM crop grower is not personally liable for damages and is thus unlikely to counter-sue the State should coexistence measures fail to prevent adventitious contamination of his/her neighbour’s crop.

(vi) It provides baseline information, which may encourage private sector insurance companies to develop their own insurance services.

On the basis of the above, the Working Group is of the opinion that a fund for redress for economic loss arising from adventitious admixture above the legal threshold levels represents a useful approach to dealing with the issues of liability and redress until such time as the insurance market provides this service.

However, the creation of a fund represents a more interventionist approach to the growing of GM crops, and while in principle it may offer a number of benefits, there are practical considerations that should be addressed before such a fund is established. These are as follows:
(i) Source of funding

In addressing this question the Working Group was conscious that the benefits of a fund accrue to both GM and non-GM crop growers alike. The size of the fund would need to be adequate to cover any economic loss that is calculated based on specific criteria as set down for access to this fund, irrespective of any benefits accruing to GM crop growers from the cultivation of GM crops.

Therefore the following are options for funding:

a) A levy on the GM crop sector (GM crop growers, biotech companies and other industry beneficiaries).

On the basis that the growing of GM crops will result in economic benefits to growers and the biotech industry, it could be argued that responsibility for the redress of economic loss incurred by non-GM crop growers should be covered by the main beneficiaries i.e. the GM crop sector. Therefore, a fund developed by placing an obligatory levy on the GM crop sector would be a realistic option. However, this could be viewed as a levy or tax on GM crop cultivation and therefore be regarded as representing a barrier to production, and as such, the size of this levy would need to be carefully considered. Other Member States (e.g. Denmark) have opted for this approach.

b) A levy on the general crop sector (GM and non-GM crop growers)

A crop specific levy on all growers, both GM and non-GM, is another option. This may be regarded as being disproportional and unwarranted on non-GM crop growers, due to the fact that they carry out normal agricultural activity (as opposed to the new production type introduced by GM crop growers) and do not benefit economically from GM technology. However, non-GM growers will be the main beneficiaries of the fund and contributions could be viewed as equivalent to normal insurance contributions.

c) Revenue from fines where coexistence measures are breached.

Revenues generated from fines arising from breaches of mandatory coexistence measures could be used to maintain the fund. However, it is anticipated that this source of revenue would be very limited.

d) State funded

The Working Group is of the opinion that it is not the responsibility of the State to be directly involved in the provision of insurance for the economic risks associated with the growing of GM crops. However, the State has responsibility to put in place measures to protect non-GM crop growers from direct economic loss as a result of the introduction of the new (GM) crop type. At the same time, these measures should not make prohibitive the cultivation of GM crops. In this regard, State contribution, either partially or wholly, to a redress fund could be considered. However, such a contribution would have to be on a cost recovery basis. The recovery of costs should be from contributions from the main beneficiaries i.e. the GM crop sector.
grower, biotech companies and other industry beneficiaries. This would support the current positive but precautionary policy the State established on GMO technology.\(^7\)

(ii) **Start-up time and duration of fund**

The fund could be established before the cultivation of GM crops begin or, after a period of time once cultivation of GM crops has commenced. The latter option would allow for a better assessment of the extent to which a fund would be required. The fund could be a permanent or temporary measure. This will depend on whether the insurance industry enters the market and the extent to which GM admixture of non-GM crops occurs under the coexistence measures proposed in this Report.

(iii) **Losses covered**

Redress from the fund should be restricted to covering economic loss, as defined earlier in this chapter, as a result of the adventitious admixture of non-GM produce by GMOs. In addition, the rules governing the distribution of any monies from this special fund should be very strict and controlled. To this effect, the Working Group has developed the following suggestions in relation to accessing the fund:

(i) Economic loss should be calculated when the following criteria apply:
- When the statutory labelling GMO thresholds are exceeded in non-GM produce.
- Where the loss is verifiable and quantifiable and based on the current year’s calculation.
- Where the loss is limited to the difference in the market value of the crop pre- and post-admixture and also those costs associated with remedial measures for ensuring purity in subsequent crops.
- Where losses may continue for more than one year provided there is sufficient evidence that reasonable efforts were made to minimise them by the claimant.

(ii) Non-GM crop growers must be able to provide reasonable evidence that the source of admixture was external and was through no fault of their own, e.g. testing of home-saved seed, adherence to rotation interval, etc.

