NEWS FOCUS

Bt brinjal: Good or bad?

The question in the title is more difficult to answer than it may seem at first. A 'good or bad' question is value laden, and often saying something is 'good' assumes that something else is 'bad' in comparison. This makes it almost impossible to answer the 'good or bad' question when it comes to *Bt* brinjal versus non-*Bt* brinjal[1]. *Bacillus thuringiensis* (*Bt*) brinjal has some obvious advantages. It also has some apparent and some potential problems. This article will not attempt to categorize *Bt* brinjal as good or bad, but will present a discussion about it, based on interviews with various scientists.

An oft-asked question is, 'Do we need *Bt* brinjal?'. At present, brinjal is a widely cultivated plant owing to its popularity as a vegetable among Indians, and its hardy nature allows it to be grown under sub-optimal conditions all through the year. In 2008, the area under brinjal cultivation was around 512,000 ha, and the production was around 8.450 Mt (http://faostat.fao.org/site/567/Desktop Default.aspx?PageID=567#ancor). Thus brinjal accounts for about 8.14% of the total area under vegetable cultivation and 9% of the total vegetable production in India[2]. Further, as scientists like P. M. Bhargava (founder and former Director of Centre for Cellular and Molecular Biology, Hyderabad) say, we have other methods such as integrated pest management (IPM) that includes the use of biopesticides and sustainable agricultural practices, such as the use of organic farming, that may be better alternatives to *Bt* brinjal (P. M. Bhargava, pers. commun.) A. V. Balasubramanian advocates an in-depth study of indigenous technical knowledge, an endeavour his Chennai-based organization, Centre for Indian Knowledge Systems (CIKS), is devoted to. He suggests that traditional methods such as the use of *Strychnos nux-vomica*-mixed cow dung compost, and application of tobacco-water spray to overcome pestilence be examined (http://www.ciks.org/btbrinjal.html). 'The most important things to do are a thorough review and analysis of literature on the control of fruit and shoot borer through organic, indigenous and IPM methods', he says (pers. commun.). But the brinjal fruit and shoot borer (BFSB), *Leucinodes orbonalis*, against which *Bt* brinjal has been developed, causes 25.8–92.5% damage to the brinjal crop and a reduction in yield from 20.7% to 60%, forcing the farmer to spend approximately Rs 4800 per acre in a season on pesticides[3]. Scientists such as K. N. Ganeshaiah[4] (University of Agricultural Sciences (UAS), Bangalore) and G. Padmanaban[5] (Indian Institute of Science, Bangalore) say that *Bt* brinjal is any day a much better option than the current method of using pesticides to control BFSB. However, it is also true that GM crops like *Bt* brinjal proffer resistance to only a narrow range of pests, and thus the overall use of pesticides may not be substantially reduced (see Box 1). Yet others such as C. R. Bhatia, former Secretary of DBT, opine that IPM is an ideal way to combat pestilence, but suggest that resistant varieties such as *Bt* brinjal must also be used (pers. commun.). IPM, or relying on traditional agricultural practices alone may not be sufficient to feed the growing population[6].

Uma Shaanker[1] (UAS, Bangalore) sees the *Bt* technology as an event of inevitability. Agriculture, he says, has evolved a great deal over the years. Pesticides became useful only because agriculture changed from a few plants grown among many others to cultivation of vast stretches of the same variety. Pests that raided these monocultures were controlled using chemical means. But now, as pests are becoming resistant to chemical toxins, other avenues need to be explored, and *Bt* technology is a powerful route.

Another question that is often asked is 'Why brinjal?'. Brinjal is a crop that is highly susceptible to pest attack. Since a gene similar to the one used in *Bt* cotton could be incorporated into brinjal to confer pest resistance, it was an ideal choice. 'Certainly there are more important problems in major crops such as rice or wheat that should be addressed but they are not doable in a short time' (CRB, pers. commun.).

