GM FARM TRIALS

POST 146
Post Note September 2000

Concerns that growing genetically modified (GM) crops on a commercial scale in the UK may have adverse effects on the environment prompted the government to launch farm-scale evaluations (FSEs) in spring 1999. These will assess the abundance and diversity of wildlife (biodiversity) in fields of GM crops compared to fields of conventional crops. But the FSEs have been the target of a high profile campaign to destroy the crops.

This note details recent developments in the FSEs and examines the issues that arise.

BACKGROUND

Genetically modified herbicide tolerant (GMHT) crops are designed to survive treatment with one of two broad-spectrum herbicides. This allows a farmer to use the herbicide in question to control weeds after the GMHT crop has emerged. Since their introduction in the US in 1996, GMHT crops have accounted for an increasing proportion of crops grown around the world. No GM crops have been grown on a commercial scale in the UK as the result of an agreement reached between the government and SCIMAC[1] (Supply Chain Initiative on Modified Agricultural Crops) in November 1999. This states that wide-scale planting of GM crops in the UK will not occur until the government is satisfied that the potential adverse effects on the environment have been assessed.

One potential effect identified by ACRE[2] and English Nature[3] (EN) is the possibility that GM crops may reduce biodiversity by further intensifying agriculture. Another, identified by the RSPB[4], is that any such intensification could cause bird numbers to drop still further. The farm scale evaluations (FSEs) were thus designed to investigate whether intensive farming using GMHT crops (i.e. the changes in herbicide management this involves) is any more harmful to bio-diversity than conventional intensive farming.

Crops to be tested (**Table 1**) in the FSEs have already been assessed in small-scale field trials; for instance, UK field trials for GMHT oilseed rape began in 1989. In addition to the farm-scale biodiversity evaluations, separate studies will assess the potential for gene transfer from GM to non-GM plants (gene flow).

TABLE 1 GM SEEDS USED IN THE FSEs

CROP	TOLERANCE TO	No. OF SITES (year 2000)
Sugar beet	Glyphosate[1]	15
Fodder beet	Glyphosate	9
Spring oilseed rape	Glufosinate ammonium[2] (GA)	12
Winter oilseed rape	Glufosinate ammonium	25
Forage maize	Glufosinate ammonium	12

Notes 1 Glyphosate's tradename is Roundup (Monsanto)
2 GA's tradename is Liberty (Aventis)

THE FARM SCALE EVALUATIONS

DETR, the Ministry of Agriculture, Fisheries and Food (MAFF) and the Scottish Executive are funding a consortium of government-funded research centres to conduct the FSEs consisting of:

- Centre for Ecology and Hydrology (CEH);
- Institute of Arable Crops Research;
- Scottish Crops Research Institute.

Scientific methods, data analysis and peer review are overseen by a scientific steering committee including experts from academia, NGOs and government. Protocols were developed during the 1999 season and the FSEs began in the 2000 season; they are expected to continue until plantings in 2002.

Selecting the Farms

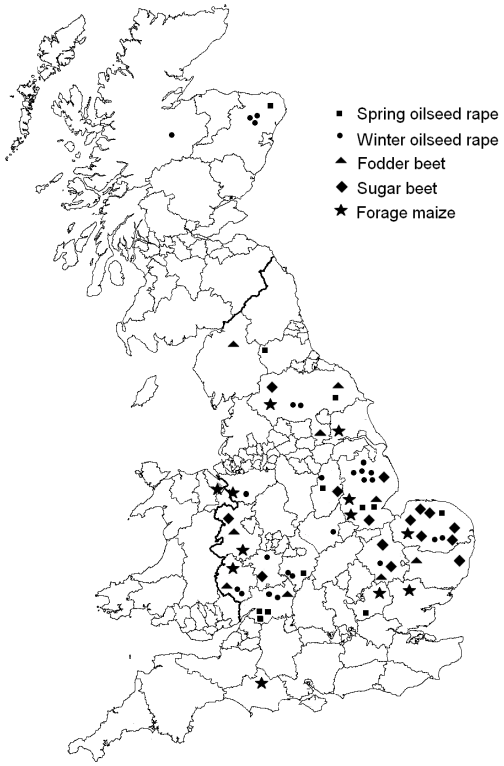
Farms were selected to be representative of UK agriculture in terms of soil type, climate and agrochemical use (**Figure 1**). They were chosen from a list of farms drawn up by SCIMAC. Each provides a field that is split into two halves of up to 10 hectares in size. A GM crop is grown (to SCIMAC guidelines) in one half and the non-GM equivalent (to the normal practice on that farm) in the other. Biodiversity in each half will be assessed during a single growing season: GM crops will then be destroyed.

