

Genetic pollution – a multiplying nightmare

Genetically engineered (GE) plants contain genes which have been transferred from unrelated species. These may come from bacteria, viruses, other plants or even animals. If these 'foreign' genes are then transferred into other organisms, this causes genetic contamination or pollution of the natural gene pool. Genetic contamination may arise in four situations if:

- wild, related flora growing nearby are pollinated by a GE crop;
- non-GE or organic crops in neighbouring fields are pollinated by the GE crop;
- a semi-wild, weed or 'feral' population of GE plants develops if the GE crop survives in the agricultural or natural environment;
- micro-organisms in the soil or the intestines of animals eating the GE crop acquire the foreign genes.

Unlike other forms of pollution, genetic contamination has the potential to be a problem that multiplies as plants and micro-organisms grow and reproduce. Therefore, environmental damage caused by genetically modified organisms (GMOs) cannot be confined to the original habitat in which they are first introduced. This briefing considers what is known about these risks and the evidence that is emerging from experimental and commercial growing of GE crops. It focuses on oilseed rape (canola) but the same principles and concerns apply to all GE crops.

Contaminating nature

Today's conventional crops have been bred from wild species by generations of farmers and plant breeders. In the regions where they

evolved, closely related wild species exist which can cross with the crops and produce hybrid plants. In the case of GE crops, this could involve the transfer of the foreign genes ('gene flow') into the wild plant hybrids. The likelihood of hybridisation occurring depends on the compatibility of the two species involved and the performance of the hybrid (how well it grows and reproduces).

The risk to native biodiversity from gene flow from GE plants is global. For example, in South America, where maize originated, wild varieties of maize will be at risk. In Asia, wild relatives of rice are found close to paddy fields. In North America, wild relatives of squash are common, and in Europe, oilseed rape and sugar beet have wild related plants with which they can cross. If this occurs, not only will the gene pool be irreversibly altered with unknown future consequences, but acquiring the characteristics of the GE plant could turn the wild plants into 'super-weeds' that would be difficult for farmers to eradicate. Tolerance to a chemical weedkiller (herbicide tolerance) and insect and disease resistance - the three main types of genetically engineering crops being developed - could all give wild plants an advantage over normal plants and make them more persistent weeds.

The likelihood of genetic pollution is particularly strong in the case of oilseed rape,



which is well known for its ability to cross-pollinate with wild relatives, which are widespread throughout Europe. Studies have demonstrated, for instance, that spontaneous hybridisations can occur between oilseed rape and wild radish, wild turnip, wild cabbage and hoary mustard^{1,2}. Another brassica grown commercially on a large scale in India, Indian mustard, has been shown to cross with wild turnip, Ethiopian rape and oilseed rape³. Whilst the number of hybrids that are formed may be very small, gene flow to wild relatives will be inevitable if GE crops are grown on a commercial scale.

GE crop supporters argue that any hybrids will be weak and that herbicide tolerance will not give wild plants an advantage so they are unlikely to survive or spread. However, research has shown that herbicide tolerance genes do not have a negative impact on survival and that hybrids can be fitter than expected and can regain fitness over following generations^{4,5}.

Environmental conditions and the size and weight of pollen greatly affect its movement on wind or via insects but it can sometimes travel many kilometres (see 'Contaminating food' below). Growing borders of non-GE crops around a GE field in an attempt to protect native flora by 'absorbing' or 'using up' pollen has been shown to be ineffective when GE crops are grown on a commercial scale because the border would have to be much larger than the field itself⁶.

Contaminating food

GE crops can cross even more easily with non-GE crops of the same species growing nearby, leading to genetic contamination of the food and animal feed produced from them. The extent will vary according to the crop involved – some (e.g. wheat) are largely self-fertilising and pollen may only travel a few metres. Others (e.g. oilseed rape) outcross as well as self-pollinate and their pollen may be transported for many kilometres on the wind or by insects.

In 2000, non-GE oilseed rape seed imported by Advanta into Europe from Canada was found to have been contaminated by GE rape grown over 4 kilometres away⁷. Because the seed Advanta was importing was a hybrid, it was produced by planting male sterile plants

interspersed with a few (usually about 20%) male fertile plants to pollinate them. Under these growing conditions, there is less pollen than normal in the field and so pollen transported into the field has a greater chance of pollinating the crop. Since more and more emphasis is being placed on the use of hybrids, such contaminations are likely to increase. Even with traditional non-hybrid varieties, pollen from GE oilseed rape has pollinated other oilseed rape 2 kilometres away⁸ and small scale experimental trials have been shown to be poor predictors of what will happen when oilseed rape is grown on a large scale⁹. Evidence of contamination of indigenous varieties of maize by GE maize has already been reported in Mexico, where maize originated¹⁰.