(iii) Access to the fund should be available to:
- Non-GM crop growers, where the cause of admixture cannot be determined.
- Non-GM crop growers where the liable party can be identified, but where attempts to reach a private settlement have failed. It could be argued that there is little incentive for GM crop growers to adhere to the coexistence measures in this scenario. However, GM crop growers will be incentivised to adhere to coexistence measures by imposing sanctions in the event of breaches.

(iv) Sectors of the farming community who choose to impose non-statutory, additional or stricter requirements on their production systems in order to gain market or

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\(^7\) GMO Consultation Paper 1998
price advantage, should themselves be responsible for ensuring those requirements are met.

(v) All and any other losses are still pursuable at the discretion of the claimant through the civil Courts.

(vi) Administration of fund

The Working Group is of the opinion an Independent Body should be responsible for the administration of the fund.

Recommendations

I. Where a non-GM crop grower incurs a verifiable and quantifiable economic loss as a result of the maximum labelling threshold in his/her crop being exceeded through admixture by the actions of a third party, the affected grower should be compensated.

II. Where economic loss arises as a result of admixture, and where the liable party can be identified, every effort should be made by affected parties to reach a settlement.

III. A redress fund should be established for the redress of economic loss if and when the necessity arises. Such a fund should be established by the State but on a cost recovery basis. The recovery of costs should be from contributions from the main beneficiaries i.e. the GM crop grower, biotech companies and other industry beneficiaries.

IV. An Independent Body should be established to carry out the administration of the fund. Payments from this fund should be strictly controlled.

V. Notwithstanding the establishment of a redress fund, National law on liability would still apply and non-GM crop growers are entitled to pursue a civil action through the Courts.
Chapter 9 Monitoring and review of coexistence measures and future research

9.1 Monitoring for the validation of coexistence measures

9.1.1 Background

The coexistence measures recommended in this Report should be subject to ongoing monitoring and evaluation in order to verify their effectiveness. Information from such monitoring activity is necessary for continuous improvement and adjustment of measures where necessary. The Commission Guidelines state:

‘The management measures and instruments adopted should be subject to ongoing monitoring and evaluation to verify their effectiveness and to obtain the information necessary for improving the measures over time. Best practices for coexistence should be revised periodically to take account of new developments brought about by scientific and technical progress and which could facilitate coexistence.’

Monitoring for the effectiveness of coexistence measures and factors to be considered are discussed in sections 9.1.2 to 9.1.5.

9.1.2 Monitoring procedure

Monitoring to verify the effectiveness of coexistence measures involves two key principles - as follows:

9.1.2.1 Compliance inspections

To establish the effectiveness of crop management coexistence measures, it is necessary to monitor their implementation and establish what coexistence measures have been undertaken at farm level. Establishing what measures are implemented is facilitated through the compliance inspection programme. Compliance inspection encompasses management measures prior to, during and post cultivation.

While establishing which coexistence measures have been taken by the grower, compliance inspection alone may not be sufficient to pinpoint the causes of admixture. In addition, where the measures as set out in this Report do not prove to be fully effective, admixture could arise where there is no evidence of non-compliance e.g. an inadequate separation distance. Consequently, it may be necessary to complement inspection for compliance by crop sampling and analysis for GMO presence and content (section 9.1.2.2).

The level of compliance with both technical and procedural requirements is also an indicator of the effectiveness of the coexistence implementation measures. Examples include: where there is intentional non-compliance with coexistence measures, alterations may be necessary to measures which discourage growers from such infringements i.e. strengthening of liability rules and more burdensome sanctions; or, unintentional non-compliance may warrant
adjustments to measures which educate and make growers more aware of their responsibilities regarding their implementation; or, the adjustment of measures that prove difficult to implement.

The results from compliance inspection therefore, play an integral part in decision making for any adjustment in both technical and implementation measures.

### 9.1.2.2 Crop sampling and analysis

As outlined in Chapter 4, possible causes of admixture include: use of impure seed, out-crossing due to inadequate separation distance, volunteers, mechanical movement of seed or grain, etc. In addition to compliance inspection, it may be necessary to carry out a programme of crop sampling and analysis to pinpoint the exact causes of admixture.

The sampling schedule must be comprehensive to allow the cause of admixture to be detected and should include:

(i) **Sampling of the GM crop**
   - Seed for sowing of GM crops should be sampled for authentication i.e. presence and nature of genetic modification.

