Briefing Paper on Bt Brinjal

What is Bt Brinjal?

Bt Brinjal is a transgenic brinjal created out of inserting a gene [Cry 1Ac] from the soil bacterium *Bacillus thuringiensis* into Brinjal. The insertion of the gene into the Brinjal cell in young cotyledons has been done through an Agrobacterium-mediated vector, along with other genes like promoters, markers etc. This is said to give the Brinjal plant resistance against lepidopteran insects like the Brinjal Fruit and Shoot Borer *(Leucinodes orbonalis)* and Fruit Borer *(Helicoverpa armigera)*. It is reported that upon ingestion of the Bt toxin by the insect, there would be disruption of digestive processes, ultimately resulting in the death of the insect.

Bt Brinjal is being developed in India by M/s Mahyco [Maharashtra Hybrid Seeds Company]. **Now, the company wants to take up large scale field trials with the permission of the GEAC in 2006-07.** ***The importance of this development can be understood from the fact that no GM Brinjal has been released for an advanced stage of field trials in open conditions anywhere in the world and that this is the first time that GEAC could be giving permission for large scale open trials for a food crop in India – in a country which has repeatedly proven itself incapable of regulating GM technology and has allowed contamination as a routine affair. The proliferation of illegal Bt Cotton in the country is a good testimony to serious irreversible lapses that could happen at the trials stage. Needless to say, a vegetable, more than other food items, goes through very little processing and is directly consumed through cooking and therefore requires great caution in decision-making.***

The transformation work on Bt Brinjal started in Year 2000. Biosafety tests like pollen flow studies, acute oral toxicity etc., were taken up along with back-crossing programme from 2002. After two years of greenhouse evaluation, in 2004, multi-locational field trials were conducted in 11 locations with five hybrids [Mahyco's MHB-4 Bt Brinjal, MHB-9 Bt Brinjal, MHB-10 Bt Brinjal, MHB-80 Bt Brinjal and MHB-99 Bt Brinjal]. This was also the year when ICAR [Indian Council for Agricultural Research] took up trials with the same hybrids under the All India Coordinated Research Project on Vegetable Cultivation in 11 locations. While the ICAR second year trials continued for these five hybrids in 2005, three more new hybrids were assessed by the company [MHB-11 Bt Brinjal, MHB-39 Bt Brinjal and MHB-112 Bt Brinjal] and ICAR in the same year in eleven centres.

Mahyco has sub-licensed the technology, as part of the USAID-supported, Cornell University-led ABSPII project [consortium of public and private sector institutions] to Tamil Nadu Agricultural University (TNAU), The University of Agricultural Sciences, Dharwad and The Indian Institute of Vegetable Research, Varanasi (IIVR). This transfer of technology was apparently free-of-cost, with the public sector institutes allowed to develop, breed and distribute their own Bt Brinjal varieties on a cost-to-cost basis.

In addition to Mahyco, the National Research Center for Biotechnology at the Indian Agricultural Research Institute (IARI) is also experimenting with Bt Brinjal. They developed a Bt eggplant using a Cry1Ab gene that is claimed to control 70 percent of the fruit borer

attack. This institute had taken up agronomic trials in a controlled environment in 1998/99, 1999/2000, and 2000/2001. In 2003 they were permitted to conduct field trials in five locations - Delhi, Karnal, Pune, Tamil Nadu Agricultural University and the Indian Institute of Horticultural Research. Another company called Bejo Sheetal company, based in Jalna, Maharashtra, is also working on Bt Brinjal.

Brinjal in India

India is the Centre of Origin for Brinjal or Eggplant. Brinjal has been cultivated in India for the last 4000 years or so and has many historical references in various languages. It is grown all over the country, year-round and is one of the most popular vegetables of India. The area under cultivation is estimated to be around 5 lakh hectares. The total production stands at around 82 lakh metric tonnes. It is mainly grown in small plots as a cash crop by farmers. The average yields of Brinjal in India are reported to be around 200 to 350 quintals per hectare. The main growing areas are in the states of Andhra Pradesh, Bihar, Karnataka, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal.

There are many local varieties in India, in addition to improved varieties and hybrids. Some of the public sector improved varieties include Pusa Kranthi, Pusa Purple Cluster, Syamala etc. Hybrids include Arka Navneet, Pusa Hybrid 6, Utkarsha, Pusa Hybrid 5 etc. from the public sector in addition to private sector hybrids.