Assessing Biodiversity

Biodiversity differences are assessed by measuring the number and variety of organisms in the GM and non-GM halves of each field. Studies will assess seeds in the soil and vegetation in the field and field margins, as well as a range of other organisms such as slugs, snails and insects (**Box 1**). It is not possible to assess impacts on every species; 'indicator organisms' have thus been chosen as sensitive markers of the prevailing environmental conditions. The British Trust for Ornithology is also assessing effects on mammals and birds in a related study.

1 SCIMAC represents the biotechnology industry, from seed stock to crop.
2 ACRE is the Department of Transport, Environment and the Regions' (DETR) Advisory Committee on Releases to the Environment. It advises Ministers on human and environmental safety aspects arising from the release of GMOs.
3 EN is the Government's statutory adviser on wildlife.
4 Royal Society for the Protection of Birds.

FIGURE 1 FARMS PARTICPATING IN THE FSEs



Note: Farms shown are those participating in the year 2000.

Assessing Gene Flow

In addition to assessing the impact on biodiversity, the FSEs will be used to study the potential for gene flow. This could occur between GM and non-GM crops, or between GM crops and closely related species growing wild nearby. The extent to which this is likely to occur depends on factors such as:

- Whether the crop flowers during the growing season (oilseed rape and maize do, whereas fodder and sugar beet do not[5]).
- The proximity of closely-related species growing wild. Oilseed rape, sugar beet and fodder beet all have close wild relatives that are found in the UK; maize has none.
- Factors that affect the distribution and/or viability of pollen. These include weather conditions, the presence of physical barriers such as hedges and the number and nature of insect pollinators.

MAFF's Central Science Laboratory was awarded a contract to study crop-to-crop gene flow in June 2000. It is currently deciding how best to do this. Full details of the methods used and results obtained will be published following peer-review by the Scientific Steering Committee.

[5] A small portion of the beet crops may bolt – i.e. flower in response to cold - but the trial protocols require bolters to be removed.

BOX 1 BIODIVERSITY INDICATORS USED IN THE FSEs

Soil seed bank. Studies will compare the number and variety of seeds found in the soil in the GM and non-GM fields (differences may be expected because of the different herbicide treatments). The results will be used to predict the implications of changes for biomass and habitat within the field.

Vegetation. Samples of seedlings and young plants are counted and identified before and after spraying. A total biomass sample will be collected at crop maturity. Some measurements will also be taken in the season following harvest, and if there is a significant difference, in the subsequent season also. Field margin studies will include looking for signs of plant death due to spray drift, identifying species in the sample area and estimating the vegetation cover.

Invertebrates. Slugs and snails are counted both in the fields (twice a year) and in the field margins. Other species identified and counted include carabid beetles, spiders and weevils as well as flying insects such as bees and butterflies. Certain insects and other organisms present on vegetation are also assessed three or four times during spring and summer. These include bugs (heteroptera), springtails (collembola) and caterpillars (of butterflies, moths and sawflies).

ISSUES

Greenpeace, Friends of the Earth (FoE) and Gene-Watch have criticised the FSEs on a number of grounds. Indeed, in 1999 Greenpeace organised a campaign to disrupt them by destroying GM crops on farms taking part. Apart from general concerns over the safety and/or need for GM foods[6], the sustainability of intensive agriculture, etc., specific issues relating to the FSEs fall into two main areas:

- dispersal of GM pollen;
- reservations over the design of the evaluations.

Dispersal of GM Pollen

Growing GM crops such as maize and oilseed rape on a farm scale will lead to the release of GM pollen to the environment. GM crops in the FSEs are planted in accordance with SCIMAC guidelines which include separation distances of up to 600 metres (**Table 2**). However, pollen can travel hundreds of metres downwind under normal weather conditions; in exceptional conditions much longer transports of tens to hundreds of km may occur. Furthermore, honey bees can pick up pollen from around a 5km (~3 mile) radius of their hive. This raises possible concerns over gene flow, GM contamination and the adequacy of current separation distances.