This leads us to the next logical question, 'How safe is *Bt* brinjal for human consumption?'. *Development of fruit and shoot borer tolerant brinjal*[3] describes about 22 tests performed on the brinjal variety, including acute oral toxicity test, primary skin irritation test in rabbit, mucous membrane irritation test in female rabbit, assessment of the allergenicity of protein extracts from *Bt* brinjal, feeding studies of animals such as fish, chicken, goats and cows, and field trials conducted in about 19 locations during 2002–2006. However, scientists are divided about the veracity of these experiments. Padmanaban says, 'You can always find flaws because these are very elaborate experiments. But more importantly, the particular gene has been around for more than a decade. *Bt* corn has a similar gene. Of course, people argue that *Bt* corn is fed only to animals; but then you have all the animal experiments. And I'm sure *Bt* corn will go into breakfast cereal for instance. Plus, *Bt* brinjal has been tested for 8–9 years'[5]. Other scientists argue

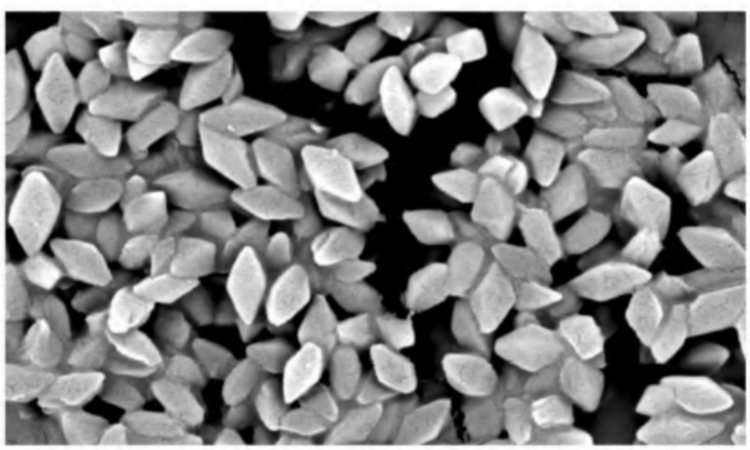

Figure 1. Crystals of *Bacillus thuringiensis*. Source: http://en.wikipedia.org/wiki/file:Bacillus_thuringiensis.JPG

Box 1. Pesticides and integrated pest management

The usage of organo-chemicals, such as organo-chlorines, organo-phosphates, carbamates and pyrethroids as pesticides probably began with the discovery of DDT in the late 1930s[11]. Despite popular dissent triggered by Rachel Carson's book, *Silent Spring* (1962), pesticides and other agricultural chemicals continue to be widely used world over.

In India, of the total agricultural chemicals used, insecticides constitute about 61.4%, probably because insect pests abound in the tropical climate of our country[12]. Farmers prefer chemical insecticides to bio-pesticides due to their cheaper rates, despite their higher toxicity even when compared to other agricultural chemicals such as fungicides[12].

Farmers' lack of knowledge of the exact identity of the pests, lack of proper methods of application of pesticides, usage of 'pesticide cocktails', application of higher dosage of pesticides due to development of resistance in pests, improper methods of disposal of empty pesticide cans, etc., only compound an already difficult problem[12]. Chemicals that have become obsolete or are banned in developed countries are often dumped into developing countries like India[13]. These chemicals may even pose a severe threat to human health. For instance, the pesticide endosulphan, used as an aerial spray in cashew plantations in Kerala, was found to cause human deformities, congenital anomalies, mental retardation, etc. (http://www.endosulphanvictims.org/history.htm). But due to lack of strong scientific evidence to back these findings, farmers continue to use these chemicals on their farms[12,13].

Integrated pest management (IPM) is a strategy that came into being to minimize pesticide use. The focus shifted from pest eradication to maintaining the pest population below a threshold level. A combination of cultural, biological and chemical methods is used in IPM. Cultural methods include non-chemical agricultural practices that farmers traditionally practise on their fields. Biological methods aim to use natural predators to control pest populations, cultivation of resistant crop varieties, usage of pheromones and certain practices such as crop rotation and mixed and multiple cropping. Chemical methods are resorted to only when pestilence exceeds a certain limit, and only at times when they would be most effective against the pest and have the least impact on the environment[11]. However, awareness about IPM among Indian farmers is abysmal – a recent study reports that only 34% of the farmers surveyed knew about IPM and only 5% followed complete IPM measures[12].