(ii) **Sampling of surrounding/neighbouring non-GM crops of the same species prior to, (if relevant), during and after cultivation.**
   - Sampling of seed, volunteers (if any) and indigenous related wild species (if any) prior to cultivation of the non-GM crop will establish whether admixture originated from an external source.
   - Sampling to defined radii for investigation of out-crossing as a source of admixture.
   - Sampling of the harvested produce to establish presence/level of admixture.

### 9.1.3 Costs associated with monitoring and crop sampling

During the initial years of GM crop cultivation, monitoring of all GM crops is envisaged to validate coexistence measures. This will have cost implications, which should be borne by the State. However, costs could be reduced by:

(i) **The analysis of the samples taken from harvested product of non-GM crops at first. Decisions regarding the analysis of samples taken during the growing season (during cultivation) could then be made depending on the presence and/or level of admixture found in the harvested product.**

(ii) **The encouragement of merchants/processors to test for the presence of GMOs in non-GM crop produce. The availability of these results to the State would enhance**
the testing programme and reduce the State cost of analysis for validation purposes. The results from these tests would also serve as a general indicator of the effectiveness of measures for coexistence i.e. frequency and level of admixture.

(iii) Concentration of monitoring on target/specific crops to obtain a ‘true test’ of the effectiveness of coexistence measures i.e. crops where GM and non-GM of the same species are grown in close proximity.


9.1.4 Post-release monitoring under Directive 2001/18/EC and possible linkage to coexistence monitoring

Biotech companies (referred to as ‘Notifiers’ in the authorisation process) seeking EU approval permitting the cultivation of new GM events are required, under Article 13(2)(e) of Directive 2001/18/EC, to submit as part of the notification for the placing on the market of a GMO, a plan for monitoring in accordance with Annex VII of the Directive. The notifier is responsible for carrying out the Monitoring Plan and for reporting the results to both the EU Commission and to the Member States, particularly with respect to the identification of any adverse effects.

Member States are not precluded from carrying out additional monitoring in the form of case-specific monitoring or general surveillance. The aim of such surveillance is to enable the Competent Authority to take appropriate measures without delay, should any undesirable and unidentified effects arise in the framework of prior risk assessment. This is not, however, considered a substitute for the monitoring plan, which remains the responsibility of the notifier for implementation (although, with the consent of relevant parties, may form part of it).

The monitoring objectives are to:

(i) Confirm that any assumptions regarding the occurrence and impact of potential adverse effects of the GMO, or its use, in the environmental risk assessment are correct.

(ii) Identify the occurrence of adverse effects of the GMO, or its use, on human health or the environment, which were not anticipated in the environmental risk assessment (ERA).

There are two types of monitoring plan required under Directive 2001/18/EC i.e.:

(i) Case-specific monitoring.

(ii) General surveillance monitoring.

(i) Case specific monitoring defines a specified time period in which results are to be obtained and focuses on all the potential effects on human health and the environment identified in the risk assessment, taking into account, among other
things, different locations, soil types, and climatic conditions e.g. volunteer establishment and invasiveness and gene flow to related weed species/wild relatives.

(ii) **General surveillance monitoring** in contrast, seeks to identify and record any indirect, delayed and/or cumulative adverse effects that have not been anticipated in the risk assessment and are carried out over a longer time period and possibly, a wider area.

Working Groups have been set up at EU level to elaborate on monitoring plans for both case specific and general surveillance, taking on board previous work carried out in other fora with a view to providing further guidance for notifiers and Competent Authorities for the setting up and auditing of Monitoring Plans and to harmonise the monitoring of GMOs in the EU.

While monitoring plans under Directive 2001/18/EC have a different objective to that of monitoring for the validation of coexistence measures, some of the parameters to be measured are common to both e.g. gene flow. Consequently, the Working Group is of the opinion that coexistence monitoring could complement monitoring under Directive 2001/18/EC and vice versa. This would serve to improve the overall effectiveness of monitoring, avoid duplication of effort and improve cost-effectiveness.

### 9.1.5 Sample testing service

The Working Group was conscious of the necessity for an efficient, accurate, reliable and economical analytical service for testing for the presence of GMOs in both seeds and plant material.

The State Laboratory currently carries out analysis for GMO content on behalf of the DAF, EPA and the FSAI. However, the capacity of the laboratory to provide an analytical service for an extensive batch of samples in a timely manner may not be a viable option in the medium to long-term, if/when GM crops are grown on a larger scale in this country.

While private laboratories could provide the service, the cost per sample may add an excessive burden on non-GM crop growers if there is a requirement for a large number of samples to be tested. Economy of scale could, however, reduce cost per sample if GM crop growing becomes widespread in Ireland.

