Environmental and health concerns of genetically engineered (GE) crops in animal feed

Introduction

There are many social and environmental issues surrounding animal feed. For example, the huge expansion of (genetically engineered) soy monoculture in Argentina has resulted in a sharp decline of traditional food crops such as maize and wheat and also in many small farmers being driven from the land[1]. This briefing concentrates on the environmental and health concerns of growing genetically engineered (GE; also called genetically modified) crops and their use in animal feed. These are environmental effects, health risks for humans and animals and the risk of unexpected and unpredictable effects from the genetic engineering process itself.

1) Environmental impact of GE crops

The environmental impact of GE crops is the major concern regarding the use of GE crops as animal feed. Every crop used for animal feed must be grown somewhere.

GE soya, GE maize and other GE crops are all used in animal feed. These GE crops can make up a substantial proportion of animal feed. The environmental impacts from growing GE crops for animal feed are considerable. This is particularly true on a global scale, as many ingredients for animal feed are subject to global trade (e.g. soya). So, for example, eating a chicken fed GE soya in Europe would increase the amount of GE soya grown, say, in Brazil, with all the associated negative environmental and social impacts.

Outcrossing

Of particular concern for all GE crops is the outcrossing (cross-pollination) of GE crops to wild relatives or traditional varieties of crops. For example, outcrossing of GE oil seed rape (canola) in Canada, has led to oil seed rape populations becoming resistant to more than one herbicide[2] and in the UK, GE oilseed rape is now thought to have outcrossed to a wild relative[3]. GE contaminated wild or feral populations and traditional crop varieties can persist and become reservoirs of GE transgenes for further contamination. There is concern that such outcrossing could swamp populations of wild relatives[4]. In addition to possible adverse effects on biodiversity, such GE contamination is a threat to food security because traditional crop varieties and wild relatives are where new genes (e.g. for drought resistance) for improving crops through conventional breeding techniques are likely to be found.

Effects on biodiversity

In addition to the above general concerns of GE crops, the following specific environmental effects are now well documented for GE insect and herbicide resistant crops. These include:

a) for GE *Bt* insect resistant crops[5]

- **toxic effects on non-target organisms such as butterflies**. For example, long-term exposure to *Bt* pollen from insect resistant GE maize has been found to cause adverse effects on larvae of the monarch butterfly in North America[6].
- **toxic effects on beneficial insects.** For example, GE Bt crops adversely affect green lacewings[7]. Lacewings are beneficial insects that play an important role in the natural control of crop pests.

The toxic effects of GE *Bt* crops on lacewings are via the prey that they ate, which in turn had been ingesting the GE *Bt* crop.

- **emergence of pest resistance, leading to increased spraying of insecticides.** For example, in the US there are complex requirements for planted areas of non-*Bt* crops, in order to slow down insect resistance to the *Bt* toxin. However, refugia may not be practical on small farm holdings in Europe and elsewhere, which are very different to the large field sizes in the US. This problem has been identified with *Bt* cotton in India[8].
- **adverse effects on soil ecosystems.** For example, *Bt* crops secrete the toxin from the root into the soil[9] and *Bt* crop residues left in the field contain the active *Bt* toxin[10]. The *Bt* toxin persists in soils, particularly if there is a cold winter period[11]. This raises the possibility of the accumulation of *Bt* toxins in the soil[12], possibly causing problems for non-target organisms in the soil and the health of the soil ecosystem.

b) for herbicide tolerant crops[13]:

- **toxic effects of herbicides on ecosystems.** For example, Roundup (used in conjunction with Monsanto's Roundup Ready GE crops) has been shown to be toxic to tadpoles, affecting aquatic communities, reducing biodiversity[14] and at least one formulation of Roundup has been shown to be a potential endocrine disrupter, i.e. could interfere with hormones[15].
- **loss of weeds and weed diversity and associated biodiversity.** For example, it has been shown there are fewer butterflies in the margins of GE herbicide tolerant oil seed rape, because there were less weed flowers (and hence nectar) for them to feed on.
- **increase of weed resistance/tolerance to herbicide.** Evolution of weed resistance to Roundup is now a serious concern in the US and other places where Roundup Ready crops are grown on a large scale[16]. This weed resistance means that increasing amounts of herbicide have to be used to control these weeds[17], or that additional herbicides have to be used in addition[18].
- **effects on soil microorganisms.** For example, the use of herbicides on GE soya leads to reduced amounts of beneficial nitrogen-fixing bacteria in the root zone[19]. It has also been reported that glyphosate usage in one year may encourage the growth of the fungus, fusarium, on wheat grown the next year[20].

Toxic proteins in animal excreta

Pigs[21] and cattle[22] fed GE crops excrete some GE DNA and large fragments of the *Bt* protein. The excretion of large fragments of *Bt* protein from animals fed GE crops is of environmental concern as, despite being fragmented, the *Bt* toxins retain their toxicity[23]. The *Bt* protein could build up in the soil, potentially reaching toxic levels to certain insects.

"Accidental or mechanical spread of feeds into the soil may artificially introduce GM into environment. Fecal excretion of fragments of the cry1Ab gene and Cry1Ab protein into the soil may be additional concern."[24]

2) Uncertainty over the safety of GE crops as animal feed and human food

There is growing uncertainty over the safety of feeding GE crops to animals. There is increasing evidence that there is no proper testing of GE crops in terms of their food safety to both humans and animals.

Where are the independent studies?