that the bacterium has been coming as a culture for the last four decades or so, and is being used as a pesticide by farmers, and so there is a good chance that the *Bt* gene has already entered our food chain (Figure 1)[4]. Some are confident about the safety of *Bt* brinjal, and say 'The Genetic Engineering Approval Committee (GEAC) should have made a firm recommendation and not asked the Government to take the final decision. If some members were against the approval, the GEAC should have given its recommendation along with the dissenting note of the members not agreeing to the recommendation' (CRB, pers. commun.). J. Gowrishankar (Centre for DNA Fingerprinting and Diagnostics, Hyderabad) says, 'In the three decades of regulation since the Asilomar conference, there has been no clear uncontested validation of any example of unintended risks or consequences of GMOs anywhere in the world'[7]. (The Asilomar conference was held in 1975 in California to determine whether or not to continue abiding by the 'moratorium letter' signed after a conference in New Hampshire in 1973. The 'Moratorium Letter', signed by Paul Berg, James Watson and other leading molecular biologists of the day, had called upon the scientists of the world 'to suspend voluntarily all recombinant studies until the potential hazards of such recombinant DNA molecules have been better evaluated or until adequate methods are developed for preventing their spread'[8].) He reinforces his point by referring to an interesting observation – what he calls the 'controlled trans-Atlantic Experiment'. About 300 million people on the western side of the Atlantic (in countries such as USA) have been exposed to GM crops for about two decades. About the same number of people on the eastern side (in European countries) have been protected from GM crops by their governments, offering a wonderful opportunity for comparison between the 'experiment' and 'control' populations[7] (see Box 2).

Although some scientists are convinced that GM crops, including *Bt* brinjal, are safe for human consumption, others such as Bhargava point out many inadequacies in the tests that were conducted on *Bt* brinjal – lack of clear cut parameters for monitoring the tests that have been carried out, insufficiency of the data that is made available for thorough review, lack of details of the methods followed for some of the tests, lack of validation of the tests by an independent and reliable organization and so on. The data that has been made available also has some flaws. For instance, he says, 'On the GEAC website (*Bt* brinjal – part I), there is a description of base-line susceptibility studies and the toxic (*Bt*) protein estimation in cooked brinjal fruits... What is very interesting is that even the non-*Bt* brinjal (uncooked) is positive for *Cry1Ac* gene product (the *Bt*-toxin), which does not make any scientific sense' (pers. commun.). Some scientists, such as J. Manjrekar (M. S. University of Baroda) point out that a few of the members of the GEAC expert committee that approved *Bt* brinjal had conflict of interest[9], thus suggesting that GEAC's assessment of the product may not be absolutely unbiased. He further says, 'While the GEAC had a fairly exhaustive list of scientific tests and requirements to be met by a candidate GM crop, in the case of *Bt* brinjal it appears that this list frequently served more as some kind of check-list: so long as some kind of experimental material had been provided against a particular requirement, the committee seemed to be satisfied'[9]. Further, he says, 'Some of the standards and criteria for what consti-

Box 2. GM crops – the beginnings

In the 1970s, Mary-Dell Chilton of the University of Washington, Seattle, and Marc van Montagu and Jeff Schell of the Free University of Ghent, Belgium, elucidated the mode of infection of the crown-gall causing bacterium, *Agrobacterium tumefaciens*. The pathogen's ability to transfer a part of its plasmid into the plant's genome was quickly exploited to transfer genes that would confer agriculturally advantageous traits to plant cells. Monsanto started using *Agrobacterium* in their attempt to develop a number of transgenics in the 1980s. Development of insecticide-resistant crops, using the *Bt* gene, began in 1987. In the 1990s, China introduced viral-resistant crops on its fields. In 1994, Calgene became the first company to produce a GM crop, the tomato Flavr Savr, on a commercial scale. The tomato had an inverted gene of polygalacturonase, that would produce RNA capable of binding to those produced by the intact gene of the enzyme, and would thus prevent softening of the fruits due to enzymatic action. But unfortunately since 'there simply was not much "flavr" to save, let alone savor' the tomato became a commercial failure[8]. In 1996, Monsanto developed Roundup Ready soybean, a herbicide-resistant crop. This was followed by a number of other GM crops, and by May 1996, the USA had approved seven GM crops for commercialization[14].

