FARM SCALE TRIALS OF GM CROPS:
Answering the Safety Questions?

GeneWatch UK

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Farm scale experiments with genetically modified (GM) crops have recently begun in the UK and are, according to Government Ministers, key to the decision about whether to allow the commercialisation of these crops in this country. This briefing describes the experiments and their rationale and questions whether this is an appropriate time to be moving to large scale experimentation and how likely it is that the trials will achieve their objective.

Background

Farm scale trials in the UK are being conducted with three GM crops:

- fodder (forage) maize which is tolerant to the herbicide glufosinate (Liberty)[1];
- oilseed rape (both spring and winter varieties), also tolerant to glufosinate[2];
- sugar beet tolerant to glyphosate (Roundup)[3].

The oilseed rape and maize have been developed by AgrEvo, the company that also produces glufosinate. The sugar beet has been developed by Monsanto, which also manufactures glyphosate. Glufosinate and glyphosate are broad spectrum herbicides which kill all green plants except those protected as a result of the genetic modification. The intention, therefore, is that farmers will be able to spray the GM oilseed rape, maize or sugar beet with the relevant herbicide to remove weeds without harming the crops.

The trials are being conducted to try to address concerns about the potential impact of growing herbicide resistant crops on the agricultural environment and wildlife. The widespread use of herbicides in conventional farming has already been associated with declines in farmland birds and other species and there are fears that the increased use of broad spectrum herbicides with resistant GM crops will result in the highly efficient removal of weeds and a consequent decrease in food supplies for invertebrates and birds. Therefore, the intention of the trials is to compare the effect of herbicide use on the diversity and abundance of plants and invertebrates (the food sources for higher species) in GM herbicide tolerant (GMHT) and non-GM crops under farm conditions. The results will then be extrapolated to determine whether any wider effects on birds or other farmland wildlife could occur.

In large part, these trials are intended to answer the criticisms made by English Nature and others that the approval process of GM crops takes no account of the potential for such secondary effects.

Conducting and Managing the Farm Scale Trials

The experiments with oilseed rape and maize are a joint project between the Government and SCIMAC (Supply Chain Initiative on Modified Agricultural Crops – an industry body). The cost to the Government of funding the trials in 1999-2000 is £233,000 and is expected to be £702,000 in 2000-01[4]. Total public funding will be approximately £3.3 million over four years.

The research contracts to monitor the trials have been awarded to a consortium led by the Institute of Terrestrial Ecology (ITE) and including the Institute of Arable Crops Research (IACR) and the Scottish Crop Research Institute (SCRI).

Box 1: The GM crops involved in UK farm scale trials

Oilseed rape

The hybrid plants to be grown in the experiments are developed from the male sterility/ fertility restorer system developed by AgrEvo's subsidiary, Plant Genetic Systems. They are tolerant to glufosinate and contain the following transferred genes:

- PSsuAra – promoter gene from the plant *Arabidopsis thaliana*
- *bar* – the glufosinate tolerance gene from *Streptomyces hygroscopicus*
- 3'g7 and 3'nos – from the vector *Agrobacterium tumifaciens*
- PTA29 – promoter gene from the tobacco plant *Nicotiana tabacum*
- *barnase* and *barstar* – the male fertility and fertility restoration genes from the bacterium *Bacillus amyloliquefaciens*

Maize

The fodder maize already has approval for marketing in Europe (C/F/95/12/07) but does not yet have plant variety listing in the UK so cannot be sold to farmers. In France, the marketing approval is under legal challenge from groups including Greenpeace.

Tolerant to glufosinate, the GM maize contains the following foreign genes:

- *pat* – gives tolerance to glufosinate (of synthetic origin but identical to *pat* gene of *Streptomyces viridochromogenes*)
- cauliflower mosaic virus 35 S promoter and terminator genes
- disrupted copy of the ampicillin resistance gene under control of bacterial regulatory sequences
- origin of replication sequence from the pUC plasmid.