Independent studies on the wholesomeness of GE crops for either animals or humans are severely lacking from the scientific literature. One recent review of such studies found only 10 GE food and feed studies in the peer-reviewed scientific literature, half of which were performed in collaboration with biotechnology companies[25]. Indeed, this situation continues, with the majority of recent studies being short-term studies in collaboration with biotechnology companies[26].

The dossiers submitted to the regulatory authorities by the biotechnology companies when seeking approval for their GE crops generally contain compositional data and short-term animal feeding trials. In many of these studies, important differences are often seen in the composition of GE and non-GE plants (e.g. vitamin content) and in the responses of animals (e.g. glucose levels), but these are often termed "not of biological relevance" by the biotechnology companies and the regulatory authorities[27]. Therefore, the regulation of GE crops, both for food and animal feed, is a failure in many countries. We do not know if GE crops are safe for animal or human consumption. This is reflected by the continuous scientific and political controversy over the safety assessment of GE food and GE feed. In the EU, there is much disagreement between the member states and the European Commission on the authorisation of GE products. For example, in August 2005, a GE herbicide tolerant maize, MON863, was approved by the Commission for use in animal feed in spite of the fact that the environmental ministers from 14 EU countries voted against it's approval[28].

Antibiotic resistance

Several GE crops fed to animals today (e.g. Syngenta's insect-resistant GE maize, Bt176) contain antibiotic resistance genes. They could severely undermine the effective treatment of diseases if the antibiotic resistance is transferred to bacteria that can be harmful to human and animal health, rendering the use of that antibiotic useless. Precaution clearly demands that any use of antibiotic resistance genes in GE crops be prohibited. The phasing out of antibiotic resistance genes is required by the EU and FAO/WHO[29].

In the last few years, several studies have shown that DNA from food and feed (including GE food and feed) is not broken down in animals or humans as easily or completely as previously thought. GE DNA has been found in the gut and faeces of animals[30]. The survival of GE DNA in the gut of animals raises the possibility of horizontal gene transfer of GE DNA to gut bacteria. If GE foodstuffs contain antibiotic marker resistance genes, this could ultimately affect the use of certain antibiotics to treat infections. The excretion of GE DNA raises concerns over the transfer of antibiotic resistance to bacteria.

Plant DNA in animals

Plant DNA from feed has been detected in muscle of chickens[31], and organs of calves[32]. Although GE DNA has not yet been detected in animal tissues, it cannot be excluded, especially for animals fed GE crops long-term. If GE DNA did enter the tissues of animals fed GE feed, it raises the possibility that GE DNA could be unwittingly ingested by consumers of meat from animals fed GE crops.

Although there is no published study that has found GE DNA in cow's milk, plant DNA has been shown to be present[33]. Therefore, the possibility of GE DNA in milk cannot be excluded, especially for animals fed GE crops long-term.

Allergies

Farm workers have been identified as a group "at risk" from allergies relating to the handling of GE crops, which would occur even if the GE crops were only intended for animal feed[34]. The harvesting of GE crops and certain food processing techniques generate dusts that could cause individuals to develop allergies to the novel protein(s) in GE crops through both inhalation and skin contact.

3) Unexpected and unpredictable effects with GE crops

Current GE crops involve the random, often forcible, insertion of genes from a different organism into the plant's own DNA. This can give rise to unexpected and unpredictable effects. For example, the insertion may interrupt one of the plant's own genes or cause alterations to an existing plant protein.

During the genetic engineering process, the insertion of genes can cause deletions and rearrangements of the plant's own DNA[35]. This can also give rise to unexpected and unpredictable effects. For example, Roundup Ready soya contains fragments and rearrangements and it has been shown that these are active (i.e. produce RNA). These discoveries were only made several years after commercial growing of Roundup Ready soya[36]. Similar irregularities caused by the GE process have also been found in several types of GE insect resistant maize (Bt11, Bt176, MON810)[37]. These irregularities raise the possibility of unexpected, untested novel proteins being produced in the GE crops.

There have been several examples of unexpected effects of commercial GE plants, e.g. GE Roundup Ready soya gave rise to unexpected crop losses in hot, dry weather due to stem splitting caused, most probably, by increased lignin[38] and cotton bolls have inexplicably dropped from Roundup Ready cotton plants[39]. Lower levels of phytoestrogens were found in GE Roundup Ready soybeans compared to conventional soybeans[40]. Phytoestrogens are hormone-like substances in plants that are believed to have a positive health effect. This difference was only discovered after Round up Ready soya had been grown commercially for several years.

Any such unexpected changes caused by the GE process are unlikely to be picked up in the regulatory process as any changes in plant protein production induced by the unidentified DNA may be significant but not immediately obvious. Changes might only appear after several generations, or in a time of plant stress[41]. Such unexpected and unpredictable effects could impact on environmental, animal and human health.

Conclusions

GE crops have many well-found negative environmental effects. These effects are especially well documented for herbicide tolerant and insect resistant crops. The consequences of using GE crops for animal feed are that GE crops will be grown and entail these environmental effects. In addition, there is a continuous scientific controversy over the safety of GE crops for animals and humans. Unexpected and unpredictable effects of GE crops on animal and human health cannot, therefore, be excluded.

Greenpeace believes that the many (potential) negative effects of GE crops on the environment justifies a ban on the growing of GE crops. In addition, because there are serious doubts over the safety of GE crops for humans and animals, the precautionary principle should be invoked and GE crops should not be used as food or feed.

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