In India, the Environment Protection Act was passed in 1986, under which the Genetic Engineering Approval Committee (GEAC) was constituted in 1989, to examine and give clearance to genetically modified organisms[15]. The first permit to conduct field experiments using transgenic crops was granted to M/s Pro Agro Ltd in 1994, and the experiments were conducted, in 1995, using transgenic rapeseed. The first insect-resistant plants to be introduced into India were *Bt* tomato and *Bt* cotton, which were granted permission for field testing in 1996 (ref. 14).

tutes a safe product may need to be reconsidered. It is important to be aware that some of the "internationally accepted norms" are not in fact universally accepted but continue to be the subject of much debate. It is also important to remember that norms can at times be set up or accepted by governments or government agencies under considerable commercial pressure. I believe it would be useful to obtain inputs and suggestions on the formulation of adequate criteria and norms from some of the critics of existing procedures'[9].

Another aspect of the tests on *Bt* brinjal about which dissatisfaction has been expressed is that the protein used in the tests was Cry1Ac protein derived from bacteria, whereas the actual protein in the brinjal is a Cry1Ab–Cry1Ac fusion product. The Expert Committee–II (EC-II) that conducted the studies claims that the two proteins differ by only one amino acid. However, scientists say that it is possible that the two proteins actually differ by 6–7 amino acids, and thus may ultimately be quite different in their conformations. Further, the protein derived from bacteria which was used for the tests may differ from the protein synthesized in the brinjal plant. Many scientists feel that the number of animals tested and the time period for which the tests were conducted are inadequate. Gene transfer to other organisms such as gut microflora and development of antibiotic resistance in these organisms, and the lack of sufficient study on the digestibility of the Bt protein and the products formed after digestion are a few of the other concerns that have been expressed[9]. However, some scientists say that the 'EC-II report is an excellent, cogently reasoned, scientific document'. In fact, Gowrishankar has argued that GEAC and other regulatory authorities can be safely disbanded, since GM crops have not been proved to be unsafe so far (pers. commun.).

Figure 2. Some of the indigenous varieties of brinjal. Source: Report of National Consultations on *Bt* brinjal (http://moef.nic.in/index.php).

Another concern that has been expressed by both scientists and the general public is the loss of indigenous varieties of brinjal (Figure 2). If the *Bt* brinjal variety turns out to be economically beneficial, the farmers can be easily persuaded to cultivate it, and in this way, traditional varieties can be potentially replaced by *Bt* brinjal. But such homogenization is the normal consequence of the acceptance of any new technology[1]. Ganeshaiah points out that replacement of traditionally grown varieties by other crops is nothing new – cultivation of crops such as *same* and *ragi* declined due to the large scale cultivation of rice and wheat[4]. However, Padmanaban sees a way out of this apparent 'necessary evil' – he suggests that the *Bt* gene can be directly incorporated into the varieties that the farmers grow. So the farmer can continue to grow his variety of brinjal, with the *Bt* gene added. 'There are 2000 varieties of brinjal. How did they develop? They're all brinjal all right; that means there is the brinjal signature in their genetic sequence. There have been changes that have taken place in other regions. . . Now, when hundreds of genes have been exchanged, what does it matter if another two genes are exchanged?' he asks. Incorporation of the *Bt* gene into local varieties might be dangerous if the gene is toxic, or if it confers dominance on the modified plants, making them weeds; but since it has been found the *Bt* gene is innocuous, there may not be any apparent threat[5].

This brings us to the issue of natural gene flow that may result in unintentional transfer of the *Bt* gene into closely related plants, say a land race of brinjal, by means such as pollination. Some are uneasy about the possibility of such contamination 'impinging upon the right of farmers for safe and sustainable use of indigenous agro biodiversity' (A. V. Balasubramanian, pers. commun.). Though it is known that gene flow is a natural process, the fact that the *Bt* gene does not occur naturally in brinjal has been a cause of some concern. Though the frequency of the *Bt* gene might be low initially, it may confer a certain fitness advantage to the plant into which it has moved, and thus may go up in frequency over a period of time. This by itself may look fairly harmless. But it becomes a formidable problem when one considers the intricate interactions (many of which are yet to be studied) that the land race may have with other organisms in its vicinity, such as insects that may depend on it for food. So, in short, if the *Bt* gene goes into the land race, you cannot say 'Well, it is good for the land race too'[1] (AVB, pers. commun.). Scientists such as Manjrekar assert, 'No GM crop should be cleared in the absence of adequate and feasible guidelines that will ensure that such contamination does not occur' (JM, pers. commun.). But there are opposite points of view here as well, with scientists pointing out that the nitrogen responsive semi-dwarf rice and wheat varieties that were introduced into Indian fields during the Green Revolution in the 1960s have not made the local tall varieties disappear (CRB, pers. commun.).

