Open Meeting

GM Gene Flow:

Scale and Consequences for Agriculture and the Environment

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The open meeting was organised by the Royal Society Of Edinburgh for the GM Science Review which is part of the National Dialogue on GM.

This report was prepared by Catherine Henderson on behalf of the Royal Society of Edinburgh and submitted to the GM Science Review Panel.

Executive Summary

Bringing together scientists from all over Scotland, and beyond, The Royal Society of Edinburgh hosted an open meeting to discuss the science behind a very specific area of public concern, namely, Gene Flow - the vertical (between generations) and horizontal (between species) movement of foreign genes from GM crops to other plants and organisms.

An informative and lively evening lay ahead, as some of the latest scientific findings were presented and the possible implications of these results discussed. Four speakers were chosen to cover the different areas of science behind the issue of plant Gene Flow. A ten-minute taster from each revealed that their backgrounds and expertise varied as widely as their views.

The mechanisms, frequencies, impacts and prevention of Gene Flow were all on the agenda. As were individual concerns and beliefs about what the future of GM technology may hold. Although the speakers were limited in the time they had to speak, their talks provoked plenty of thought and critical discussion. The speakers had also prepared review papers covering the area of their talks, which had been made available on the web before the event.

The discussion between the four speakers and three members of the Government's Science Review Panel provided some much-appreciated moments of clarity. Areas of uncertainty were identified and the precision with which some of the scientific data had been established was questioned. From the discussion it was possible to see why public confusion may arise, and identify areas where future research is needed. The speaker/Panel discussion also revealed that the scientific basis for public concern differed dramatically from that of the majority of speakers, who suggested that the public has got caught up in debating the risks and benefits of the processes rather than the products of biotechnology.

The atmosphere had been building all evening and the audience was eager to have its say. The ecological significance of predicted Gene Flow was the hot topic everyone had come to talk about, and the discussion that ensued was everything we had anticipated. A new generation of GM plants, which have the potential to survive in increasingly extreme conditions, was identified as the main cause for concern. For example, giving plants the ability to survive in salty water (salinity tolerance) represents a new level of risk; inadvertently changing stress tolerance levels in already serious agricultural weeds would have huge environmental implications. As the audience continued to challenge speakers and make their own suggestions, the chair was delighted at the success of the open discussion. The Panel had the chance to benefit from issues that could be answered by the scientists in the audience actually working in those areas.

While this meeting was limited in time, it was successful in initiating many areas of discussion that will hopefully continue to feed the debate. It gave scientists the opportunity to engage in open discussion in an environment not influenced by funding, industry, government or non-governmental organisations. It gave a very honest view of the science, the scientific method, and the scientists behind GM technology.

GM gene flow: scale and consequences for agriculture and the environment.

What are your thoughts on the possibility of Genetically Modified (GM) crops being grown in the UK to produce food? On what basis have you formed these views?

Due to the emergence of strongly expressed views both for and against the use of GM crops, the UK government has organised a Public Consultation to air as many of the relevant facts and issues as possible. Part of this public debate is to review the science behind GM crop production and use. The Government's Science Review is being co-ordinated by a UK Science Review Panel. They will be summarising what scientific facts have been established about GM Gene Flow, the precision to which they have been established, where there is uncertainty, and in what areas further research is required so as to inform the government and the public.

Bringing together scientists from all over Scotland, and beyond, The Royal Society of Edinburgh hosted a public meeting to discuss the science behind a very specific area of public concern. Namely, Gene Flow - the vertical (between generations) and horizontal (between species) movement of foreign genes from GM crops to other plants and organisms. Understanding Gene Flow is important if we are to assess the impact of GM crops on human health and the environment. As yet, these effects are not well known and are largely disputed. The Gene Flow review meeting provided an ideal opportunity to discuss some of the latest scientific findings on the flow of genes from genetically modified crops to other parts of the environment and the implications that these results have on risk assessment.

From the line-up of speakers, it soon became apparent that an entertaining, as well as informative, evening lay ahead.

Speakers

A huge gathering of enthusiastic plant scientists and agricultural experts had come to take part in the open discussion. It appeared that most of the audience was anticipating great conflict and debate from the speakers, whose reputations and review papers went before them. The audience was not disappointed. A ten-minute taster from each of the speakers revealed that their background and expertise varied as widely as their views.

Dr. Geoff Squire

Based at the Scottish Crop Research Institute, Dr Squire co-ordinates the Institute's 'environment' research theme, consisting of around 70 scientists working on the biophysical and biological interactions among soils, plants, microbes and invertebrates. His particular research interests include the effects of Gene Flow on plant dynamics and crop purity.

Main points:
Crops and wild plants have always lived side-by-side and exchanged genes. Oilseed Rape can exist both as a crop and a weed, and has formed the main source of concern in the topic

of Gene Flow because it is an outcrossing species whose crop and weed forms exchange genes freely.

