HEALTH & OTHER IMPACTS OF G.E. CROPS/FOODS

The science behind Genetic Engineering is reductionist and unreliable - gene regulation within a genome is not fully understood by modern science and for that reason, not replicable. GE however presumes that it is replicable and uses a variety of other materials like promoters, markers etc., to get a trait expressed. However, the unintended consequences are many. For instance, it has been found that with genetic engineering, there is coding for proteins of unknown functions that was discovered! The impacts of this are unknown.

There are three or four distinct possibilities emerging from the science and technology of GE and most of these are categorized under the framework of "biosafety" (the safety or impact implications from a GMO on human beings, on other living organisms, on the environment etc.). There could be another set of possibilities on the agronomic front, on the actual performance of a GE crop vis-à-vis a conventional counterpart in terms of yields, pest incidence, crop economics and so on. Impacts could also be classified as socio-political resulting in farmers' *a priori* rights related to seeds and biodiversity being violated.

A. Alterations to the toxicity or nutritional value of a cultivar

This means that a food that has been considered safe so far might have an altered constitution and impact due to changes induced, related to allergens, toxins, vitamins, anti-oxidants etc. Some GE foods are found to be missing on some vitamins that the non-GE counterparts had. Food safety and quality is therefore changed. However, testing does not capture these changes before the release of the GMO for commercial use since one does not even know all the right questions to ask, leave alone have testing designs and methodologies worked out for assessing such impacts!

It has to be remembered here that it is the interaction of human beings with nature, with careful breeding and selection that has resulted in a vast variety of cultivated and uncultivated foods that are available to us today with a variety of nutritional compositions. More importantly, this food has been made safe by careful work over centuries. GE however has the potential to make food that is safe to become unsafe.

The following are results from some studies taken up to assess the safety/toxicity of GM foods – it is worth noting that very little research of independent nature is available on a variety of potential impacts of GE crops, for transparent scientific review and funding is hard to come by for such research to take place. There are also several instances of scientists being fired from service, funding suspended and generally persecuted for any anti-GM studies that they bring out.

1. In 1996, a major GE food disaster was narrowly averted when researchers in Nebraska in the USA learned that a Brazil nut gene spliced into soybeans could induce potentially fatal allergies in people sensitive to Brazil nuts. People with food allergies, whose symptoms can range from mild unpleasantness to sudden death, may likely be harmed by exposure to foreign proteins spliced into common food products[1].

2. In 1998, Hungary-born nutrition and toxicology scientist Dr Arpad Puzstai in the Rowett Research Institute in Scotland, UK, reported preliminary results from a 3-year, multi-centric study of rat-feeding tests with GM Potatoes[2]. He and his team found unexpected and worrying changes in the size and weight of the body organs of rats fed with GM potatoes. Liver and heart sizes were getting smaller, and so was the brain. There were also indications that the rats' immune systems

[1] Nordlee J A, Taylor S L, Townsend B S , Thomas L A & Bush R K, 1996: "Identification of a Brazilnut allergen in transgenic soybeans", The New England Journal of Medicine, Volume 334: 688-692

[2] S. W. Ewen, A. Pusztai, 1999: "Effect of diets containing genetically modified potatoes expressing Galanthus nivalis lectin on rat small intestine" Lancet 354(9187):1353

were weakening. For reporting this on a TV show, he was sacked from his job and discredited by the scientific community. It is suspected that the damage to the gut lining of the rats fed with GM potato could be linked to the Cauliflower Mosaic Virus promoter used in almost all GM crops that are being developed!

3. Recently released reports from a secret study done for Monsanto in 1998 by Institute of Nutrition of the Russian Academy of Medical Sciences and suppressed for 8 years, showed that GM potatoes did considerable damage to the organs of the rats in the study[3]. In comparison, the rats in the "control groups" which were fed on normal potatoes or on a non-potato diet were healthier and had much less organ and tissue damage. The potatoes used in the study were Monsanto GM New Leaf potatoes bred in 1995 from the Russet Burbank variety to be resistant to the Colorado Beetle. The GM event was registered as 082, and the potatoes are included in the Bt group of GM crops. They also contain an antibiotic resistance marker gene. The GM potatoes were the most dangerous of the feeds used in the trials and on the basis of this evidence, it was concluded that they cannot be used in the nourishment of people.