One more reason why some scientists feel that India still may not be ready for vegetables such as *Bt* brinjal is due to the lack of an efficient labelling system. Without labelling it would be impossible for a consumer to know *Bt* brinjal from non-*Bt* brinjal, with ample opportunity for the vegetables to get mixed up at any stage from production and transport to marketing (AVB and JM, pers. communs.).

Yet another cause for concern is the possibility that farmers may ultimately have to depend on companies such as Monsanto to supply their seeds for every season, and thus may lose their independence with seeds. In response, scientists such as Bhatia say that this is the case with all hybrids, which have become popular with farmers because the high yield from these varieties compensates the initial investment that the farmer may have to make on seeds. They further point out that the farmer can use seeds from their previous harvest if they cultivate the open-pollinated cultivars of *Bt* brinjal developed by Tamil Nadu Agricultural University (TNAU) and University of Agricultural Sciences, Dharwad (CRB, pers. commun.).

A problem that may surface in the long run is that of the development of insect resistance. Resistance itself is not a new phenomenon – scientists have been developing newer drugs against pathogens as they evolve mechanisms to evade the effects of the older ones. Farmers find it necessary to spray eternally increasing doses of pesticides as pests gradually develop resistance to the chemical toxins. This is, in fact, one of the reasons why *Bt* brinjal may be a healthier way to fight pestilence. Fortunately, our experience with drugs against human pathogens may teach us a lesson or two about how to delay the development of resistance to the *Bt* gene. One way is gene pyramiding – if two genes acting at two different sites of the pest are incorporated into the crop, resistance can be greatly delayed[4,5] (CRB, pers. commun.). Another way is to develop crop rotation strategies – cultivation of the *Bt* crop may be stopped for a generation or two if any indications of resistance are detected; this will make sensitivity return. In the long term, newer genes that act on completely different sites on the insect, such as the mouth or the cuticle, may be discovered. This would make the prospect of a '*Bt* world' less forbidding – if *Bt* genes with similar mechanisms of action, such as the deactivation of the gut of the insect, are incorporated into all crops, resistance developed against one gene would effectively nullify the potential of all other genes[5,10].

Though scientists differ in their assessment of the advantages of *Bt* brinjal, the things that they deem important for the future course of action are rather similar. Though Mahyco has claimed to have performed a number of tests regarding the safety of *Bt* brinjal for human consumption and its effect on the environment, there are several aspects that are still untested. One such is the study of changes in the glycosylation pattern of the protein[1] (PMB, pers. commun.). Such a study was conducted in Australia in 2005 on GM peas (*Pisum sativum)* developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO). This plant had a gene for the enzyme alpha-amylase inhibitor-1 (α-AI1) from the common bean (*Phaseolus vulgaris*), which conferred 99.5% resistance against the pea weevil, a major pest. The GM crop was successful in all tests conducted over a period of ten years, but ultimately was not commercialized as it failed the immunogenicity tests in mice. This was due to a slight change in the glycosylation pattern of the protein in pea, when compared to that in bean (http://www.gene.ch/genet/2005/Nov/msg00107.html). Such a change may occur in the Cry1Ac protein expressed in *Bt* brinjal too.

Scientists like Ganeshaiah stress the importance of studying the residual effect of the *Bt* gene in soil, and its effect on soil microflora. Such a study is inherently complex, as the normal soil microflora itself is not well documented[4]. Manjrekar says, 'The studies done on environmental impact of *Bt* brinjal are ridiculously inadequate, and I feel carefully designed studies are very important. Issues of environmental effect, such as unforeseen effects on non-GM varieties of a crop, on related species, on non-target organisms, horizontal spread of transgenic material, etc., need to be addressed seriously. Unlike a drug released in the market, GM crops cannot be simply recalled off the shelves once they have been released for large-scale cultivation, particularly where there is no guarantee on the containment of the transgene' (JM, pers. commun.). Other aspects that need examination are the likely lifetime of the product, possible shifts in pest patterns through the emergence of new pests which may have moved into a novel niche, changes in yield of GM crops over time, etc. (JM, pers. commun.).