- Gene Flow in oilseed rape occurs at low frequency over several kilometres, mediated by a range of insect vectors and wind-borne pollen.
- Current estimates of cross-pollination between nearby fields are less than 0.1%, i.e. 1 seed in 1000 set on the plants in a field would be from a pollen source outside the field.
- This frequency depends on the arrangement of nearby fields. For example, if large fields of GM crops surround a small field of wild crops, the frequency of cross-pollination from the GM crops into the wild crop population will increase.
- Impurities in crops result a lot more from weeds being left behind from previous crops than by pollen movement.

Two important issues:

1. Impact on habitat – All indicators show that the ecological effects of oilseed rape coming into the arable system are very small. Field management is more important than the plant itself, with regard impact on the ecosystem. Herbicide tolerant weed populations should have no selective advantage except where the specific herbicide is used.
2. Purity – Although low-level impurity will be difficult to manage, it will be possible to limit impurities to 1%. Impurities cannot be prevented in the harvested yield of outcrossing crops, or crops that give rise to weed populations, but could be reduced by rigorous field management and regional segregation of crops.

Dr Mike Wilkinson

A Reader in Plant Genetics at the University of Reading, Dr Wilkinson is frequently asked to speak on the subject of risk assessment, crop genetics and conservation genetics.

Main points:

- The likelihood of transgene (artificially modified gene) movement from GM crops into wild relatives varies with geography. The majority of crops in the UK have no wild relatives with which they can form hybrids and so effectively cannot act as a source of Gene Flow into wild plants. Oilseed rape on the other hand, is capable of forming hybrids with its wild relatives.
- The number of hybrid plants generated in any single year and in any one geographic area has variable importance in influencing transgene spread and ultimately of causing ecological change. It is, therefore, vital to calculate the frequency of Gene Flow (initial hybrid formation) to monitor and model the spread of transgenes. We are currently in the process of estimating total number of hybrids per year in the UK.
- Increasing isolation distances between the GM crops and wild relatives decreases hybridisation frequency.

Dr Ricarda Steinbrecher

Director of Econexus, a non-profit organisation, Dr Steinbrecher collaborates with researchers in the UK, USA and Norway on issues of genetic engineering, toxicity, and gene-ecology. Since 1995, Dr Steinbrecher's interests have focused on genetic engineering

in food and farming, its risks and potential consequences on health, food and the environment.

Main points:
Horizontal transfer of genes from GM crops to other unrelated organisms does occur. To what extent, however, does horizontal gene transfer impact on the flow of transgenes from GM crops into the environment?

- The nature of transgenes may increase the likelihood of horizontal gene transfer occurring, because they have increased homology with, and often have, bacterial origins.
- The consequences of gene flow are not known because the experiments have not been done, and too many assumptions have been made.

Professor Tony Trewavas

A researcher in the molecular signalling of plants, Professor Trewavas has been at the University of Edinburgh for 32 years. He is also a Fellow of the Royal Society, Royal Society of Edinburgh, and of the World Innovation Foundation.

Main points:

- The science is quite clear concerning the crops on trial in the UK. The debate is really about values, feelings and beliefs.
- GM crops pose no greater risk than those derived from conventional breeding.
- There should be no blanket approval of GM crops; rather we should continue to carry out case-by-case risk assessments.
- Preventative gene flow measures are possible using either chloroplast transformation or 'terminator' technology.
- Benefits of GM technology counteract the detrimental effects that conventional and organic methods have on the environment. GM technology is extremely valuable and environmentally friendly.

Speaker/Panel discussion

After thought-provoking talks from the speakers that were packed with scientific information and, in places, strong personal belief, it was time to hold a discussion with members of the Panel. All in all, this part of the discussion provided some much-appreciated moments of clarity.

- Clarifying the science

An important aim of the meeting was to identify areas of uncertainty. An immediate source of confusion arose from Dr Wilkinson and Professor Trewavas' talks about the occurrence and survival of hybrids. It soon became clear that the scientific terms being used were part of the problem. Reluctantly swapping the likes of 'Introgression hybrids' for a bit of media jargon, Professor Trewavas successfully made his point: "Hybrid weeds do survive, but they are not 'Super weeds', in that they do not acquire any special properties that make

them more of an environmental concern". Ultimately, both speakers agreed that although hybrid weeds do survive, they don't necessarily persist.

- Precision of scientific facts

During the talks, the speakers presented a vast amount of scientific data about the science of GM Gene Flow, but with what precision have these facts been established? One serious area of concern of Dr Steinbrecher is that a lot more research needs to be done. This research should not only establish the consequences of GM Gene Flow, but also ensure that the correct conclusions are being drawn about the behaviour of transgenes.

