Bt Brinjal: Need to Refocus the Debate

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The Bt brinjal debate has featured technological worries relating to genetically modified crops, which appear relatively minor in comparison to the critical issue of who controls Indian agriculture and therefore who controls food security in India. While there cannot be a mere technological fix to the problems of Indian agriculture, technology – and therefore GM – will still be part of the solutions. Sadly, techno-worries – pitched by many who are opposed to technology and modernity – have held centre stage in the Bt brinjal debates.

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The Bt brinjal[1] debate has appeared in the public eye as an ideological disagreement between two opposing camps; the anti- and pro-genetically modified (GM) crops. There is no denying that the vitriol of the debate is in part due to ideological differences. What is missing in the debate is the awareness that the opposition to Bt brinjal falls into two distinct categories, and that conflating those two is a grievous error in determining public policy.

Anti-GM groups have sought to brand GM technologies as intrinsically harmful and to identify GM exclusively with rapacious multinational corporations (MNCs). This brings ideologically distinct groups together in an uneasy and ill-fitting unity, in which left-oriented progressive movements find themselves in an awkward alliance with nativist and anti-modern opinion. The pro-GM argument has portrayed GM technology with a patronising air of triumphalism without reference to the MNC ownership of GM technologies. This has made the Indian scientific community sound like a handmaiden of global agribusiness.

The issue of genetic modification of crops and livestock is undoubtedly complex and replete with serious issues. The key questions are: is it practically possible in India to evaluate the risks and benefits of such technologies and to what extent are the concerns specific to GM technologies?

We are in a situation where GM crops and their acceptance have been growing at a rapid pace. In 2009, the number of farmers planting GM crops globally reached 14.0 million, an increase of 0.7 million over 2008[2] with 15 countries having areas under biotech crops of more than 50,000 hectares (see the table). A study by the US Academy of Sciences also concluded recently that GM crops have benefited the US farmers.[3] The Chinese have now permitted Bt rice – the clearance being given in November 2009 and promoted aggressively public sector based GM crops.[4]

The gene revolution is thus out of the bottle and it does not seem feasible to put it in again. What is necessary is an India-specific look at how to handle GM crop technology and its risks.

Risk Analysis and the Precautionary Principle

Major technological advances have always come with attendant risks. The task is to find ways and means for evaluating such risks to enable us to take decisions on the introduction of such technologies.

It is in the context of evaluating advance in technologies that the precautionary principle has gained currency. It now underpins much of the debate on the introduction of new technologies as also a number of international protocols and treaties.[5] Simply put, a precautionary

Table: Global Area of Biotech Crops in 2009: By Country
(Million Hectares)

Rank	Country	Area	Biotech Crops
1*	USA*	64.0	Soybean, maize, cotton, canola, squash, papaya, alfalfa, sugarbeet
2*	Brazil	21.4	Soybean, maize, cotton
3*	Argentina*	21.3*	Soybean, maize, cotton
4*	India*	8.4	Cotton
5*	Canada*	8.2	Cotton
6*	China*	3.7	Cotton, tomato, poplar, papaya, sweet pepper
7*	Paraguay*	2.2	Soybean
8*	South Africa*	2.1	Maize, soybean, cotton
9*	Uruguay*	0.8	Soybean, maize
10*	Bolivia*	0.8	Soybean
11*	Philippines*	0.5	Maize
12*	Australia*	0.2	Cotton, canola
13*	Burkina Faso*	0.1	Cotton
14*	Spain*	0.1	Maize
15*	Mexico*	0.1	Cotton, soybean
16	Chile	<0.1	Maize, soybean, canola
17	Colombia	<0.1	Cotton
18	Honduras	<0.1	Maize
19	Czech Republic	<0.1	Maize
20	Portugal	<0.1	Maize
21	Romania	<0.1	Maize
22	Poland	<0.1	Maize
23	Costa Rica	<0.1	Cotton, soybean
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize

*15 biotech mega-countries growing 50,000 hectares or more of biotech crops.
Source: Clive James, ISAAA Brief 41-2009.

approach means taking action to protect peoples' health or the environment, before there is conclusive scientific cause-and-effect evidence of damage.[6] While there is consensus that a precautionary approach is needed for introducing new technologies, the interpretation of this principle is quite different, depending on which side of the technological divide the parties are.