4. A 1999 study by Dr. Marc Lappe published in the Journal of Medicinal Food found that concentrations of beneficial phyto-estrogen compounds thought to protect against heart disease and cancer were lower in GE soybeans than in traditional strains[4]. In this study, the researchers analyzed the phytoestrogen concentrations in two varieties of genetically modified herbicide tolerant soybeans and their isogenic conventional counterparts grown under similar conditions. An overall reduction in phytoestrogen levels of 12-14 percent was observed in the genetically altered soybean strains. This has implications for food quality and nutrition with Genetic Engineering.

5. In a study taken up by a Russian scientist called Irina Ermakova [at the Institute of Higher Nervous Activity and Neurophysiology of the Russian Academy of Sciences, with preliminary results reported in 2005], most offspring of GM-Soy-fed rats died in addition to showing growth abnormalities when compared to the offspring of non-GM-soy-fed rats[5]. Within three weeks, 25 of the 45 (55.6%) rats from the GM soy group died compared to only 3 of 33 (9%) from the non-GM soy group and 3 of 44 (6.8%) from the non-soy controls. The results indicate that conventional soy did not have a negative effect on the death rate, while a GM soy diet increased the death rate by a factor of eight.The soy she was testing was Monsanto's Roundup Ready variety, which has bacterial genes inserted in it to withstand applications of glyphosate [of Monsanto's brand called Roundup]. In the photo on the left, the larger rat, 19 days' old is from the control group while the smaller rat, 20 days' old is the from the GM soy-fed study group.

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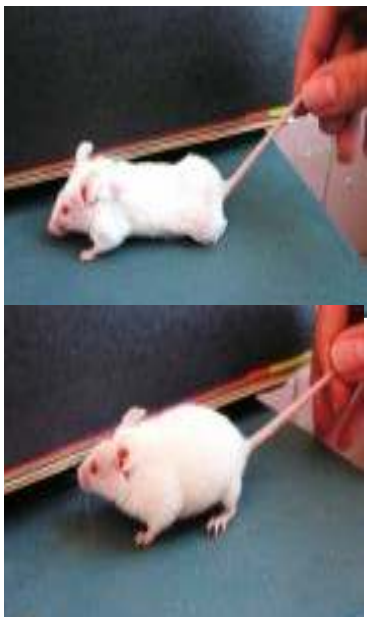
[3] Commentary by I.V.Ermakova, Agrarian Russia, No 4, 2005, pp.62-64 on the original study called "Medical-biological investigations of transgenic potatoes, resistant to the Colorado beetle (under agreement with Monsanto Co.)", Russian Academy of Medical Sciences, Institute of Nutrition, Moscow, 1998. Signed off by V.A.Tutelian, Deputy Director. Physiological, biochemical and morphological investigations in rats. Full Report 275 pp, including raw data.

[4] Marc Lappe, E. Britt Bailey, Chandra Childress, Kenneth D.R. Setchell, 1999: "Alterations in Clinically Important Phytoestrogens in Genetically Modified, Herbicide-Tolerant Soybeans", The Journal of Medicinal Food, Vol. 1:4, pps. 241-245

[5] Ermakova, I: Preliminary Findings presented at Symposium of National Association for Genetic Security, October 10, 2005; also, "Influence of genetically modified soya on the birth-weight and survival of rat pups" In Proceedings of the Conference Epigenetics, Transgenic Plants & Risk Assessment, Institute for Applied Ecology, Frankfurt, 2006, pp. 41-48

Further, in 2007, in a study done by Vavilov's Agrarian University in Russia, it was found that a herbicide resistant RoundUp Ready Monsanto soy approved for human consumption in the Russian Federation and in many other countries, induced serious changes in the morphology of viscera (liver, kidney, testis) of mice, in their histological and cell structures. GM-soy also is found to impact the size of litters, and the mortality of the young.

Photo below: On top is a mouse fed with GM soya and at the bottom is one fed with non-GM soya, in this Russian study



6. Studies at the University of Urbino in Italy (2002 to 2005) showed that mice fed with GM Soy had misshapen nuclei in their liver cells, suggesting a possible response to an elevated level of toxins. These mice also had dramatic reductions in enzyme production in their pancreas. Published reports from the University of Urbino, Perugia and Pavia indicate that GM soya fed to young mice affected cells in the liver, pancreas and testes[6].

7. Cooked GM soy is reported to contain twice the amount of soy lectin, which can also block nutrient assimilation[7]. The gene that is inserted into GM soy produces a protein that resembles known allergens.

