Genetically engineered (GE) Bt eggplant (talong): Health risks, environmental impacts and contamination from field trials

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Genetically engineered (GE, also called genetically modified, GM) Bt eggplant (also called talong, brinjal or aubergine) has been engineered to be resistant to injury caused by the eggplant fruit and shoot borer. A genetic cassette containing genes from the bacterium *Bacillus thuringenesis* has been inserted into the DNA of the eggplant so that it produces a protein called Cry1Ac, which is a toxin. However, there are major concerns regarding the impact of this toxin on human and animal health and the environment. It is inevitable that contamination will arise from any field trials of this GM eggplant.

A) Health concerns with GE Bt eggplant

There are several health concerns regarding GE Bt eggplant. These include the toxicity of the Cry1Ac Bt protein to animals including humans; differences seen in composition of the Bt eggplant and in animals fed the GE eggplant and antibiotic resistance.

There is concern regarding this particular Bt protein (Cry1Ac) in food crops.
The Bt eggplant uses a gene that produces the Cry1Ac protein as a toxin. Importantly, there are no commercial food crops with this type of Bt gene. It is different to Cry1Ab (as used in GM maize) in terms of its food safety. There is no history of safe use of this protein. Quite the opposite. This particular gene has caused concerns with scientists when it was used in experimental Bt rice in China[i]. These scientists urged particular concern with this type of protein.

The scientists said:
For Cry1Ac, there is concern over its potential allergenicity. Research considering the immunogenicity of the Cry1Ac toxin[ii] indicates that

- Cry1Ac protoxin is a potent immunogen.
- The protoxin is immunogenic by both the intraperitoneal (injected) and intragastric (ingested) route.
- The immune response to the protoxin is both systemic and mucosal.
- Cry1Ac protoxin binds to surface proteins in the mouse small intestine.

These research reports suggest extreme caution is required in the use of Cry1Ac in food crops. The FAO/WHO Codex Alimentarius, who are developing international standards for GE food safety testing have adopted a “decision tree” approach[iii]. This means that, should any evidence of possible allergy be found (as is the case with Cry1Ac), a very thorough and detailed assessment on the allergenic risks would need to be performed according to the FAO/WHO guidelines.

Review of Mahyco data's raises concerns
In 2009, Professor Seralini of the University of Caen, France and president of the Scientific Council of the Committee for Independent Research and Information on Genetic Engineering (CRIIGEN) released a critique, commissioned by Greenpeace, of Mahyco's data submitted in support of the application to grow and market GE Bt eggplant in India[iv].

1) Many differences in animals fed Bt and non Bt eggplant
Professor Seralini found numerous clear significant differences that raise food safety concerns and warrant further investigation. In their dossier, Mahyco dismissed many of these significant differences as "not of biological relevance" but this dismissal is not substantiated by the data presented from the feeding trials.

The report found:

- Bt eggplant contained 15% less kcal/100g and have a different alkaloïd content.
- In animals fed Bt eggplant:
  - various parameters in blood cells or chemistry were altered in goats and rabbits.
  - in cows, milk production and composition were 10-14% changed.
  - rats had diarrhoea, higher water consumption, liver weight decrease as well as relative liver to body weight ratio decrease.
  - feed intake was changed in broiler chickens.
  - average feed conversion and efficiency ratios are changed in GE-fed fishes.

2) Antibiotic resistance
The Bt eggplant includes two antibiotic marker genes, called *nptII* (neomycin phosphotransferase II) and *aad* (coding resistance to streptomycin or spectinomycin). Antibiotic resistance is recognized to be a major health problem in numerous countries, developed because of the growing frequency of antibiotic resistance. Professor Seralini considered it "*very strange to consider commercialising a food containing an antibiotic resistance, since several modern biotechnology companies have already developed transgenic plants without this kind of marker genes. The use of antibiotic marker resistance genes should be now widely avoided in Europe and the United States and it is possible that Mahyco has bought an old, unused GMO to Monsanto Company.*"

In particular, the gene for streptomycin resistance (*aad*), would render the GE Bt eggplant unsuitable for marketing in Europe, because of specific concerns of the spread of resistance to this particular antibiotic according the European Food Safety Authority[v].