The problem of new technologies is that it is not possible to know in advance the full risks of such technologies. For those opposing new technologies, the precautionary principle has become a catch-all principle where any ignorance of the impact of new technologies is used to justify its opposition. In this "strict sense", the precautionary principle would end up by being blanket opposition to all new technologies and an argument for status quo in science and technology.

However, freezing all science and technology to current levels to avoid such risks is not a viable option. This stems from the way the current ecosystem, including anthropomorphic activities within the system, is balanced. This balance is not a static equilibrium but a dynamic one in which there is a continuous evolution of nature including pests and diseases. Freezing science and technology to current levels in such a situation will be followed by an inevitable decline. Second, most of our current technologies are based on extraction of finite resources and without a fundamental change, resources will finally run out. Third, some of the harmful products of human activity will accumulate, again leading to a system that cannot stay at in current equilibrium. If we are to avoid such a decline, technology has to advance, as also our understanding of nature.

In a more nuanced sense, the precautionary principle would involve evaluating the "probability" of occurrence of hazardous events and the "impact" of such events. The problem in risk analysis is the evaluation of these two different measures. The safety threshold we set on the probability of taking a risk is obviously much lower if the impact of such an event is catastrophic. Examples are hydroelectric projects involving dams or nuclear power plants, a failure of which would have catastrophic consequences.[7] If, on the other hand, the impact is not severe but cause some damage, we can live with a higher probability threshold for such an event. The precautionary principle would then not be an absolute one of forbidding all risks but weighing up the risk of new technologies against their potential benefits before deciding on such introduction.

One of the problems of using risk analysis is that it is not possible to quantify the risks involved in new technologies. However, there are two ways of overcoming this. One is using the equivalence principle – if there are similar instances in nature of what we are trying to do, it is possible to evaluate its risks. The second is that even though we may not be able to quantify the risks, it is possible to work out the order of risks involved. For taking an informed decision, the order of risks is what we need rather than precise figures.

An example of this is the large hadron collider (LHC). Doomsday theorists had argued that high energy particle bashing in the LHC could let loose forces which could unravel the space-time continuum and therefore even the universe. Since we do not know enough about high-energy particle physics (which is why the LHC has been built), a strict interpretation of the precautionary principle would have meant that such a project should not go ahead. A more reasoned application of the precautionary principle would say that such high energy particle collisions do take place in the stars and therefore the order of risks involved can be worked out from observing such phenomena. Therefore, it is safe to build such a device even though we do not know everything about high-energy particle physics.

The weight of evidence as suggested below indicates that GM crop technology carries non-catastrophic consequences even though many opponents of the technology are arguing otherwise. Therefore, it is possible to take some risks with GM technology even though we are not fully aware of all its possible impacts.

GM Technologies and Their Risks

The difference between GM technology and selective breeding for useful traits is the ability of GM techniques to transfer genetic material between species that cannot interbreed. This allows efficient transfer of genes from one species to another, therefore stably transferring even those traits that are difficult to breed for.

Such horizontal gene transfer is achieved in plants using DNA stretches from the bacterium *Agrobacterium tumefaciens* (At) that insert themselves into the DNA of a host plant species. These DNA stretches in At are carried as exchangeable genetic material, called a plasmid. Therefore, it is relatively easy to make plasmids carrying genes of choice and either get At itself to insert them into host plants, or to use other methods such as gene guns (for plants that are not easily infected by At). Either way, insertion of the introduced genes into the host DNA is achieved. The insertion occurs imprecisely, but is not entirely random.

This method of genetic engineering is "protected" by a whole jungle of patents[8] and this, more than the complexity of the technology, gives large companies such as Monsanto their vice-like grip on agribiotechnology.

One criticism frequently heard is that horizontal gene transfer is an "unnatural" technology. This is a rather strange argument. All technologies are more or less unnatural since they are human-made and do not occur naturally. Any societal move away from food gathering has always been based on such "unnatural" technologies.

The scientific community has been concerned with the risks associated with biotechnology from the beginning. The Asilomar Conference on Recombinant DNA in 1975 set out voluntary guidelines on what could be done consistent with safety. Till the guidelines were formulated, they even imposed a moratorium on further research. However, things have changed radically since then. At that time, most scientists were in the business of doing science – today a number of them are closely tied to corporate interests. The transformation of university science to "University Inc" (Washburn 2006) has also made the case for self-regulation in science more difficult. Scientists are no longer just experts – their personal fortunes could also be riding on their opinions. In any case, the introduction of new technology into society is not merely an abstract scientific question but also a policy problem embedded within social and political issues.