Gene flow

Gene flow from GM to non-GM plants could lead to conventional crops and/or wild relatives acquiring HT traits. There is concern that this may occur beyond the separation distances recommended by SCIMAC (Table 2).

[6] See POST report on GM Foods, May 1998.

TABLE 2 SCIMAC SEPERATION DISTANCES

Crop		Distance (m)	
	Seed Crops[1]	Organic Crops	Non-GM Crops[2]
Oilseed rape	200m	200m	50m
Sugar beet	600m	600m	6m
Fodder beet	600m	600m	6m
Forage maize	200m	200m	50m (forage maize) 200m (sweetcorn)

Notes: 1. Crops of the same species grown for seed
2. Of the same species

For instance, supposedly non-GM rapeseed batches produced by Advanta Seeds Inc. in Alberta, Canada in 1998 were later shown to have a GM content of ~1.0%. This is thought to have arisen by cross-pollination of the non-GM seed crop with GM crops grown on neighbouring farms in Canada, although this has yet to be firmly established. If so, it means that cross-pollination occurred despite the fact that a separation distance of at least 4,000m was used. Some 400 UK farmers sowed a total of ~5,000 hectares of the affected oilseed rape in 1999/2000.

This example suggests that some gene flow from GM to non-GM plants is to be expected. One possible consequence of this might be that plants could collect a 'full set' of herbicide tolerance genes leading to the emergence of 'superweeds'. The extent to which this could happen will depend on: the range of herbicide tolerant traits/plant varieties on the market; the extent to which different plants can 'stack' extra genes; and the penalties and benefits conferred by the HT traits (for instance, herbicide tolerance is a benefit only in an agricultural context and may thus be unlikely to be maintained in a wild population). Another concern is whether there is a potential for horizontal gene transfer from GM plants to other species such as soil microbes. Research has suggested routes by which this might occur in the laboratory, but horizontal transfer has never been observed under field conditions.

GM 'contamination'

Inadvertent contamination of supposedly non-GM products by GM pollen (or through other mechanisms such as seed spillage) is an inevitable consequence of growing GM crops on a farm scale. Such contamination has implications for **food labeling**, **organic farmers** and **seed producers**. The main regulatory approach for food labeling has been to set *de minimis* thresholds for GM content[7]. EU regulations require manufacturers to label foods as containing GM unless they can show that the GM content is below a 1% threshold and that the contamination was inadvertent.

More recently, the Commission has announced its intention to set rules for dealing with GM contamination of foods specifically advertised as 'GM-free', and products such as organic foods. Organic farming is governed throughout the EU by Council Regulation 2092/91. A recent amendment to this states that "*GMOs and products derived therefrom are not compatible with the organic production method*" and suggests setting a *de minimis* threshold for unavoidable contamination of organic products. No figure has been proposed for either ('GM-free' or organic) threshold - both are likely to be more stringent than the current non-GM threshold (1%).

GM contamination is also a problem for seed companies, which see an urgent need to define a threshold for inadvertent GM contamination of non-GM seed. Advanta UK told the Commons Agriculture Committee[8] that a 1% GM threshold should be set for conventional seed.

Separation distances

In June 2000, the government launched:

- a scientific review of data on separation distances (**Box 2**) for different cross-pollination thresholds;
- a review of the causes of the Advanta incident;
- a consultation among interested parties, including the views of conventional and organic farmers.

The deadline for consultation was August 1st 2000, and the scientific review was published on 3rd August 2000. Separation distances required to meet the cross-pollination thresholds chosen are shown in Box 2. Ministers are currently considering the issue of these thresholds and their implications for current separation distances.

Overview – the future of the FSEs

Such concerns have led to a debate over whether the FSEs should continue. The current regulatory approach is to continue with the FSEs to assess the environmental impact of GM crops. This approach accepts that some release of GM content may occur, but assumes that the impact will be limited, and that it can be minimised through the setting of appropriate separation distances and thresholds. The results of the evaluations will be used to inform UK policy and may also prove useful in a wider context. For instance, World Trade Organisation rules require standards that differ from those agreed by international bodies to have a scientific basis.

[7] See POSTnote 129 October 1999 for more details.

[8] Agriculture Committee, 8th Report, July 2000 HC812.