The International Seed Testing Association (ISTA) is currently evaluating detection and analytical systems for GMO content in seed. In most other EU Member States the National Seed Testing Laboratories have/are developing suitable facilities and will seek ISTA accreditation. The Official Seed Testing Station (OSTS) within the DAF could be expanded to carry out such analyses in the new laboratory facilities at Backweston. In particular, for testing of certified seed, this could be the most appropriate option, as seed samples are already tested for compliance with other qualitative and health standards by the OSTS.
9.2 Review of coexistence measures

Where coexistence measures are found to be working effectively they will be maintained. There may, however, be a necessity to adjust the measures as appropriate over time. It is proposed that the measures contained in this Report should be reviewed, initially after two years, and as deemed appropriate thereafter. Adjustments to measures will be made where necessary depending on the following:

- Consultation with stakeholders.
- Results of monitoring activity.
- More up-to-date scientific information.
- Developments within the EU and experience of other Member States.
- Identification of problems or unexpected occurrences.

9.3 Future research

Taking into consideration the issues surrounding GM crops, it is prudent that Ireland continue to expand its existing GM crop research effort. During the compilation of this Report, the Working Group highlighted several areas that necessitate further investigation.

9.3.1 Economic evaluation

9.3.1.1 Economic implications of GM crop cultivation for Irish agriculture

While the production of certain GM crops may give rise to increased yields or improved quality at lower production costs, the overall economic return to the grower may well be offset by a reduction in commodity prices resulting either from reduced market demand for such GM produce, or a consequent oversupply of the market. The direct economic return as measured by the assessment of increased yield, improved quality, reduced cost of inputs, higher market value of specialist crops, or reduced return through lower commodity prices must also be measured against the broader implications of the impact on Ireland’s image as producer of ‘clean green’ food products. The positive image of Ireland as a food-producing nation marketing primary natural ingredients under the umbrella of ‘Ireland – the Food Island’ has been successful in the marketing of Irish produce on the international market. The perception of our natural environment and the purity of ingredients that flow from it have been critical in portraying our positive food image. Concern has been expressed that the introduction of GM crops will significantly damage the market value and competitiveness of conventional and organic food and feed.

The negative attitude of consumers to food derived from GM crops has prompted retail outlets to set their own standards in relation to GMO content and it is not clear if they will insist on lower thresholds than the 0.9% required with respect to food labelling. Retail outlets may see a marketing advantage in so doing, however, this will depend on consumer attitudes and response to foods containing GMOs. It is likely that there will be a significant marketing
advantage in Ireland in the short to medium term for food produced in the absence of GM crops, given current consumer perception of GM foods. This is also likely to extend to certain export markets within the EU where opposition to GM food is particularly focussed. It is critical to the successful marketing of Irish food products that, at the very least, Irish food producers and retailers are not placed at a competitive disadvantage to our key competitors in supplying the key markets, both at home and abroad.

While acknowledging the right of farmers to grow approved crop varieties, be they GM or non-GM, it is essential that these broader aspects of the economic impact of GM crop production are examined in a comprehensive, holistic manner. A full understanding of these impacts will allow government policy to be directed to the greater benefit of the Irish economy as a whole. In this regard, Teagasc are undertaking, at the request of the DAF, a study project to evaluate the national economic implications for the Agri-Food industry from the use of GM technology in crop and livestock production. A study group consisting of economists, agronomists and animal scientists is addressing this issue in more detail and Teagasc plan to publish the results of their analysis in due course.

9.3.1.2 Costs of coexistence

The introduction of GM crops into Irish agriculture and the consequent adoption of coexistence measures will have economic implications for the production of conventional and organic crops to the required purity standards. Coexistence costs associated with primary crop production will include: the testing of seed for purity, additional crop management input, prevention of seed dispersal by mechanical means, adjustments in crop rotation, crop separation and possible additional costs relating to liability cover. In addition, costs will arise for the State with respect to coexistence administration and monitoring.

Assessing the magnitude of these costs is complex, as they are dependent on a number of factors including:

- Labelling thresholds – the fundamental principle of the tighter the tolerance, the higher the cost involved in meeting that tolerance is generally applicable (Gianessi et al., 2003). For example, the costs of complying with seed production thresholds are higher than those for the production of food and feed.

- Crop species – costs for coexistence will depend on the species capacity for gene dispersal, e.g. costs for potato production would be regarded as lower than those for oilseed rape (Bock et al., 2002).