Safety Issues

What are the safety-related issues of biotechnology? There are health safety issues and environmental safety issues that arise from the genetic material thus transferred. Some of these arise from the imprecise insertion of genes by this technology. This means that pre-existing genes may get disrupted or modified, leading to unforeseen changes in plant characteristics. This is less of a problem if the technology is used in hybrids rather than in true-breeding varieties, since "normal" copies of the pre-existing genes are available. However, GM modifications in true-breeding varieties are a major advantage to marginal farmers since the seed does not then have to be bought annually.

A variant of this concern is that the inserted gene, or even the insertion process itself, may re-engineer the biology of the plant and generate poisons. This has been raised repeatedly, including by the minister of state for environment and forests in his moratorium decision on Bt brinjal, particularly since brinjal belongs to the *Solanacea* family of plants that can make poisonous substances. While this possibility certainly exists, it is not unique to GM technology. Breeders of potatoes (another member of the *Solanacea* family), for example, know well the possibility that a hybrid potato made from two good varieties can generate high levels of toxic material. Existing crop development protocols thus already address this issue, even when the crop is non-GM.

Another safety issue arises from the possibility that genes and proteins may behave differently in contexts other than the one they were taken from. This can give rise to the generation of allergic reactions. A brazilnut protein in GM soyabean and a bean protein expressed in GM peas (Prescott et al 2005) have, for example, generated significant allergic reactions. Similar studies with many other GM crops, however, did not find any allergogenicity. Again, food allergies are not unknown with non-GM foods either.

Another issue that arises, and sounds even more appropriate in cases such as Bt brinjal, is the potential of the introduced gene product, such as the Bt toxin, to cause human/livestock harm. While there is a fair amount of understanding about the mechanisms by which, say, the Bt toxin works, this, like all other safety concerns, can only be addressed case by case through pre-release testing.

A key question is, for how long is monitoring to be done in the pre-release tests? There is no obvious endpoint, since in theory, it could take years or decades to make the ill-effects of a poisonous substance manifest. But in the absence of any evidence that GM crop technology has catastrophic consequences, demands for the unattainable absolute proof of safety begin to sound like ploys to keep the technology out of use no matter what the evidence. Undoubtedly, there was need for abundant caution and rigorous testing when Bt was first introduced into crops. While it was true that Bt in its natural state in the bacteria has been long used as a bio-pesticide, that by itself did not mean that Bt is going to be safe in its new form in a GM crop. However, by now the world has experienced a fair diversity of Bt crops, including food crops. Bt corn has now been accepted for imports even in Europe. In this context, while food crops require particular attention, almost all crops enter the food chain one way or another; there is no impermeable barrier between food and non-food crops. A case in point is Bt cotton in India. Bt cotton stalks go into cattle feed and milk products obviously come from cattle. Cottonseed oil also enters the food chain. While case by case safety testing still remains the correct norm, the argument that there could still be a catastrophic danger from the Bt protein in GM crops seems less and less valid.

A major criticism of Bt GM crops is based on a reanalysis by a French group (Séralini et al 2009) of data from Bt maize trials submitted by Monsanto to the European Commission. In this reanalysis, Gilles-Eric Seralini and his colleagues used the original Monsanto data subjected to a different statistical analysis. They came out with some significant differences and claimed that this showed that there were long-term toxicity effects associated with Bt corn, specifically on certain body organs. Seralini has recently also been associated with a similar study (De Vendomois et al 2009) and with similar results for three GM crops. The issue was examined by a panel of other experts (Doull et al 2007). They rejected the Seralini study, pointing out, among other things, that if toxic effects were Bt related, they should have shown a dose-response relationship – higher doses of Bt consumption should also have shown more damage. No such dose response relationship was seen making it unlikely that Seralini et al had uncovered any significant problem.

The issue of long-term toxicity with GM crops has also been particularly raised since, once a GM crop is released, there is no effective callback. This is also the context in which the potential threats of GM technology for diversity in both crops and the biosphere have been excitedly discussed, since there is a possibility that the introduced genetic modifications would spread naturally both to other varieties of the same species, and also to other related species. How harmful is such spread likely to be to crop diversity and to biodiversity?