It is estimated that the damage caused by the Shoot & Fruit Borer in brinjal [which has been the major pest for the past two decades or so] ranges from 50 to 70% and in economic terms, it is estimated to be around $221 millions. It is to lend tolerance to this pest primarily that the Bt Brinjal has been developed.

The promises and claims

- It is reported that the average shoot damage in Bt Brinjal hybrids ranged from 0.04% to 0.3% as compared to 0.12% to 2.5% in non-Bt Brinjal hybrids.
- The percentage of damaged fruits reportedly ranged from 2.5% to 20% in Bt Brinjal to 24% to 58% in non-Bt counterparts
- No significant difference was noted between Bt Brinjal and Non-Bt Brinjal, as per the company which did biosafety tests like acute oral toxicity, sub-chronic oral toxicity in rats, allergenecity of protein to rats, germination, weediness and aggressiveness tests, soil micro-biota studies etc.
- This will help small and marginal farmers from having to use 25-80 sprays of pesticides which are ineffective, says the company
- The company claims that human health concerns due to pesticide use can be addressed with this transgenic Brinjal with its in-built tolerance
- Company promises that through this in-built tolerance, there would be substantial increase in marketable yields. Higher yields would result in higher incomes for farmers, it is expected
- The pricing of the seeds will be based on a cost-recovery model, making it affordable for all farmers, whether the seed comes from the private sector or the public sector, it is promised
- Farmers will be able to continue to save and re-use their seed for the hybrids and varieties because of this arrangement, it is reported

The reality

The current reality is that the Indian regulatory regime with regard to GM crops has never been assessed thoroughly as to whether the right questions are being asked with regard to GM risk assessment in Indian conditions. As in other parts of the world, the current safety assessments are inadequate to catch most of the harmful effects from GM crops, that too in an early warning system. It is no longer in question that GM technology is unpredictable and imprecise, that too when released in an open environment situation. Therefore, there are many worrisome issues with regard to this Bt Brinjal too.

Potential Health Hazards

Several studies on Bt crops in particular and GM crops in general show that there are many potential health hazards in foods bio-engineered in this manner. GM-fed animals in various studies have shown that there are problems with growth, organ development and damage, immune responsiveness and so on. With Bt crops, a recent study from Madhya Pradesh in India shows adverse human health impacts in farm and factory workers with allergies caused by Bt Cotton. Itching skin, eruptions on the body, swollen faces etc., were also reported, correlated with levels of exposure to Bt Cotton.

A study from Phillippines shows that people living next to Bt Corn crop fields had developed many mysterious symptoms, especially during pollination time.

It has also been shown from studies elsewhere that genes inserted into GM food survive digestive processes and are transferred into the human body. They are known to have transferred themselves into intestinal bacteria too. Bt toxin had caused powerful immune responses and abnormal cell growth in mice. It has also been shown that all the Cry proteins in Bt crops have amino acid sequence similar to known allergens and are hence potential allergens.

Potential Environmental Hazards [incl. Monoculture of Bt.]

Resistance development in the target pest is predictable and therefore, even the companies promoting Bt Brinjal are already talking about resistance management. They say that a structured refuge of 5% of non-Bt Brinjal is needed as a strategy for resistance management.

There have not been adequate tests done to assess the changes to the farm level ecology or stress intolerance of Bt Brinjal. In the case of Bt Cotton, however, it is now admitted in official records that Bt Cotton is more vulnerable to sucking pests than non-Bt counterparts, that it is more stress intolerant and so on. Disease incidence on Bt Cotton is also seen to be higher than on non-Bt Cotton.

In the case of Bt Cotton, it is only after a few years of commercial cultivation that recommendations related to some changed management practices are being made by the industry and the government. It is obvious that the research phase of the development of the transgenic did not happen long enough or comprehensively enough for such lessons to emerge during the experimentation phase. Experiments then, are happening at the expense of farmers!

Further, farmers from various parts of the country are reporting a decline in their soil productivity after growing Bt Cotton. While the regulatory tests related to Bt toxin presence and persistence in the case of Bt Cotton showed that the half-life of Cry1Ac protein in plant tissue was calculated at 41 days [which could then persist in the soil as other studies from elsewhere show], it is not clear how in the case of Bt Brinjal it is non-detectable in soil samples tested. Worldwide, it is generally accepted that more studies are needed to understand the impact of Bt toxin on soil ecology.