Peer review to ensure the scientific veracity of the studies that are conducted on GM crops and evaluation of the products by independent scientists is also considered important. This would ensure unbiased evaluation of GM crops such as

Box 3. *Bt* crops – a perspective

Bacillus thuringiensis was first isolated in 1901 by a Japanese biologist, Shigetane Ishiwatari, who was investigating the *sotto* disease in silk worms. Due to *Bt*'s apparent effectiveness against caterpillars, it was soon used to control crop pests. Since 1920, spore-based formulations of the bacterium have been used as pesticides. But this method of using *Bt* was found to have a number of limitations – the formulation could be easily washed away by rain, the *Bt* toxin would get degraded in sunlight, and the toxin was effective primarily only against Lepidopteran insects (moths and butterflies). However, newer strains of the bacterium effective against different groups of insects were discovered, and *Bt* pesticides continued to be used well into the 1980s (http://www.bt.ucsd.edu/bt_history.html).

(The fact that the *Bt* gene could harm Lepidopteran insects generated great deal of agitation by environmental groups in 1999, after a study showed that Monarch butterflies feeding on the pollen of *Bt* crops could die. It was however proved that the concentration of pollen used for the study was much higher than what could actually happen in nature, and ultimately, the uproar died down[8].)

Hornworm-resistant tobacco plants were the first transgenic plants developed using the *Bt* gene, in 1987. But the level of Cry1Aa and Cry1Ab proteins that they expressed was very low. In 1990, Monsanto altered *CryAb* and *CryAc* to resemble eukaryotic genes and thus increased protein expression in the plants. Subsequently, a number of *Bt* plants such as cotton, potato, rice, maize and peanut were developed[16].

Commercialization of *Bt* crops started in 1996 with the introduction of 'Bollgard' cotton in the USA. This was followed by *Bt* maize and *Bt* potato[17]. Cultivation of 'Bollgard' in China started in 1997. But, they rapidly developed indigenous varieties of *Bt* cotton; so much so that by 2002, the indigenous varieties accounted for about 45% of the *Bt* cotton cultivated in that country[17]. The other countries cultivating *Bt* crops are Australia, Mexico, Philippines, South Africa, and many European countries including Spain, the Czech Republic, Romania, Portugal, Germany, Poland, Slovakia, etc. (http://www.afaa.com.au/resource_guides/Resource_Cotton.pdf; http://www.europabio.org/positions/GBE/PP_080110-Socio-economic-impacts-of-GM-Crops-GMO.pdf)

In 2002, three hybrids of *Bt* cotton were released for cultivation in India. A number of other *Bt* crops have been developed in the country, including brinjal, tomato, potato, tobacco, okra, rice, sorghum, groundnut, sunflower and castor[17] (http://www.afaa.com.au/resource_guides/Resource_Cotton.pdf). Field trials of *Bt* rice started in 2001 (ref. 18). Other crops such as *Bt* cauliflower, okra, potato, etc. are also in different stages of confined field trials[19].

Bt brinjal, and would not allow vested interests to take a toll of the health of the population of the entire country[1,4]. 'If a fault is found in a paper, it is retracted. Such things must also be possible at any point in the development of GM crops. It should not be sacrosanct', says Uma Shaanker[1]. Manjrekar reiterates these views. He also stresses the importance of ensuring the availability of details of these experiments to concerned citizens (JM, pers. commun.).

Uma Shaanker highlights the importance of studying the performance of crops such as *Bt* cotton that has been cultivated in India since 2002 (see Box 3). In 2009, India ranked second in global production and consumption of cotton and accounted for a quarter of the global area under cotton cultivation. Of the 9.5 mha under cotton cultivation in India, 7.6 mha are under *Bt* cotton (http://www.apaari.org/wp-content/uploads/2009/10/bt-cotton-2nd-edition.pdf). In general, cotton fibre is used for textiles, cottonseed oil is used in cooking, cottonseed meal is protein rich and is used as cattle feed, and cellulose-rich short cotton fibres, which cannot be used in textiles, are used in the preparation of substances such as stabilizers in the food industry (http://www.gmo-compass.org/eng/grocery_shopping/crops/161.genetically_modified_cotton.html). It would be reasonable to assume that *Bt* cotton too would be used for similar purposes. Aspects such as intraspecific gene flow, sustenance of yields and amount of pesticides that were required to be sprayed for the *Bt* cotton crop[1], the fate of *Bt* cotton once it is harvested, and the effect of *Bt* cotton on human and animal consumers are not well documented, making it impossible for us to learn lessons from our experience with *Bt* cotton and apply them to *Bt* brinjal.