Most GM crops have one (or two) genes introduced into them. These genes can be easily bred into any variety of the crop, as is done, for example, with Bt cotton. This does not appear to lead a "loss" of the variety in the sense of flattening out the genetic diversity landscape, since the same number of varieties, with differing trait profiles albeit with an introduced gene, would still be available.

How likely is it for the introduced gene to last forever in the gene pool of the species? Evidence is somewhat scanty. However, any organism that makes an additional gene product (a protein, typically) is spending some extra resources in doing so. If the gene product is not useful to the organism, the net result is likely to be a decrease in its fitness, which means that such organisms will eventually die out and the introduced gene will be lost from the population. We certainly have such examples from the microbial world with naturally acquired genes in bacteria.

However, it is nonetheless true that GM crop usage has led to a reduction in the diversity of crop varieties being planted. It is useful to note that this is not related to the "GM" nature of the technology, but to the imperatives of the marketplace and to the fact that the technology is owned and marketed by MNCs which, in order to achieve the profit scales they need, will aggressively drive high-volume seed sales. Such corporate control of agriculture is likely to promote the process of monoculture that tends to thin down biodiversity on the ground. Thus, this is not an issue intrinsic to GM technology, but to its ownership.

These issues need to be seen in the larger context of Indian agriculture and food security. With a growing population and with persistent problems of poverty and malnutrition to address, there is little doubt that increases in food production would be immensely useful. What is the possible role of GM crop technologies in this context?

As there is no reason to think that GM crop technology carries catastrophic consequences, it is indeed proper to consider its possible advantages for Indian agriculture and food security seriously. However, anybody who thinks that any one category of approach, nativist or GM, is going to be a panacea for India's food security is refusing to acknowledge the sheer diversity and complexity of agricultural practices and needs across the country. For example, anti-GM favourites such as the integrated pest management system (IPMS) or the system of rice intensification (SRI) depend on their success on rigorous practices and additional equipment, and may be successful in some situations and not in others. (Incidentally, it is somewhat ironic that the IPMS also includes the use of the *Bacillus thuringiensis* (Bt) toxin in its non-GM form as a pesticide.) The use of GM crop technology as a part of our food future can expand the choices available to a wide variety of farming communities but cannot be the only choice in our basket.

A part of this debate is similar to the one that still continues over the green revolution, where one view holds that a particular mode of technology diffusion led to unsustainable energy and water-intensive agriculture, leading to the exclusion of small and marginal farmers and worsening of their position. However, it is also true that the green revolution changed the productivity of Indian agriculture substantially.

One of the problems of the green revolution is indeed that it rests on chemical fertilisers, pesticides, water and energy. Without these elements, it is difficult to sustain higher production. So what happens to areas that do not have irrigation potential? Or how can we reduce the consumption of chemical pesticides and fertilisers? While GM is certainly not the only answer to these questions, there is little doubt that it can very much be a part of the answering strategies. It is possible to grow more drought-resistant or salinity-tolerant crops, or use less pesticide, for example. Some of these do not need transgenic technologies. Molecular genetic marker-assisted selective breeding is a tool that can help in achieving some of these aims. Achieving true breeding of hybrids will also help in a different way. All of these together could not only increase productivity of agriculture but also help in correcting some of the imbalances of the green revolution.

Bt Brinjal Case

The Bt brinjal is the first in a list of other Bt food crops in the pipeline. That is one of the reasons why the Bt brinjal case has assumed this importance.

What are the pros claimed for Bt brinjal? The fruit-and-shoot-borer insect pest undoubtedly causes large scale crop damage despite wide pesticide usage. It is claimed that 60% of the crop damage due to pests is of this kind. Obviously, this is a relatively easy biotech fix – introduction of Bt in brinjal would provide it a degree of pest resistance. All field trials show that there is some degree of protection with Bt brinjal from such pests.

It is true that the Bt resistance would probably be temporary – it would provide a short window before insects evolve the ability to eat such crops. Nevertheless, even if a temporary improvement in pest resistance takes place, the farmers would avoid significant crop loss. This is a major reason that farmers have adopted Bt cotton despite its higher cost.