- Extent of GM cropping – the areas of GM crops relative to their non-GM counterparts will influence crop production costs to the agriculture sector. For example, relative areas will influence the cost and frequency of testing for GMO content, adjustments in crop rotation and the level of necessary crop management and machinery hygiene, etc. Relative areas of GM and non-GM crops will also have implications for the extent and period of monitoring required and the associated costs. In addition, the administration costs to the State will depend on the extent of GM cropping.
Analysis of the economic issues that arise from the production of GM crops has largely concentrated on a direct comparison between the returns from a GM crop versus a non-GM crop. Recent research completed by Teagasc does indicate that the cultivation of certain crops with certain modifications may provide a significant financial incentive to the Irish farmer (Flannery et al., 2005; www.gmoinfo.ie). While strands of this research parallel recently completed work (Gianessi et al., 2003), it does not specifically address the predicted costs of coexistence to the Irish (GM/conventional/organic) grower.

A number of reports have given some indication of costs and economic returns of GM crop production elsewhere (Bock et al., 2002; PG Economics, 2003; Tolstrup et al., 2003). The Report from the Danish Working Group on the coexistence of GM crops with conventional and organic crops, concluded that the costs of complying with the required thresholds for crops of maize, potato and cereals are in the range of 0 to +2% of the total growing costs for conventional and organic production. For oilseed rape and sugar beet, the costs increase to between 3% and 9% respectively of the average growing costs for conventional production (Tolstrup et al., 2003). The Group did not estimate the costs of the use of separation distances and cropping intervals. The EU Joint Research Centre is funding research studies aimed at identifying the cost of implementing coexistence, in particular in Spain, where the production of GM maize has already commenced.

While direction can be taken from these reports, it is not always appropriate to compare the costs of coexistence in another Member State, with those applicable to Irish production systems. The primary decider with regard to the adoption of GM crops by growers will clearly be whether there is an economic incentive associated with the cultivation of the GM crop. The commercialisation of second and third generation GM crops (e.g. disease resistance, energy substitution) may be more applicable to Ireland than what is available commercially at present. Research is required to examine the potential benefits of these GM crops and the cost of adhering to coexistence best practice in Irish farming production systems. While this can be determined and the financial implications of coexistence at each stage of the production chain calculated, the Working Group recommend that this research is undertaken so that growers are fully aware of the necessary issues prior to the cultivation of any GM crop in Ireland.

### 9.3.2 Improving knowledge on how best to ensure coexistence

Areas identified by the Working Group that require further investigation include:

- The nature and extent of pollen dispersal from oilseed rape, and the potential for cross pollination with cultivated and wild relatives and volunteers with a view to the establishment of the most appropriate separation distance for the coexistence of GM and non-GM oilseed rape under Irish production systems.

- The precise effect of buffer zones and their relevance for Ireland.

- Any deficiencies with respect to Irish technical data that would improve the model of coexistence being developed for Ireland.
9.3.3 GM crops and biodiversity

The impact of GM crop cultivation on biodiversity is evaluated during the risk assessment under Directive 2001/18/EC. Crop management may indirectly impact on biodiversity e.g. species balance/level, in the same manner as changes in crop ratios of conventional and organic crop production. However, the FSE studies (Burke, 2003) conducted in the UK, highlighted the need for each GM crop regime to be fully optimised in order to minimise the impact on biodiversity. The more recent BRIGHT report (Sweet et al., 2004) highlights the advantages of such an approach with regard to the cultivation of winter oilseed rape.

From an agro-ecological context, further research into the impact on biodiversity of GM crop cultivation will be essential. While it would be advisable that some initial research be undertaken prior to the introduction of a GM crop species, most research could be conducted in conjunction with the initial commercial plantings as the scale of these is expected to be minimal. Any negative impact arising can then be counteracted by the introduction of appropriate on-farm management measures.

Recommendations on monitoring and research.

I. The coexistence measures recommended in this Report should be subject to on-going monitoring and evaluation for their validation by the DAF, or under its supervision. The measures should be reviewed initially after 2 years and, based on experience, as deemed appropriate thereafter.

II. Research should be commissioned on the: (i) economic impact for Ireland from GM crop cultivation; (ii) costs of coexistence measures; (iii) coexistence of GM and non-GM oilseed rape; and (iv) impact of GM crop management regimes on biodiversity.
Chapter 10  Bibliography


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