In the case of pollen flow, it is well known that there is ample opportunity for cross pollination in the case of Brinjal. The rates of natural cross pollination may vary depending on genotype, location, insect activity etc. However, it has been reported that the extent of natural outcrossing is from 2 to 48% in the case of India. Further, it is not clear whether there is enough data on the wild and weedy plants that are either close relatives or have some degree of cross-compatibility with these brinjal varieties. The pollen flow studies on Bt Brinjal in India have been done only in one year [2002, even as the backcrossing programme was on?], in two locations, with reported outcrossing put at 1.46% and 2.7% in these two locations. Such pollen flow studies cannot obviously rely on data from one season and two locations. Studies elsewhere have shown that the likelihood of outcrossing from genetically engineered crops is much higher than in non-engineered crops. For obvious reasons, the same care that is taken for maintaining seed production standards [of 200 metres], has to be applied for the worst case scenario with Bt Brinjal. In such a case, will Bt Brinjal farmers, who are mostly small and marginal farmers, be able to conform to such guidelines?

Let us also consider a scenario where our predominant pest management strategy relies more and more on one gene – the Bt toxin gene, across crops for a range of pests. Such a monoculture of the gene across crops and varieties is bound to spell doom sooner or later.

Other issues

- As already pointed out, the risk assessment in India does not compare the GM alternative with that of other alternatives like IPM/NPM/Organic etc. Further, the socio-economic risk assessment does not ask fundamental questions related to the interests of the poorest and most marginalized farmers.

- Biosafety testing in India does not recognize the need for studying the medium- and long-term impacts of the GM technology. In the absence of such testing, we are only sitting on a potential disaster which would end up in a cocktail situation very soon, where even correlating an effect with a particular cause will become a challenging task.

- No tests were conducted to check for the effect of Bt Brinjal on the crop raised subsequently; similarly, feeding tests did not include open grazing of the animals on Bt Brinjal plants [in the case of Bt Cotton, open grazing is being reported to cause morbidity and mortality in animals]. It is alarming to note that despite several shortcomings pointed out with biosafety testing in the past, almost the same set of tests with same protocols are being conducted with Bt Brinjal as in the case of Bt Cotton without giving the food crop the due importance and diligence it deserves for its potential adverse impacts.

- Even on the limited number of biosafety tests done, there is no independent safety testing undertaken by the vast public sector research establishment of the country. There is a serious and objectionable conflict of interest in the fact that majority of the tests were undertaken by the company promoting Bt Brinjal [pollen flow studies, Cry1Ac protein express, baseline susceptibility, protein estimation in cooked fruits, soil analysis, substantial equivalence studies etc. etc.]. Out of the various tests conducted, only 4 were conducted by public sector institutions.

- With the promotion of GM agriculture in general and with Bt Brinjal in this case, the rights of non-GM farmers to stay GM-free get badly affected. This is because segregation and co-existence is impossible in this country.

- While the companies are promising a pricing policy based on a cost-recovery principle, it has to be noted that such cost-recovery itself would be much higher than other seed accessible to farmers as of now. This involves both direct costs of research as well as indirect costs of aggressive promotion and PR that the companies would indulge in. The past history of MMB in the case of Bt Cotton shows that the company will go to the Courts if required to secure its rights related to pricing. Therefore, it is difficult to believe the promises on pricing.

- In the past, several biosafety violations and unscientificities in trials were investigated by civil society organizations, including on Bt Brinjal. However, the Indian regulatory system showed its incompetency yet again by not fixing any liability on the violators and by not strengthening its research regulation regime to this day. Even though biosafety of the product was not cleared, trials were allowed to take place in farmers' fields with no monitoring mechanism from the side of the GEAC and the state governments concerned.

- There have been no independent tests conducted by the Ministry of Health, considering that this is an important food crop in the country. The entire approval process in the country is being pushed at high speed by the Department of Biotechnology, some bilateral agencies like the USAID and the private biotech industry. This is unacceptable since the primary stakeholders like farmers and consumers and some Ministries like Health are not being involved in these decision-making processes.

Are there no alternatives to Bt Brinjal?

The Bt Brinjal field trials have been compared with their non-Bt counterparts and some national checks to understand the benefits that might potentially accrue to the farmers. They have not been compared to other safer, inexpensive alternatives, however.