Perhaps a major flaw in the Indian system is the lack of a formal entity to continuously monitor and certify GM crops, like the Environmental Protection Agency (EPA) in the USA. Ideally, we require a virtual centre (the actual establishment of a separate institution, with adequate infrastructure and scientific staff may itself take 5–10 years) that makes use of the existing technical expertise and knowledge of scientists at various institutes across the country, such as the Indian Council of Agricultural Research, Indian Agricultural Research Institute, National Plant Genome Research Centre, National Institute of Nutrition, the numerous agricultural universities and other scientific establishments. This centre should be given the responsibility of continuously assessing the performance of GM crops in the country, certifying seeds that are sold to the farmers and so on[5]. A number of problems can be solved this way. For instance, there have been reports of the death of goats after consuming the leaves on *Bt* cotton. Some use this to say that the *Bt* gene is dangerous, while others claim that the goats died due to some other reason. But there is no reliable evidence to prove either way. There is currently no authority to check whether the tests performed are really done using the *Bt* seeds, or whether the seeds sold to farmers are authentic – there have been

Box 4. The National Biotechnology Regulatory Bill

The National Biotechnology Bill was proposed in 2008, and its main proposal is the setting up of the National Biotechnology Regulatory Authority, to 'regulate the research, manufacture, importation and use of genetically engineered organisms and products derived thereof'. The responsibilities of the proposed Authority include providing scientific advice and technical support to the central and state governments on framing policies regarding biotechnological goods, and for safety assessments of biotechnological products; to serve as a national point of contact for international activities in the field of biotechnology; to develop guidelines for risk assessment and to facilitate scientific co-operation and exchange of information; to notify the public of all field and clinical trials and of all regulatory decisions made by the Authority; to implement public outreach programmes; to conduct continual quality improvement and risk assessment of biotechnological products and so on. All research, import and manufacture of genetically modified organisms will be subject to approval by the Authority (http://dbtindia.nic.in/Draft%20NBR%20Act_%2028may2008.pdf).

Though the nature and functions of the Authority seem to be addressing the dire need for a regulatory body to supervise the tests done on genetically modified organisms before their release and to make sure that the certified products reach the farmers, the statement that 'Any person, in connection with a requirement or direction under this Act, who provides any information or produces any document that he knows is false or misleading, shall be guilty of an offence' (http://dbtindia.nic.in/Draft%20NBR%20Act_%2028may2008.pdf) has been widely debated. There has been dissent among the scientists and the general public who feel that this provision might stifle criticism of GM crops, and may dilute scientific rigour in the examination of products such as *Bt* brinjal.

concerns about 'illegal' seeds of GM crops reaching the farmers through the black-market (CRB, pers. commun.). There is no mechanism to even check if Monsanto's recent announcement that pink bollworms have developed resistance to *Bt* cotton in three regions in Gujarat is true[5]. In addition to ensuring quality science behind the products and reports, such a Centre would also promote confidence among the general public about the safety of their food[5] (PMB, pers. commun.) (see Box 4).

Lastly, scientists like Soumitra Sen (Indian Institute of Technology, Kharagpur) believe that there are general misconceptions about rDNA technology and the precision of genetic engineering, and there is a common belief that GM foods are 'unnatural'. However, he feels that the public fears will be significantly reduced once the acute necessity and benefits of biotechnology, and in particular genetic engineering, for the long-term benefits of Indian agriculture are understood (pers. commun.). It is important to educate the public about the technology behind *Bt* brinjal – it is important for them to know what they are being asked to eat! Myths abound regarding the nature of Mahyco's vegetable. Many people still think the '*Bt*' in *Bt* brinjal stands for 'biotechnology'. Many believe that *Bt* brinjal has a 'pesticide that cannot be washed away' and so it is 'poison on a platter'. While the scientific debate over *Bt* brinjal must continue, it is essential not to allow such unscientific perceptions to take root in the minds of people.

1. Based on interview with R. Uma Shaanker, 20 February 2010.
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3. Development of fruit and shoot borer tolerant brinjal, Mahyco, 2008; http://www.envfor.nic.in/divisions/csurv/geac/images/cry1AC/TOXICOLOGY%20AND%20ALLERGENICITY%20STUDIESvol1.pdf
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