However, if the technology remains hostage to transnational agribusiness, the cost of seeds would remain high. Under such circumstances, the farmers would not only buy high-value seeds, but may also use higher level of pesticides to protect their high-cost crop. This is the reason that while in China, Bt cotton saw a drop in the use of pesticides (Huang et al 2003), Indian Bt cotton did not – Indian farmers[9] tended to use even a higher amount of pesticides than with non-Bt cotton. Therefore, one of the benefits of Bt brinjal – the lower use of pesticides – may not materialise in India.

One major criticism of the basis on which the Genetic Engineering Approval Committee (GEAC) cleared Bt brinjal, has been the alleged unreliability of the safety data. Safety data submitted by the company, with a vested interest in a favourable outcome, are deemed to be suspect in this argument. And in this context, the real issue that arises is a question we are depressingly familiar with: do we have strong implementation of these regulatory processes and protocols? The answer to that is likely to tend to be more and more in the negative with the greater the involvement of powerful interests, such as deep-pocketed MNCs. Again, who owns GM technology appears to be far more crucial an issue than its "GM"-ness.

The entire data presented before the GEAC comes from field trials conducted by Monsanto-Mahyco. It is correct that such data may indeed be biased and this is not the right way of going about such important trials. The problem here is that this is the current regulatory scenario in all areas; whether it is drugs or foods – the procedure is essentially similar, contrary to what the honourable minister for environment and forests appears to think. Neither is India's regulatory system in this regard unique – this is what is currently being followed globally. There is indeed a strong case for doing independent transparent drug and food trials, but this is part of a larger agenda not limited to GM crops alone.

There have been questions raised regarding the safety protocols that need to be followed. Some experts have even asked for a much larger number of tests to be done for proving the safety of the GM crops. It must be pointed out that the more onerous the trials, the more difficult it is for the smaller companies to secure approvals. Only companies with deep pockets can then get the necessary approvals, making all GM crops a monopoly of large agribusiness. Indian protocols are substantively in line with international protocols; rather than wholesale changes in them, what is needed is a more rigorous, transparent and open process of implementation.

There is also talk of setting up a regulatory board for approvals and making the GEAC as only an advisory body concerning safety. This could be a useful modification, since safety is only one aspect of introduction of a new crop; there are larger issues that need to be addressed.

For example, in order not to have resistant pests evolve quickly, it is advisable to have 20-50% of the total sown areas be under non-Bt crops to serve as *refugia*, which prevents/delays the fixation of resistance traits in insect pests. While this is easy in large farms as common in the US, how practical is it for small vegetable farms, which is the norm in India? How effective is the practice of mixing about 25% non-Bt seeds to achieve this objective as is being done by Monsanto? How likely is it that the recent, relatively rapid emergence of Bt-resistant pink bollworm in India is related to the failure of these strategies? Monsanto certainly appears to think so.[10] This is not just a technical issue of safety of the Bt products for human consumption but of the nature of the agri-economics of the country. GEAC may not be able to address such issues optimally, and any future regulatory agency should be empowered to deal with them.

What is notable is that the minister for environment and forests, in overruling the GEAC recommendations, has not used non-technical grounds such as ownership of technology, export market considerations and the like. Instead, he has questioned the technical correctness of the GEAC decision itself and therefore expressed a lack of trust in the competence of his GEAC. Under such circumstances, the GEAC should either have been dissolved or the members should have resigned. There is no purpose to a GEAC which seems to have the lost the confidence of the minister even in the narrow technical area which is supposed to be within their competence.

Who Owns GM Technology?

There are certain misconceptions regarding GM technologies that need to be deconstructed. Much as Monsanto would have us believe otherwise, the Bt toxin genes, which are at the heart of the Bt crops, are not owned by Monsanto. India does not allow such patents, unlike in the US (and this is beginning to be seriously contested ground in the US as well).[11] Monsanto owns the process patents to insert this gene into various varieties and it is this ownership of such process patents that makes possible a monopoly over Bt crop seeds. In India the legal position does not allow Monsanto to claim a product monopoly over Bt seeds.

This is part of the reason why Monsanto promotes hybrid seeds, so that farmers have to buy from seed companies every season. As noted earlier, there is nothing in the Bt or GM crop technology to necessitate being dispensed as hybrid seeds. It is possible through GM technologies to create new true-breeding varieties with novel traits. This would let farmers store and use seeds from their crops. In fact, an interesting component of the current strategy for Bt brinjal is indeed that while hybrids will be sold commercially, true-breeding varieties can be generated and disseminated non-commercially.