Sugar beet

The sugar beet is tolerant to the herbicide glyphosate and contains the following transferred genes:

- a chloroplast transit peptide gene from the plant *Arabadopsis thaliana*
- the EPSPS gene from *Agrobacterium* giving tolerance to glyphosate
- a synthetic glyphosate oxidoreductase enzyme gene which stimulates the breakdown of glyphosate by the sugar beet
- the GUS marker gene from *Escherichia coli* giving ß-glucuronidase activity
- some, but not all, of the varieties to be tested include a neomycin resistance gene, NPTII, from *Escherichia coli.*

Total public funding of farm scale trials will be approximately £3.3 million over four years

A steering committee has been appointed to oversee the work and is composed as follows:[5]

Professor Christopher Pollock (chair)	Research Director of the Institute of Environmental and Grassland Research
Professor Mick Crawley	Imperial College
Dr David Gibbons	Head of Conservation Science, RSPB
Dr Nick Sotherton	Director of Research, Game Conservancy Trust
Dr Nicholas Aebischer	Director of Biometrics, Game Conservancy Trust
Dr Jim Orson	Director of Morley Research Centre
Dr Alastair Burn	English Nature

Administrative support will be provided by officials from the DETR and meetings will be attended by representatives of the research consortium, the Government departments funding the ecological studies, SCIMAC, and Dr Brian Johnson of English Nature (to represent statutory nature conservation agencies). These

representatives will not be members but will provide information to, and be advised by, the committee on progress with the ecological studies and the farm scale evaluations.

The GM oilseed rape trial is being conducted under an experimental release consent (98/R19/18). Because the maize has been given approval for growing in Europe, no consent is required. The sugar beet experiments also come under an experimental consent (98/R22/12) but there is no Government involvement in the trials although they will follow the protocols laid down for the oilseed rape and maize experiments.

All the products from the 1999 trials are to be destroyed, with harvested material being buried in landfill sites or incinerated and remaining green material treated with herbicide and incorporated into the soil on site[6]. There are currently no guarantees that harvested material from trials in future years will not enter the food chain if they are given the necessary consents[7].

The basic experimental design consists of growing a GM crop and a non-GM equivalent and comparing the biodiversity in each

The Experimental Design

Outlines of the experimental design for the trials have been given in a DETR briefing note and in a letter to *Nature* from the steering committee[8].

The hypothesis to be tested is[1]:

> *"That there are no differences in the diversity and abundance of wildlife associated with the management of GMHT crops compared with the management of equivalent non-GM crops."*

The basic experimental design therefore consists of growing a GM crop and a non-GM equivalent and, at specified times, comparing the number and diversity of insects and plants and seeds remaining in the soil. The GM and non-GM crops will either be grown in two separate fields (paired-field design) or in a single field split into two (split-field design). The split-field design has the advantage of growing both crops on land with the same history, while the paired-field design has the advantage that mobile species cannot simply move from one half of the field to the other in response to the management practice. The design has not yet been finalised, however, and the choice of system will be informed by the data collected during the first year of experiments. The split field approach seems the most likely to be used.

Cumulative impacts of repeated sowings, which would occur in commercial practice, will not be considered

The trials are expected to last for four years with the first year being used to establish methodologies. A GM crop will only be grown once on any one field so the cumulative impacts of repeated sowings, which would occur in commercial practice, will not be considered. According to the DETR, 2 to 3 farms will be used for each crop in the first year and in subsequent years this will be in the order of 20 farms for each crop. However, the Government has given approval for AgrEvo's greater aspiration[9]:

> *"The current consent refers to up to approximately 25 sites per year for farm scale trials. In line with proposals for managed development of GM crops … this is likely to increase to up to approximately 50 sites per crop per year from 2000 onwards."*

Although the DETR briefing implies that the size of each trial site will be approximately 10 hectares, AgrEvo has written to the DETR about the oilseed rape trials to say that[10]:

"Farm scale trials
…In the first year trial areas will be nearer to 10ha but may increase up to 50ha in future years."

12,350 acres of oilseed rape could be grown in UK farm scale trials from 2000 onwards

The Government has given approval[11] for this increase in the size of oilseed rape fields and for sugar beet to be grown in fields of up to 15 hectares[12]. Since spring and winter oilseed rape are treated as two separate crops, up to 5,000 hectares (12,350 acres) of oilseed rape alone could be grown in UK farm scale trials from 2000 onwards. However, Friends of the Earth have challenged the legality of this increase in scale and the exact acreage to be grown in 2000 remains uncertain.

The sites on which the crops will be grown will be chosen by the scientists based on a selection offered by SCIMAC. The sites to be used have to be notified to the DETR at least 15 days before planting and an advertisement must be placed in a local newspaper not more than 10 days after this. Therefore, local residents may only hear that a farm scale trial is to take place 5 days before the crop is planted, or not at all in the case of maize where no public notification is required.