8. The only human feeding trial on GM crops was done in Newcastle upon Tyne, England. Results published in Nature Biotechnology in January 2004 showed that when humans ate GM soy products, the gene that had been inserted into the soy transferred into the DNA of gut bacteria[8]. This means that long after you decide to stop eating GM soy, your own gut bacteria may still be producing this potentially allergenic protein inside your digestive tract.

9. In 2003, Filipinos living next to a GM cornfield developed skin, respiratory, and intestinal symptoms and fever, while the corn was pollinating[9]. The mysterious symptoms returned the following year, also during pollination, and blood tests on 39 of the Filipinos showed an immune response to the Bt toxin – this was the result of the GM corn.

10. In 2004, a Monsanto study report on a new type of GM Bt maize kept secret showed significant harm caused to rats fed on the variety, called MON 863. The study showed kidney abnormalities and unusually high levels of white blood cells[10].

11. In 2005, scientists at the Commonwealth Scientific and Industrial Research Organization [CSIRO] in Canberra, Australia tested a transgenic pea containing a normally harmless protein in

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[6] Malatesta M, Caporaloni C, Gavaudan S, Rocchi MB, Serafini S, Tiberi C, Gazzanelli G. (2002): "Ultrastructural morphometrical and immunocytochemical analyses of hepatocyte nuclei from mice fed on genetically modified soybean", Cell Struct Funct. 27: 173-180; Manuela Malatesta, et al, (2002): "Ultrastructural analysis of pancreatic acinar cells from mice fed on genetically modified soybean", Journal of Anatomy, Volume 201 Issue 5 Page 409

[7] Stephen R. Padgette et al, 1996:, "The Composition of Glyphosate-Tolerant Soybean Seeds Is Equivalent to That of Conventional Soybeans," The Journal of Nutrition, vol. 126, No. 4

[8] Vidal,J.,2002. ***The Guardian***, July 17. Accessed from www.foodstandards.gov.uk/sciencetopics/gmfoods/gm reports

[9] Terje Traavik & Jeffrey Smith, 2004: "*Bt*-maize (corn) during pollination, may trigger disease in people living near the cornfield", http://www.mindfully.org/GE/2004/Bt-Corn-Human-Disease24feb04.htm

[10] Seralini et al, 2007: New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity, Archives of Environmental Contamination & Toxicology, Vol. 52, No 4

bean (alpha-amylase inhibitor 1), and found that it caused inflammation in the lungs of mice and provoked sensitivities to other proteins in the diet[11].

The US Food and Drug Administration had data dating back to early 1990s showing that rats fed GM tomatoes with anti-sense gene to delay ripening (of Calgene company) had developed small lesions in their guts. Soon after, the regulatory systems in the USA were changed!

Some researchers warn that Antibiotic Resistant Marker [ARM] genes used in most GE crops might unexpectedly recombine with disease-causing bacteria or microbes in the environment or in the guts of animals or people who eat GE food. German researchers have found antibiotic resistant bacteria in the guts of bees feeding on gene-altered rapeseed (canola) plants (unpublished). Professor Hans-Heinrich Kaatz of the Institute for Bee Research at the University of Jena found that genes used to modify oilseed rape (canola) were transferred to bacteria in the guts of bees. He experimented with honey bees and GM oilseed rape, which had been modified to resist a specific herbicide; he removed oilseed rape pollen from legs of bees and fed the pollen to young bees. When he examined the intestines of the young bees he found that some carried the gene that resisted the herbicide.

There are other studies which have looked at the allergenicity, immunogenicity etc., of various Bt genes, of the cauliflower mosaic virus and so on and the findings reinforce the findings of some of the above studies.

B. Changes that have ecological impacts

There are different environmental impacts that could be expected from genetic engineering in agriculture which can be classified as impacts on the pest & disease ecology, on unintended beneficial organisms, on soil microbial activity, on pest and weed resistance and finally, biological contamination due to gene transfer.

a) Increased outcrossing is a very serious hazard, flowing out of GE. Gene flow from transgenic cultivars to non-transgenic cultivars is a distinct possibility. Accumulation of such transgenes in related and wild relatives results in many untested products and there could be a collective impact on eco-systems and food safety. Even physically, such GE crops cannot be segregated from non-GE crops in most growing conditions.