The Panel raised a question that highlighted this point quite well: "Have experiments been done to see if dietary GM or non-GM chloroplast DNA can be transferred to animal or human gut flora?" For many scientists chloroplast transformation appears to be an obvious method to prevent Gene Flow in pollen, which has no chloroplasts, but just how safe is it? While Professor Trewavas was happy to go by the fact that there are no chloroplast genes present in bacterial genomes that have been sequenced, it still remains that no experiments have been performed to see if transgenes inserted into the chloroplast will transfer to gut bacteria.

- Establishing the scientific basis for public concern

The question that dominated the meeting, and one that seemed to baffle many of the scientists present was: "What is it about GM crops in particular that raises concerns with the public?" At this point in the evening the answers to this question were fairly limited. Perhaps public concern coincides with the areas of research that they feel are lacking in precision, or is it because GM crops have been altered artificially? In which case, a majority of the Panel and speakers agreed that the public has got caught up in debating the risks and benefits of the processes rather than the products of biotechnology. After all, a herbicide tolerant plant is a potential problem, whether produced by conventional methods or by GM.

Throughout the meeting, often in response to the question above, various scientists stressed the importance of putting the issue of GM Gene Flow into a wider agricultural context. Current crop trials in the UK are based on the introduction of genes into plants that are already present in the environment. In addition, there has always been Gene Flow between crops; vast amounts of DNA existing freely in the environment; and a potential threat to the ecosystem is by conventional farming methods.

- Issues of concern for the speakers

It was interesting to see how public concern compared to that of scientists. Before opening the discussion up to the audience, the speakers were given the chance to express any individual worries they had about the future of GM.

Professor Trewavas showed particular concern about the idea of introducing traits into plants that cannot be done by conventional breeding. He gave the example of using plants

to produce pharmaceuticals, this he believes has the potential to change things radically if the transgenes were not contained and escaped into the environment.

Dr Squire felt that future research needed to put the issue of GM Gene Flow into wider context by comparing how important it is to a range of other potential threats. For example, comparing the flow of transgenes to existing effects that herbicides/pesticides have on soil, plants, and animals and the impact this has on the correct working of the 'system'.

During this part of the discussion it became increasingly obvious that both members of the panel and the speakers feel that a lot more needs to be known about conventional breeding and factors that influence the arable ecosystem as it stands now, before accurate risk assessments can be made. While it appeared that there is an increasing amount of knowledge on the science of GM crops and, tonight's area of concern, Gene Flow, it is difficult to evaluate the potential risk without comparison to the risks from other breeding methods.

Audience Discussion

The atmosphere had been building all evening and the enthusiasm of the speakers was spreading faster than you could say 'Gene Flow'. The audience was definitely eager to have its say.

A member of the audience got the discussion off to a roaring start by asking the question that everyone wanted to talk about: "Is the Gene Flow, that can be predicted, ecologically significant?"

The heated response that ensued started with the Panel and speakers, before quickly spreading back to the audience. Dr Johnson suggested that whilst most of the scientific data presented in the talks accounted for mechanisms and frequencies of Gene Flow, we currently do not know what effect the flow of transgenes and other crop genes is having on the fitness of wild plants via hybridisation. This was met with huge disagreement from Dr Wilkinson who, while acknowledging that experiments on fitness were limited, insisted that they were ongoing.

Another member of the audience picked up on the earlier discussion about the public's fixation with GM Gene Flow when other aspects of conventional plant breeding are already having massive impacts on ecology. The huge changes that have been made to Oilseed rape in the last 20 years by conventional breeding, for example, pose far greater impacts on the environment than GM crops. So why is no one concerned?

As suggestions started being put forward, the audience member who raised this issue became increasingly agitated that it was not being addressed: both the audience and speakers were explaining changes in the crop and not the effect it would have in wild relatives in the wild community. Eventually the heart of the issue was identified. Dr Wilkinson proposed that concern was arising with a new generation of transgene constructs in GM technology, which effect factors such as stress level tolerance in plants. Dr Johnson, using the example of GM salinity tolerance in rice that was being developed in the Middle

East, quickly backed this up. A problem could arise if transgene constructs coding for ‘big time’ salinity tolerance were inadvertently introduced to weedy rice. Rice with high levels of salinity tolerance could then grow in very brackish water. If this type of transgene construct were to get into weedy rice, which is already a serious agricultural weed in many parts of the US and South East Asia, then you would have a problem.

With this aspect of public concern successfully identified, the audience began to contribute other examples and their underlying scientific basis. The chair seemed delighted to have tapped in to fresh sources of knowledge, highlighting the benefits of open discussion.

The atmosphere started to settle as we finally felt we were getting somewhere. While the audience continued to challenge the speakers and make their own suggestions, Professor Dale took the opportunity to highlight one of the positive benefits of GM technology. Due to the nature of transgene constructs, and in particular our knowledge of their genetic sequences, we have been able to analyse changes in crops and GM technology with some precision. As a result, scientists have developed a better understanding of the dynamics of agricultural systems and have been forced to answer many questions.

As a society we are now left with the most difficult question of all: what level of Gene Flow from GM crops is acceptable?