Management of the crop trials will follow the SCIMAC code of conduct and guidelines for growing herbicide tolerant crops[13] as well as the pesticide manufacturers' recommendations. (SCIMAC's recommended separation distances between GM and non-GM crops are shown in Table 1). However, specific management decisions (such as when to apply herbicides, etc.) will be taken by the farmers themselves and will not be under the researchers' control. The rationale for this is to make management practices realistic.

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Table 1: SCIMAC recommendations for the separation distances between GM and non-GM crops[13] compared to recorded pollen movement distances

Crop	Certified seed crops (same species)	Registered organic crops (same species)	Non-GM crops (same species)	Pollen movement distances when fertilisation of same species has been recorded *
Oilseed rape	200m	200m	50m	4,000 metres[14]
Sugar beet	600m	600m	6m	Up to 1-2km at a time leading to gene flow up to 30km[15,16]
Forage maize	200m	200m	Sweetcorn: 200m Forage maize: 50m	500-700 metres[17]

* These are conservative measures of possible pollen dispersal distances (via wind or insects) based on records of actual fertilisation by pollen that has moved such distances.

The Right Time for Large Scale Experiments?

Many individuals and organisations (including GeneWatch UK) have criticised the way in which GM crops have been evaluated in the past. One such criticism is that the scope of the assessments has been too narrow and that it is difficult to extrapolate from small scale trials to the wider environment. Critics have also argued that, in the past, experiments have concentrated too much on agronomic traits (such as yield) rather than looking at ecological effects and that any studies which did consider ecological impacts have only been conducted over one or two years - far too short a time to gather reliable data on environmental effects.

Does this mean that the larger farm scale experiments should be welcomed? The recognition that secondary effects on biodiversity and agricultural practice is certainly long overdue, but the decision to move from experiments in greenhouses and small plots to completely uncontrollable large scale trials is premature.

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Firstly, there should be proper consideration of what could be achieved on a smaller scale before farm scale trials are carried out. A careful examination of the gaps in currently available data and a systematic assessment of what we need to know have not been undertaken. In addition, other research which should inform the design of farm scale trials has not been completed. In particular, MAFF are funding a research project known as BRIGHT (Botanical and Rotational Implications of Genetically Modified Herbicide Tolerance) which began in April 1999 and is due to be completed in 2003. As well as measuring weed diversity, the intention is to *"provide farmers with practical guidance on the appropriate management of herbicide tolerant crops"*[18]. This is the kind of information that should be available *before* moving to farmer controlled experiments.

Secondly, and crucially, there is the issue of gene flow and genetic pollution. In the case of oilseed rape, gene flow - both to related wild species and non-GM crops - is considered inevitable[14]. Like oilseed rape, sugar beet also evolved in Europe and the existence of wild relatives means that genetic pollution is equally inevitable[15]. With maize, pollen flow over large distances is possible[17] and although no wild related species exist in the UK which can be cross pollinated, the growing of maize is gradually increasing in the UK and genetic contamination of non-GM maize is therefore more likely. Since some of this maize is grown organically and organic standards specifically exclude GM crops, a conflict of interests exists.

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The inevitability of cross-pollination has been endorsed in a report from the John Innes Centre[19], and the separation distances recommended by SCIMAC (see Table 1) will be ineffective in preventing it. The expansion of the farm scale trials in 2000 will exacerbate the potential for the contamination of non-GM crops still further through the increased number of trial sites and larger fields producing even more GM pollen. Honey is also likely to be affected as bees cannot be prevented from using the crops as a source of pollen.

The seriousness and irreversibility of any impacts raise questions about whether the rush to experiment with GM crops on a large scale is justifiable. Not only are

scientific data needed but a wider social debate about whether, and under what circumstances, it is acceptable to jeopardise sources of organic or conventional crops.

Can the Experiments Answer the Questions?

The main doubt about the farm scale trials is whether scaling up from small test sites (usually sub plots within a larger field) will provide all the answers about the long term cumulative damage to biodiversity that herbicide resistant crops may cause. At the end of the research programme there is every chance that there will be as many unanswered questions as there are now.