Professor Seralini concluded that
"*All that makes a very coherent picture of Bt brinjal [eggplant] that is potentially unsafe for human consumption. It will be also potentially unsafe to eat animals with these problems, having eaten GMOs… Indeed,* ***it should be considered as unsuitable for human and animal consumption****… The agreement for Bt brinjal [eggplant] release into the environment, for food, feed or cultures, may present a serious risk for human and animal health and the release should be forbidden.*"

B) Impacts of GE Bt eggplant on the environment

There are several concerns regarding the impact of GE Bt eggplant on the environment including toxicity to biodiversity, including beneficial insects, and a changes in the relative abundances of types of pests on eggplant. Importantly, GE Bt is different to the Bt sprays used in conventional and organic farming.

GE Bt is different to that used by conventional and organic farmers

In its natural form, *Bt* has been used by farmers practising organic and other sustainable growing methods since the 1950s as a spray to kill pests without damaging non-targeted insects or other wildlife. However, the *Bt* toxins produced by insect resistant crops such as Monsanto's GE maize, e.g. MON810 are significantly different and have been shown to be harmful to beneficial predator insects.

Natural *Bt* sprays have little effect on non-target organisms because the bacterial "pro-toxin" is in an inactived state and only becomes toxic when processed in the gut of certain (targeted) species of insect larvae. In contrast, many insect resistant plants contain an artificial, truncated *Bt* gene and less processing is required to generate the toxin. It is therefore less selective, and may harm non-target insects that do not have the enzymes to process the pro-toxin, as well as the pests for which it is intended (Fig. 1).[vi]

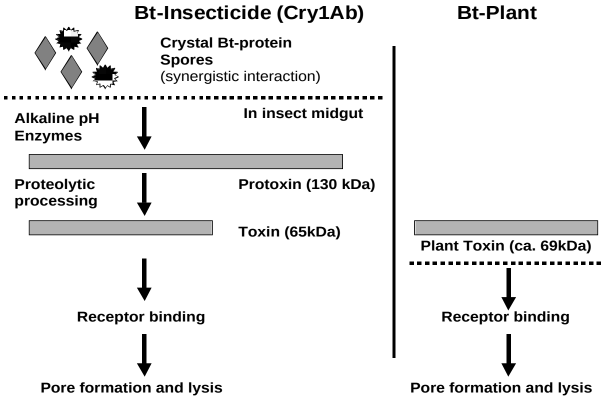

Fig. 1 Differences between Bt-insecticides and GE Bt-plants[2].

Bt proteins from natural *Bt* sprays degrade relatively quickly in the field as a result of ultraviolet light and lose most toxic activity within several days to two weeks after application[vii]. In *Bt* crops, however, the *Bt* toxin is produced throughout the entire lifespan of the plants.

Bt eggplant affects biodiversity

The type of Bt in GE eggplant (Cry1Ac) is slightly different from that in GE maize (Cry1Ab). Much fewer environmental studies have been performed on Cry1Ac so little is known about its environmental toxicity. However, both are designed to be toxic to butterflies and moths so studies from Bt Cry1Ab crops (e.g. maize) can be used to infer what the toxic effects of Cry1Ac on biodiversity might be.

The Bt eggplant can affect the environment by harming insects directly or indirectly (important for beneficial insects).

1) Direct Effects: GE *Bt* eggplant, like other *Bt* crops, could be harmful to non-target organisms if they consume the toxin directly in pollen or plant debris. This could cause harm to ecosystems by reducing the numbers of important species, or reducing the numbers of beneficial organisms that would naturally help control the pest species.

The *Bt* toxins in GE eggplant are specifically toxic to Lepidoptera (butterflies and moths), but not all of these are pests. The potential for GE *Bt* crops to be directly toxic to non-target species was highlighted by research in the USA when it was demonstrated that pollen from one type of GE *Bt* maize (Bt176) was toxic to the much-loved Monarch butterfly[viii]. More recently, it has been shown that long-term exposure even to relatively low levels of *Bt* in maize pollen causes adverse effects on larvae of the Monarch butterfly[ix]. Importantly, these risks to non-target species were not identified until after commercialisation of *Bt* maize, and required several years of research for the long-term implications to be realized.