There is a possibility of reduction in biodiversity due to genetic displacement, given the advantage that the transgenic plant has over its eco-system on certain aspects.

Biological and/or physical contamination of seed stocks is irreversible, in addition to contamination of wild/related species. It is actually contamination from field trials that resulted in tonnes of long grain rice in the USA having to be withdrawn from the international markets. This resulted in losses of millions of dollars to US rice farmers as country after country rejected imports from the country. There were 39 cases of crop contamination (of non-GM crops from GM crops) in 23 countries in 2007, and more than 200 in 57 countries over the last 10 years.

b) Similar are unintended effects on beneficial insects now captured as scientific evidence through studies. If our impact assessment mechanisms are broad enough, such impacts can be captured as both direct as well as indirect effects. Long-term exposure to Bt (Cry1Ab) pollen from two Bt maize types, MON 810 and Bt 11, has recently been found to cause adverse effects on

[11] Vanessa Prescott, Peter M Campbell, Andrew Moore, Joerg Mattes, Marc E Rotherberg, Paul Foster, T J V Higgins and Simon P Hogan, 2005: "Transgenic Expression of Bean r-Amylase Inhibitor in Peas Results in Altered Structure and Immunogenicity", J. Agric. Food Chem. 53, 9023-9030

larvae of the monarch butterfly, even though these strains of Bt maize contain less Bt in their pollen than Bt 176. Although no short-term effects (4-5 days) were noted, longer-term studies (2 years) found over 20% fewer monarch larvae reached the adult butterfly stage when exposed to naturally deposited Bt pollen. Numbers of beneficial ladybird beetles were found to be lower in Bt maize plots than in non-Bt maize. Ladybird beetles feed on many food sources including on aphids, pollen, European corn borer eggs and other pest eggs, so have several routes of exposure to the Bt toxin.

In 2007, a new study published in the Proceedings of the National Academy of Sciences, USA, done by Loyola University researchers shows that Bt toxin from pollen and agricultural wastes from Bt Corn fields entering adjacent water streams impedes the growth of caddis flies, a group of aquatic insects very closely related to the crop's pests. The researchers examined the transport of crop litter (pollen, leaves and cobs) in 12 streams near a heavily farmed region of Indiana and established that a pathway does exist for Bt toxin to enter into the streams. They further fed crop litter to the flies in a lab and found that the insects grew only half as much as those on a toxin-free diet. In addition, very high doses of pollen in the water were shown to kill as many as 43% of the caddis flies, the non-targeted insects.

c) There are alterations in soil organisms and their activity due to GE plants and their exudates/ interactions with the soil biosphere around them. An Australian CSIRO study captures this. This might have implications for the subsequent crops grown on this soil including in terms of growth, plant physiological functions and in terms of diseases. *This is as yet an under-studied area in impact assessment.* According to the US Environmental Protection Agency's (EPA) scientific advisory panel, Bt proteins "are likely to be present in the rhizosphere soil not only throughout the growth of the crop, but perhaps long after the crop is harvested". The Panel drew attention to studies that showed Bt could persist in certain soil types for up to 234 days.

Horizontal gene transfer from GM crops to soil bacteria (beneficial or pathogenic) cannot be ruled out.

d) Pest ecology is found to be shifting quite dramatically in crops like Bt Cotton. GM crops meant to control a particular group of pests are changing the pest picture on a crop with secondary pests becoming a major problem. There is also resistance building up in the targeted pests creating what are being termed as 'super pests' – pests on which newer and newer actions have to be deployed to control them.

Data from China shows that use of Bt crops can exacerbate populations of other secondary pests, including aphids, lygus bug, whitefly, Carmine spider mite and thrips. Studies there have shown significant reductions in populations of the beneficial parasites Microplitis sp. (88.9% reduction) and Campoletis chloridae (79.2% reduction) in Bt cotton fields.

A Cornell University study in 2006 showed that in China secondary pests have become major pests, to the extent that pesticide use has shot up to the same levels as at the time of introduction of Bt Cotton.

Another recent study (2007) by the University of Neuchatel, Switzerland, researchers found that in Bt maize lines, there are higher amino acid levels compared to its non-GM counterpart, which made it much more susceptible to aphid infestation.