Contamination of honey with GE pollen is inevitable if the bees which produce it have been feeding on GE crops. Bees may travel long distances in their search for food and bees entering a hive some 4.5 kilometres from the nearest GE oilseed rape test site in the UK were found to be carrying GE pollen¹¹.

Contamination of conventionally grown non-GE and organic produce threatens the supply of non-GE food that consumers around the world have been shown to prefer. A 2001 survey revealed that 70% of European citizens do not want GE food¹². Genetic contamination also threatens the livelihoods of non-GE and organic farmers, who may find their produce unsaleable through no fault of their own. There are no liability laws which protect farmers from such economic losses.

Going wild

As well as the potential for GE crops to contaminate wild plants and non-GE crops through cross pollination, its own seed may also cause problems.

Some seed will be shed at harvest time, remain in the ground and germinate in future years. When the plants emerge in subsequent crops of a different species they are then unwanted weeds ('volunteers') which have to be removed by the farmer. GE oilseed rape volunteers which have acquired resistance to two or three different herbicides (known as 'gene stacking') have been identified in trials in the UK¹³ and following commercial growing in Canada¹⁴. The

problem is now widespread in Canada with separation distances between GE and non-GE crops of 175 metres proving ineffective¹⁵. Because oilseed rape seed may lie dormant in the soil for up to 5-10 years before germinating, any problems may be very long lasting and present increasingly difficult management problems for farmers.

Even non-GE farmers will be affected if their own crops are pollinated by nearby GE crops. This will not only contaminate the produce but also lead to the emergence of problematic volunteer weeds.

Seed may also be spilt during transport of the GE crop from the field to other parts of the farm or along road verges as it is moved for storage and processing. Feral populations of oilseed rape are common and can survive for many generations.

If GE crops persist in the environment in these situations, they will not only cause problems as weeds but will be a continuing source of genetic contamination for other crops and wild plants.

Moving into micro-organisms

Micro-organisms have a striking ability to transfer genes between themselves. This movement of genetic material between organisms is known as 'horizontal transfer' to differentiate it from the 'vertical transfer' between one generation and the next due to sexual reproduction. The question now being asked is whether the foreign genes in GE plants could move into micro-organisms in the soil or in the intestines of animals eating feed produced from the GE crop.

There is some laboratory evidence that genes can be transferred from GE plant material to bacteria and that DNA can persist for many months in soil¹⁶. The frequency of transfer of genes from plants to bacteria is likely to be very low - much lower than via pollen to other plants - although a lack of research data means that it cannot be ruled out.

The consequences of transfer of antibiotic resistance genes in particular could be serious. Many GE crops contain genes giving resistance to antibiotics (including neomycin,

kanamycin, ampicillin, streptomycin and spectinomycin) as 'marker genes' to indicate whether the genetic modification process has been successful. If these genes were transferred to disease-causing organisms, they may weaken or nullify the effectiveness of antibiotic treatment. This could happen if the genes were taken up by micro-organisms in the soil or in the intestines of an animal eating the GE plant and were then passed to harmful bacteria. Although transfer of genes from plant material to bacteria is rare, gene exchange between micro-organisms is common.

The antibiotics neomycin and kanamycin are not widely used but ampicillin, streptomycin and spectinomycin are. Streptomycin is also an important drug in the control of TB in India. The antibiotic marker genes serve no function in the plant and could have been removed during a later stage of the genetic modification procedure, but this would have delayed their commercialisation. Some medical organisations, such as the British Medical Association, have called for a ban on the use of antibiotic resistance marker genes¹⁷.

Prevention is the only solution

It is becoming clear that genetic pollution is not a problem that can be contained and the more GE crops that are grown, the greater the risk will be. In Canada, for instance, GE volunteer weeds resistant to a range of herbicides have emerged after only 5 years of commercial growing. This has led to the prospect of having to use even more damaging chemicals to destroy them.

Another example is the contamination of human food by a variety of GE maize known as StarLink, which is produced by Aventis. In 2000, this was found in taco shells in the USA even though it was not approved for human food use and should only have been used for animal feed because there are concerns that it could be a human allergen^{18,19}. The contamination appeared to have been caused by a combination of two factors. Firstly, post-harvest segregation between StarLink and conventional maize varieties was not maintained and, secondly, cross contamination of non-GE maize varieties occurred because farmers were not aware of,

or did not observe, separation distances to prevent cross pollination.

Even though GE crop seeds have only been sold to farmers for six years, evidence of genetic contamination is mounting. Insects and the wind will ensure that pollen is spread over many kilometres; farmers will not always follow the guidelines for reducing the risk of contamination; and plants and micro-organisms are living and can reproduce and multiply. For these reasons, and the irreversible damage to the environment and biodiversity that may arise, Greenpeace is opposed to the release of all GE organisms to the environment.

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