Indirect effects: Data from *Bt* Cry1Ab maize indicate that the beneficial insects, lacewings, have increased mortality when fed on larvae of a maize pest, the corn borer, which had been fed on *Bt*[x]. Numbers of beneficial ladybeetles were found to be lower in *Bt* maize plots than in non-*Bt* maize. Ladybeetles feed on many food sources including on aphids, pollen, European corn borer eggs and other pest eggs[xi], so have several routes of exposure to the *Bt* toxin. Non-target, beneficial species that may feed on eggplant could be similarly affected.

Changes in populations of both pests and of natural enemies have been documented in *Bt* cotton. Data from China show that use of *Bt* crops can exacerbate populations of other secondary pests, including aphids, lygus bug, whitefly, Carmine spider mite and thrips[xii]. 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[xiii].

Previous studies on non target effects of GE Bt eggplant use a very different toxin.
Studies on GE Bt eggplant have been performed but these use a very different type of Bt that is designed to be toxic to beetles (Cry3Bb), rather than the type of Bt that is in the GE eggplant or GE maize (Cry1Ab and Cry1Ac), which is toxic to butterflies and moths[xiv]. Thus, the toxic profile of Bry3Bb would be expected to be very different from either Cry1Ab or Cry1Ac because they are designed to be toxic to completely different types of organisms. Such studies have sometimes been used as evidence that there are no significant effects on non-target organisms. However, even these studies do indicate that there could be effects. "*Our results suggest that some taxa may warrant more specific study. For example, Alticinae beetles (Coleoptera: Chrysomelidae) were alternatively more abundant in either of the two treatments, and their overall abundance was significantly higher on transgenic eggplants. In light of these results and because of their taxonomic proximity to the target species, these herbivores may represent an important nontarget group to be further studied.*"

Interestingly, such studies indicate that secondary pests may be a problem, that you simply swap one pest for another. "*Sap feeders (e.g.,Homoptera: Cicadellidae) were more abundant on Bt-expressing plants in some samples in all 3 yr.*" and Several studies have shown that other pest insects are filling the void left by the absence of the one (or very few) insect pests that Bt crops target[xv] and this is now a problem with Bt maize[xvi].

Non target effects are extremely likely to occur. They are unlikely to be detected in field trials as many of these effects may not be immediate, or direct. This is something with GM maize, many of the potential effects now of concern are via pathways that have only been discovered after commercialisation, e.g. in the US, agricultural waste from Bt maize has been shown to enter streams, where it may be toxic to aquatic organisms[xvii].

C) Field trials- Contamination knows no borders

Any field trial of GE eggplant will undoubtedly lead to contamination. It is known that for foundation seed stock, an isolation distance of 200 m is recommended[xviii], so the potential for eggplant pollen to travel large distances is recognised. However, isolation distances will not prevent contamination of eggplant as it is insect pollinated and insects can travel long distances. As one UK scientist said, "*distance will not protect us; if cross-pollination can occur, it will. A bee that gets on a train could deliver its cargo of pollen to far-flung places*"[xix]. There are many other ways that GE eggplant can escape from field trials. There may be a mix up with samples, seed mixing, spillage from transport or other human error.

Once contamination of neighbouring eggplant occurs, it will undoubtedly spread further. Eggplant contains many seeds, and each seed produces many fruits. If just one seed from one GE contamination event is grown, it would multiply into tens or even hundreds of GE seeds from just one plant. If these seeds are themselves sown, they will grow into GE eggplant plants and again many GE seeds will be produced. Contamination of this type was seen in GE papaya in Thailand, which also occurred from field trials[xx].

GE is a distraction from research into ecological farming. Money and resources spent on GE research limits capacity for research and development of real, scientific ecological farming solutions.

Greenpeace opposes field trials (as well as commercial planting) of all GE organisms as the risks from such open experiments cannot be contained. The many incidents of contamination of the food chain with GE material arising from field trials (e.g. the case of the experimental GE rice LL601, which had not undergone any prior assessment for its safety for feed, food or environment)[xxi] provide a clear illustration of the wider risk to the environment and society. Further field trials (or monitoring of the impacts of commercial planting) cannot be justified on the basis that they support impact assessment as the impacts are then already real, potentially widespread and may be difficult, if not impossible, to reverse.

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