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Comparing a GM with a non-GM crop will not necessarily enable a reliable analysis of their different effects on biodiversity and it is debatable whether the resulting data could be extrapolated to assess the impacts on wildlife more generally. Specific problems include:

- how to detect possibly small but potentially significant differences reliably when management practices vary and are outside the control of the researchers;
- the lack of a realistic rotation being included. The GM crop will only be grown for one year on each field. When in commercial use it could be grown every second or third season, possibly in rotations with other herbicide resistant crops. This could lead to small incremental changes which will be undetected by these experiments;
- how to extrapolate data to assess impacts on wildlife as a whole if differences in plant and insect life are found. The relationships between numbers of insects and weeds, the species involved and other parts of the food web are not fully understood;
- the uncertainty which will inevitably remain after the trials are completed as even on this large scale the information produced will be limited.

Even though the first year of the farm scale trials was apparently intended to determine scientific protocols for following years, the sites and initial planting patterns were decided upon before the scientific steering group was appointed and this may influence the quality of data collected in 1999 and in subsequent years. Each field has its own characteristics which will affect the biodiversity. For instance, one 1999 oilseed rape trial site had a domestic garden in one corner and a copse in the middle, both of which could influence the biodiversity in the crop. A fodder maize trial site was bordered on one side by a woodland which may affect the abundance and type of invertebrate present in that part of the crop nearest to it.

The farm scale trials cannot be relied upon to predict what the future may hold in terms of GM farming

The farm scale or field scale trials may appear more representative than small scale trials, but they cannot be relied upon to predict what the future may hold in terms of GM farming.

Science or Marketing?

Inevitably, there is commercial pressure for the trials to be concluded as quickly as possible. Given the difficulties of gaining acceptance for GM crops in Europe,

it is important to the industry that investors are reassured that progress is being made - the numbers and sizes of the farm scale trials are therefore likely to be of key commercial importance. Roger Turner from SCIMAC told BBC2's *"Newsnight"* during an interview carried out at the Cereals '99 agricultural show (June 1999) that they would expect to go ahead with commercial planting in 2001 if no problems emerged in the trials in 2000. However, the farm scale trials are scheduled to last four years and serious ecological research cannot be carried out properly under such pressure.

The DETR's consent dossier on the AgrEvo oilseed rape farm scale trials indicates that AgrEvo - not the DETR nor the scientists undertaking the monitoring - are applying pressure to increase the size and number of the experimental sites, not for scientific reasons but: *"In line with proposals for managed development of GM crops"*[9].

The fact that the trials are being conducted under the industry's own voluntary guidelines is further evidence that scientific interests are secondary to commercial interests. Rather than waiting for the outcome of, or modifying, other more tightly controlled, smaller-scale research projects such as BRIGHT, bigger has been equated with better.

Conclusions

While the recognition of the potential for wider impacts on biodiversity is welcome, the move from small scale to farm scale crop trials has taken place too quickly. Increasing the scale of the experiments may have less to do with science than appeasing an industry which needs to demonstrate progress to satisfy its shareholders.

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The hope is that being seen to be taking biodiversity seriously will silence the critics. However, there are many questions which remain unaddressed, particularly concerning the issue of gene flow and whether the interests of non-GM and organic farmers should be put at risk by such large scale experimentation. Millions of pounds of taxpayers' money are being spent to investigate the safety of GM crops when this should be the responsibility of the companies involved. Despite the level of funding, the design of the experiments means that serious uncertainties will remain whatever the outcome of the trials. More fundamentally, the justification for farm scale trials and the risks they pose is itself questionable since there is no evidence that there is a market for GM herbicide tolerant crops.

Even if the experiments collect robust data, they will not prove one way or another whether the GM crops are good or bad for the environment. Experience shows that such new studies usually raise further questions and any findings will inevitably be uncertain - such is the nature of science. In particular, the conclusions which can be drawn from the trials will be seriously limited by the failure to assess the incremental effects of growing such crops repeatedly as would be the case in commercial rotations. Since all major arable crops are being engineered to be herbicide resistant, in a very few years from now the typical arable crop rotation could be using herbicide resistant crops in two or even three

years out of every four. Furthermore, although the farmers conducting the experiments are instructed to follow particular rules when growing the GM crops, these are bound to be broken in the practical farming situation but no effort is being made to investigate the consequences of such predictable variation in human behaviour.

At the very minimum, GM crop experiments should be conducted under the calm of a moratorium and not under the pressure of industry's drive to get products to market. It is only then that the best science could be conducted in parallel with a debate about the need and justification for GM crops and food.

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