BOX 2 MAFF REVIEW OF SEPARATION DISTANCES

In June 2000, the Ministry of Agriculture Fisheries and Food (MAFF) commissioned the National Institute of Agricultural Botany (NIAB) to review scientific evidence concerning separation distances and levels of crop purity. NIAB was asked to consider whether available data could be used to determine separation distances that would result in levels of cross-pollination at or below certain limits (0.1%, 0.5% and 1.0%). It looked at the evidence for each of the three crops (sugar beet, maize and oilseed rape) undergoing farm scale evaluations, and reported its findings in August 2000 (see **Table**).

Sugar beet – NIAB did not recommend separation distances for sugar beet, since the root is harvested at the end of the growing season, well before the plant flowers.

Oilseed rape – modern breeding systems mean that oilseed rape varieties often contain a proportion of male sterile (i.e. non-pollen producing) plants by design. The greater the proportion of male sterile plants in the crop, the more likely it is to cross-pollinate; NIAB thus recommended different separation distances for conventional (male fertile) and male sterile varieties.

Maize/sweetcorn – NIAB set different separation distances for maize grown for grain than that grown for silage. This is because maize grown for silage contains only 40-50% grain.

TABLE NIAB SEPARATION DISTANCES

Crop	Threshold levels of cross-pollination		
	0.1%	**0.5%**	**1.0%**
Oilseed Rape			
Conventional varieties	100m	10m	1.5m
Varieties with >10% male sterility	n/a	n/a	100m
Maize/sweetcorn			
For grain	n/a	300m	200m
For silage	420m	200m	130m

Notes: Figures are for fields of 2 ha or greater
n/a insufficient data to produce a recommendation
Source: NIAB Review, MAFF, August 2000.

This approach is not accepted by all. For instance, the Soil Association (SA) – which sets standards adhered to by ~70% of UK organic producers - opposes the introduction of GM crops because it sees them as making farmers more dependent on intensive methods. It wishes to see the FSEs abandoned; in the meantime SA has effectively set a 0% threshold for GM content and has called for a 6 mile GM-free exclusion zone around organic farms. Groups such as Greenpeace and FoE also wish to see the FSEs stopped. They view the potential for gene transfer as irreversible 'genetic pollution' with unknown and possibly damaging consequences.

Design of the FSEs

Biodiversity indicators

GeneWatch has also questioned whether the most relevant indicator species (Box 1) are being monitored. For instance, it is concerned that no attempt is being made to monitor earthworms or soil microbes, both of which are indicators of soil quality. However, researchers point out that it is not possible to measure population responses for every single species on the farm. They are confident that the species chosen represent a reasonable compromise between practicability and relevance.

Timescale/crop rotation

The fact that each evaluation will take place only over a single growing season has led to concerns that small, incremental changes may be overlooked. Such changes may not be important over a single growing season, but the cumulative effect over a typical four year crop rotation cycle could be significant. As the range of GM crops available expands, it is possible that two or three years of the rotation cycle could involve HT crops. Further studies may thus be required to evaluate cumulative effects on biodiversity of growing a succession of HT arable crops over a rotation cycle. Such effects are currently being assessed in a separate MAFF project.

Other Issues

Other aspects of the FSEs have also been questioned. Some are concerned that the study of gene flow will focus on crop-to-crop transfer rather than transfer to related wild plants, although separate studies at the CEH are evaluating the latter. Others note that the GM crops are being compared with conventional intensive agriculture rather than with organic systems. There are also concerns over the lack of consultation (with the public and organic farmers) in designing the FSEs and selecting the sites. Such concerns have led to legal challenges to halt the evaluations. The Highland Council has used its planning permission powers to try to delay a trial in Scotland, claiming that it represents a change of use (from farming to scientific experiments).

Pesticide Use

Concerns have also been expressed over one of the herbicides used in the FSEs (GA). It is not registered for use between September and March although the Advisory Committee on Pesticides (ACP) is currently considering an application for such use. ACP has allowed experimental use of GA in autumn / winter FSEs based on an assessment of data submitted, but there are concerns that this may lead to greater contamination of groundwater than use at other times of the year.

Overview

The FSEs constitute only one of the strands of evidence informing an assessment of the overall environmental impact of GMHT crops. The government's new Agriculture and Environment Biotechnology Commission has already identified the FSEs as a priority area for consideration.