A University of Arizona study, published in 2008, documented the first case of field-evolved resistance in bollworms, targeted by Bt crops and this issue is no longer hypothetical. This is evolution in action, as per the researchers. Bt-resistant populations of Helicoverpa zea were found in more than a dozen crop fields in Mississippi and Arkansas between 2003 and 2006. A team of University of Arizona entomologists analysed published data from monitoring studies of six major pests of Bt crops in Australia, China, Spain and the US, collected from 1996 onwards and came up with these findings.

The researchers concluded that Bt Cotton and Bt Corn have generated one of the largest selections of insect resistance ever known! These findings confirm the worst fears of critics about GM crops.

e) Increasing adoption of herbicide resistant crops meant that weeds are developing faster and more potent resistance to herbicides, thus converting themselves into 'super weeds'.

The increased use of herbicides like glyphosate in turn pose their own problems – glyphosate is known to impact beneficial insects, invertebrates and fish; by destroying their habitat, glyphosate also impacts small mammals and birds. Further, glyphosate is linked to adverse health impacts. Glyphosate also affects plant nutrient fixation functions as has been discussed earlier.

Increased Horizontal Gene Transfer (HGT) is another potential threat from GM crops – this could potentially have health as well as environmental impacts. HGT involves transfer of genetic material between cells or genomes belonging to unrelated species by processes other than reproduction. HGT normally occurs in nature mediated by bacteria and viruses. GE is considered to speed up this process. Other routes of HGT are direct assimilation and integration of naked transgenic DNA by all kinds of cells, direct injection of transgenic DNA by insects with sharp mouthparts etc. HGT leads to unintended contamination with unpredictable consequences. For instance, in one study published in 1999 in Applied & Environmental Microbiology, it was reported that human consumption of biotech food resulted in transfer of antibiotic resistance gene present in the engineered DNA to bacteria normally present in human saliva and respiratory tract.

In 1999, a paper published in Microbiology Ecology reported that under field conditions, transfer of antibiotic resistance gene from biotech beetroot crop residue to soil bacteria was detected.

Similarly, in 2001, it was found that Agrobacterium, which was widely believed not to infect animals and hence not transfer engineered genes from plants to animals, mediated transfer of DNA in human cancer cells. The results of the University of Newcastle study wherein DNA fragments from RR soy were found in the intestines of human volunteers has been mentioned in the earlier section.

C. Changes that have implications for food security

At a larger level, GM crops pose serious implications to food security given their unpredictability and stress intolerance. This could mean unexpected crop failures, especially in the age of climate change. Therefore, instead of actually eliminating hunger and malnutrition, GE crops have the potential to wipe out existing food security.

Other reasons which threaten food security if such food crops are derived from genetic engineering are:

- newer pests and diseases emerging over crops
- possible impacts on soil microbial activity
- "yield drag" phenomenon with GE crops, especially herbicide-tolerant crops
- in countries like India where food security of people is closely linked their purchasing power (and not just about a community's or the country's ability to produce enough food), herbicide-tolerant crops will eliminate employment opportunities for the poorest in the villages and will cause further food insecurity
- food safety and altered nutrition with GM crops will also impact food security

It has to be understood that the hazards of GE mainly flow out of the transgene-induced instability. Such changes at the genomic level have the potential to create evolutionary level changes. It has also been found that larger the number of genes and longer the transgenic DNA cassette, the greater the instability.

It is now very clear that with genetic engineering, changes certainly happen from the molecular to the eco-systems level and that the notion of “substantial equivalence” with which the GE industry sought to equate GE with non-GE just is not true. It is also obvious that not all changes are immediately apparent or can be captured in tests designed with a narrow scope. We do not even know what questions to ask for many of these aspects to be studied!

The biggest hurdle in realistic and scientific safety assessment in the case of GE crops is that genetic sequences of the products being tested could be different than that which had been described by the biotech companies during regulatory approvals. What has been tested may not be what will exist after commercial cultivation begins! It is understood that this is probably because the inserted genes rearranged over time. In the case of Roundup Ready Soybean, for instance, a Brussels lab confirmed that the genetic sequences were different than what was originally listed. But the sequences discovered in Brussels didn’t match those found by the French. This suggests that the inserted genes are unstable and can change in different ways. It also means that they are creating new proteins—ones that were never intended or tested.

Even the most stringent regulatory impact assessment regime will be flawed given that humankind does not have an understanding of the totality of the complex regulatory processes at the genetic level and given the very nature of instability induced due to GE.

It follows logically that unstable genes make accurate safety testing impossible.