The crucial difference made by who introduces GM crops is evident in a comparison between India and China. In India, Bt cotton is largely of Monsanto origin, leading to a significant difference between the price of Bt and non-Bt cotton seed. In China, the costs are only slightly higher for Bt seed, since China also has an indigenous Bt technology that is non-Monsanto. As noted above, the Indian farmers' use of pesticides has not decreased with introduction of Bt cotton in contrast to China, where pesticide use came down significantly. Therefore, who controls the technology is significant in the way farmers use Bt seeds and pesticides.

The introduction of Bt cotton brings out the issues of GM crops quite clearly. Bt cotton has been a success of sorts in India. The yields have gone up significantly and 90% of the cotton cultivation in the country is now Bt cotton. However, Monsanto has reaped a bonanza from Bt cotton in India. The farmers were initially paying a technology fee component of Rs 725 for a 450 gm packet of seed costing Rs 1,600. If this had continued, this would have meant about Rs 1,000 crore per year as direct transfer from Indian farmers to Monsanto. Even after state governments forced Monsanto to slash prices, Monsanto gets about Rs 340 crore per year from Indian farmers (Damodaran 2010). This is apart from what the seed companies get, which are also partly owned by Monsanto.

Some of the scientists in the Bt debate have tried to claim that biotechnology research is extremely expensive and this is why MNCs are essential for the development and propagation of this technology. In actual practice, unlike particle physics, biotechnology is far less capital-intensive. In any case a continent-sized economy like India's has no excuse regarding costs when it comes to food security.

The Public Domain

Contrary to what some scientists seem to be saying, the genetic modifications involved in GM technology are not cutting-edge science. What stands in the way of the widespread and careful adoption of the technology is an Intellectual Property Rights regime that seeks to create private monopolies for such technologies. Instead of looking at this end of the problem and working out how Indian public sector science can keep the gene revolution in the public domain, the Indian political establishment seems more interested in surrendering this space to global corporations. A large number of scientists are climbing onto the private bandwagons and trying to convert Indian scientific institutions[12] as sources of cheap labour for global corporations.

The problem with GM technology if it is largely corporate driven is that it seeks to maximise profits and that too in the short run. That is why the major investments in GM crops made by Monsanto and others have been for herbicide-tolerant ("Roundup-Ready" soyabean) or pest-resistant crops (Bt maize and Bt cotton). Unfortunately, such properties have only a short window, as soon enough, pests and weeds will evolve to overcome such resistance. This suits Monsanto, as the farmers will then again require new technology which would then again be patent-protected. A short window but high profit are of interest to agribusiness but may not be the best route for agriculture.

The National Farmers Commission pointed out that priority must be given in genetic modification to the incorporation of genes that can help impart resistance to drought, salinity and other stresses. Such prioritisation of the technology agenda is possible only if public research institutions take the lead in developing suitable GM crops. While there are indeed such interesting efforts being made in public sector research institutions,[13] their scale is not large enough, nor are interesting ways for the societal diffusion of the technologies so generated being imaginatively thought of despite interesting prior models available globally.[14]

An interesting step away from this corporate model of agribiotech development has been the establishment of an "open source biology" platform, centred around new microbes useful for making transgenic plants. The most advanced initiative of this kind is the Australia-based CAMBIA/BIOS (Constans 2005). While the first acronym refers to the broader scope of promoting biological innovation for agriculture (Centre for the Application of Modern Biology to International Agriculture), the second refers to the Biological Innovation for Open Society, the specific arm of Cambia dedicated to open-source biology. This initiative focuses on freeing the basic technological tools of biotech[15] for general use, so that innovation at the application level is not restricted, particularly by the biggest multinationals. Unfortunately, the Indian scientific institutions have neither focused on such initiatives nor have they tried to develop independent options with respect to GM technologies.

The problem here is not with the technology but with Indian public sector scientific institutions. The significant difference then and now is that while green revolution came from public domain science – it was largely funnelled through universities and Indian Council of Agricultural Research (ICAR), the gene revolution is under the control of a few global corporations. Even worse, the Indian public research bodies are under pressure to become conduits for such global corporations instead of developing independent technologies.