There is a lot of experience in mechanical control as well as non-chemical IPM strategies within the Indian research system. Further, there is much experience of non-chemical brinjal cultivation in farmers' fields by many practicing organic and NPM farmers in the country. Simple things like pheromone traps for mass trapping, sanitation of the field [timely removal and destruction of affected shoots & fruits], mechanical barriers, use of some local plant extracts for pest control etc., have all worked well for farmers. However, the evaluation of Bt Brinjal is not taking place against such options as part of the Risk Assessment.

Given below is tabulated information from the ICAR-supervised, Mahyco-commissioned multilocational trials in their second year [2005-06] for five hybrids and in their first year for

3 other hybrids, compared with their non-Bt counterparts and with some popular checks. The table also has comparative figures from experiences with IPM packages applied in some locations.

	Bt Brinjal (mean of Mahyco hybrids from 8 locations) – 2005-06	Non-Bt counterparts (mean of non-Bt counterpart hybrids from 8 locations)	Two checks (mean of Pusa Hybrid 6 and Navkiran)	IPM by GAU* (two locations in farmers' fields) – 2001	IPM by ANGRAU** (at VRS, Hyderabad) 2000-02)	Non-Chemical IPM by OUAT*** (farmers' fields) – Summer 2004
(Cumulative) Fruit Damage	13.5% (5 hybrids in Year II)	28.7% (5 hybrids in Year II)	29.4% (5 hybrids in Year II)	10.64%	17.72%	13.07+/- 7.54
	16.02 (3 hybrids in Year I)	27.72% (3 hybrids in Year I)	27.69% (3 hybrids in Year I)			
Marketable yield	231.69 q/ha (5 hybrids in Year II)	157.08 q/ha (5 hybrids in Year II)	182.15 q/ha (5 hybrids in Year II)	266.25 q/ha	203.98 q/ha	214.5+/- 16.3 q/ha
	223.39 q/ha (3 hybrids in Year II)	190.36 q/ha (3 hybrids in Year II)	192.86 q/ha (3 hybrids in Year II)			

* Technical Bulletin 28 – "Development of an IPM strategy for EFSB in South Asia" – AVRDC, 2003
** Treatment 1 – NSKE-Profenofos-Cypermethrin, on Bhagyamathi brinjal, as reported by Chiranjeevi et al (2005)
*** Dept. of Entomology, College of Agriculture, OUAT, Rath & Dash (2005)

It has to be noted that the data presented by ICAR on Bt Brinjal was not statistically analysed. For instance, the yields across hybrids in the Hyderabad test centre were only 12.04 quintals per hectare. However, the average marketable yield from all locations (231.69 q/ha) conceals this figure. From six centres, the yields were lower than this average, which got skewed by high yield reported from one centre. Similar are dangerous conclusions that can be drawn with data on disease incidence if such conclusions are based on the mean figures being presented. It is also interesting to note that in the ICAR trials, in the case of all the 8 hybrids of Bt Brinjal, their mean fruit weight is far lower than their checks.

As the above table shows and as practicing NPM and organic farmers from various parts of the country would testify, pest management in Brinjal does not need either pesticides or GM seeds when safer, cheaper alternatives in the control of farmers are available.

What is needed is a public support system for such alternatives to be promoted, spread and practiced. Such alternatives inevitably show that the farmers benefit out of increased net incomes, derived from internalizing various inputs including Seed.

References:
- Development of Fruit & Shoot Borer Tolerant Brinjal, paper presented to GEAC on May 22, 2006 by M/S Mahyco
- XXIV All India Coordinated Research Project (VC) Annual Report 2005-06, pp 164-174, 2006
- Rath LK and Dash B, "Evaluation of a Non-Chemical IPM Module for the Management of Brinjal Shoot & Fruit Borer", Veg. Sci.32(2): 207-209, 2005
- Chiranjeevi CH, Narayanamma M and Neeraja G, "Evaluation of IPM Module for the management of Brinjal Shoot & Fruit Borer", Veg. Sci. 32(1): 105-106, 2005
- ABSPII – USAID and Cornell University, "Fruit and Shoot Borer-Resistant Eggplant-Fact Sheet", 2005
- Gupta, Ashish et al, "Impact of Bt Cotton on Farmers' Health", Investigation Report, 2005
- "Background Note on Bt Cotton cultivation in India", MoEF website, Government of India, 2002
- "Development of an IPM strategy for Eggplant Fruit & Shoot Borer in South Asia", Technical Bulletin 28, AVRDC, 2003