Thus, finally, the critical issue concerning the GM crop introduction decision is not whether GM crops are without risks, but whether the regulatory protocols developed and used for testing them are sufficient for the purpose of evaluating their safety. As noted above, GM crops appear to have non-catastrophic consequences of the kinds and scales that society is familiar with. Therefore, it is not unreasonable to suggest that familiar safety-testing protocols will serve societal needs well in this context too. Protocols for testing GM crops have been developed by international and national bodies over time. They will continue to be strengthened and improved, but either-or positions vis-à-vis GM crops are unlikely to contribute to that process.

The Monsantos of the world are likely to dominate the next generation of GM technologies, bringing back the issue of who controls Indian agriculture and therefore the food security of the country. This is the key issue in introducing GM technologies in the country and this is where none of the concerned ministries – the ministry of agriculture, the ministry of science and technology or the ministry of environment and forests appear to be showing as much concern and speed as warranted.

Clearly, while there cannot be a mere technological fix to the problems of Indian agriculture, technology will be part of the solutions. The farm sector is also seeing a huge squeeze on its income – the prices of inputs are rising faster than the output prices. The increasing corporatisation of inputs, as exemplified by the Monsanto-driven Bt-crops, exacerbates this squeeze further, and must be an issue of concern. The technological worries relating to GM crops appear relatively minor in comparison, yet, sadly, it is these techno-worries that hold centre stage in the ongoing debates. If the Bt brinjal debate ends without addressing this central issue, it would end up being much ado about nothing.

NOTES

1 Brinjal is a classic case of a south Asian word, *vatigagama, baingan, begoon, vanga*, whatever, going *maghribi* with west Asian communities as *badengan/al-badenjan*, further to Iberia/Europe as alberginia/aubergine or beringela and coming back to its *mashriqi* home as brinjal to subcontinental English via the Portuguese Gama.

2 Global Status of Commercialised Biotech/GM Crops: 2009, ISAAA Brief 41-2009: *Executive Summary*, http://www.isaaa.org/resources/publications/briefs/41/executivesummary/default.asp
ISAAA is a body funded by industry as well and could have obvious bias in favour of GM crops. However, its data seems to be consistent with other sources.

3 The Impact of Genetically Engineered Crops on Farm Sustainability in the United States, National Academies, 2010, Brief Report: http://dels.nas.edu/dels/rpt_briefs/genetically_engineered_crops_report_brief_final.pdf

4 The Chinese caution in introducing GM food crops appears to have been the result of the European market becoming anti-GM and therefore the fear of their rice/rice-product exports being banned from the European market (Herring 2009).

5 A number of international treaties incorporate some version of the precautionary principle. Some examples are:
Rio Declaration on Environment and Development, 13 June 1992 (U.N. Doc./CONF.151/5/Rev.1)
Commission of the European Communities (2000), *Communication from the Commission on the Precautionary Principl*e. CEC COM (2000) Brussels, February, 2000.
Cartagena Protocol on Biosafety, Convention on Biological Diversity, January 2000.

6 "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically", from the January 1998 *Wingspread Statement on the Precautionary Principle,* Quoted in The Precautionary Principle in Action: A Handbook, Joel Tickner, Carolyn Raffensperger and Nancy Myers, http://www.biotech-info.net/handbook.pdf

7 Engineering always recognises that any design has to incorporate a factor of ignorance – called factor of safety. This is precisely because we do not know fully all the properties of materials that we use in our designs.

8 Example, Golden Rice, engineered to produce beta-carotene, a source of vitamin A, is subject to approximately 40 patents that had to be negotiated before it could be considered for widespread dissemination. This is now slated to enter certain Asian countries including India by 2011/2012.

9 Unpublished study conducted in two villages by All India Kisan Sabha, 2009.

10 http://www.monsanto.com/monsanto_today/for_the_record/india_pink_bollworm.asp

11 http://www.aclu.org/free-speech-technology-and-liberty-womens-rights/association-molecular-pathology-et-al-v-uspto-et-al

12 This is the erstwhile CSIR model in which CSIR was to earn its revenue doing, among other things, contract research for global MNCs. The India-US Knowledge Initiative also appears to be promoting this model of tying Indian science institutions to US private companies.

13 Examples can be seen in: http://www.springerlink.com/content/9630863213q8j1m2/

14 For example: http://www.grandchallenges.org/ImproveNutrition/Challenges/NutrientRichPlants/Pages/Bananas.aspx
http://www.organicconsumers.org/ge/papayas.cfm

15 An interesting set of interviews with Richard Jefferson on Cambia's aims and objectives is available at www.newsclick.in

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