G74a

The Ecologist Asia, 01 Jul 2003

With growing opposition to genetically-modified crops in Europe and western countries, the GM giants are focussing their resources on breaking into, by any means, the huge markets of the developing world. India is a prime target.

BURSTING the GM bubble

The failure of GMOs in India

by Vandana Shiva and Afsar H. Jafri

On April 25, 2003 the Genetic Engineering Approval Committee (GEAC) under the Ministry of Environment and Forests (MoEF), denied commercial clearance to Monsanto's Bt cotton for the northern Indian states. This vindicated the apprehensions of many organisations and individuals who had warned the government about the severe repercussions to Indian farmers and their livelihood if further clearance to Bt cotton is allowed. This was in view of the large scale failure in the first year of Bt cotton's commercial planting in approximately 40,000 ha.

This was the third consecutive victory for food security and food safety after the denial of commercial clearance to ProAgro-Bayer for GE mustard as well as the rejection by NGOs CARE India and Catholic Relief Services of 10,000 million tonnes of food aid – a corn-soya blend suspected of containing Bt corn "Starlink". This was achieved despite a massive mainstream media campaign in favor of transgenic mustard by ProAgro-Bayer as well as pressure from USAID and the US Embassy, which tried hard to subvert the GEAC's decision-making process through the intervention of the Prime Minister's Office (PMO).

These setbacks to GM agriculture have been welcomed simply because, GMOs or no GMOs, Monsanto's seeds are spreading disaster. Recently Monsanto hybrid maize seeds have failed in more than 350,000 acres in about 11 districts of north Bihar, leaving thousands of farmers in deep distress. Monsanto sold its 700 metric tonnes of "Cargill hybrid 900M" maize seeds in the flood prone areas of north Bihar. Similarly, water intensive hybrid maize seeds were introduced in drought prone regions of Rajasthan, putting an extra burden of chemical inputs and water on farmers. Monsanto India Ltd. has already been barred from selling seeds in Bihar for allegedly marketing substandard products. An intensive campaign by the Research Foundation for Technology, Science and Ecology (RFTSE) in Udaipur, Rajasthan forced local NGO Karamsheel to snap its ties with Monsanto's Hamsafar programme, designed to aid the propagation of its maize seeds.

The failure of Bt cotton in India

The GEAC's denial of permission to commercialise Bt cotton in the northern states comes after the massive failure of Bt cotton in the south. The GEAC, in spite of being aware of the ecological hazards and the GM corporations' false claims of reduced pesticide use and higher yields, had given permission to Monsanto-Mahyco to commercialise Bt cotton in the southern states on March 26, 2002. It had asked for a year's additional trials in the north. Though the official version of the Bt trials by the Indian Council of Agricultural Research Punjab (ICAR) as well Monsanto-Mahyco is not available, independent studies by citizens' groups found that the Punjab farmers have rejected Bt Cotton, the first-ever genetically modified commercial cotton hybrid seed, due to its poor harvest. Malwa, a cotton rich area in southern Punjab is highly dependent on this cash crop, but successive failures have left farmers in the lurch. Though the Punjab Agriculture University was against the sowing of Bt Cotton seeds, several farmers smuggled Bt Cotton seeds in from Gujarat hoping for better results. The yield was, however, lower than claimed. The Daula village Sarpanch Mr. Darshan Singh said: "... We had to spray four to five times the normal amount of chemicals on Bt Cotton. The crops were attacked by various pests, especially the American Bollworm. The Bt Cotton yield was lower than that of the local varieties, which are more profitable."[1]

Moreover, Bt cotton seeds are costlier. Farmers who sowed Bt Cotton got a yield of 250 kg. per hectare while the local variety yielded almost double this amount. Mr. Baljinder Singh, research scientist with Monsanto India Ltd, insists: "Our aim is to reduce the cultivation cost". But farmers remain unconvinced.

The Research Foundation for Science, Technology and Ecology conducted a study in the states of Maharashtra, Madhya Pradesh, Andhra Pradesh and Karnataka which showed that not only did Monsanto's cotton not protect the plants from the American Bollworm, but there was an increase of 250-300 per cent in attacks by non-target pests like jassids, aphids, white fly and thrips. In addition, Bt plants became prey to fungal diseases like root rot disease or *fusarium*. Bt cotton varieties gave very low yields. Even the staple lengths of whatever little cotton was produced were so short that the cotton fetched a very low price in the cotton market.

The failure of Bt cotton has prompted the Agricultural Minister of Andhra Pradesh, Mr. V.S. Rao, to state that "overall information is that the farmers have not experienced very positive and encouraging results" with Bt cotton. The state government also said that farmers are not getting the yields they were promised and the poor quality crop fetches a lower price in the market.[2]

The Joint Director of Agriculture, Mehboobnagar, Andhra Pradesh, in a letter[3], on the performance of Bt cotton in Mehboobnagar District, to the Commissioner and Director of Agriculture of Andhra Pradesh, has recorded that Bt cotton failed in his district on the following counts:

1. Drying and falling of squares without boll formation.
2. Reduced boll formation.
3. Small sized bolls.
4. Very short staple length.
5. Very little resistance to boll worm, requiring 2-3 sprays to control the pest.
6. No resistance to dry spells.
7. Low yields (only 2 -3 quintals for Mech 162).
8. Low market value.
9. Cost-benefit ratio not on par with non-Bt cotton.

The Joint Director of Agriculture, Government of Andhra Pradesh, Mr. M. Laxman Rao, has stated regarding the experience of Andhra farmers with Bt cotton, "the seed did not have the impact as it was propagated. It has failed to show good results in the yield as well as in pest control." Other Divisional Assistant Directors of the department observed high pest incidence in the Bollgard seed than in other varieties. One of them commented, "Going by the hi-pitch propaganda, the Bt seed should have much resistance, but the ground reality is to the contrary."[4]

Though the government of Andhra Pradesh declared Bt cotton a failure and even decided to compensate the affected farmers, the former Minister of Environment and Forests, Mr. T.R. Baalu gave a statement in the Parliament that Bt cotton had performed 'satisfactorily'. This statement is based on the report of GEAC members on their two day tour of a few Bt farms in AP, a tout that was, not surprisingly, was guided by Monsanto and Mahyco!

A Greenpeace investigation, where the team visited the same farmers as the GEAC team, stated categorically that "the statement of the Minister of Environment and Forests, Mr. T.R. Baalu in the Rajya Sabha on December 16, 2002 is a gross misrepresentation of farmers' experiences. The government has lied to the nation on the Bt cotton performance."[5]

The Greenpeace study also revealed the following:

- The expert team's visit was directed and managed by Mahyco-Monsanto.
- The number of farmers who were met represent a small sample size of those engaged in Bt cotton farming; farmers with bad Bt cotton experiences were not met.
- The scope of the assessment was too narrow.

This is what some leading agricultural scientists, experts and academicians in India have to say about Bt cotton:

"Bt cotton is a hoax here. If there is a genetic mechanism to resist the pest, it should not have attacked at such a scale. The experiment has completely failed."

-Dr. M.Y. Parmar, Dean, Anandwan College of Agriculture, Punjabrao Deshmukh Agricultural University, Maharashtra.[6]

"(We expected the) new variety of a crop would give some relief regarding bollworms. There was no truth in the propaganda that Bt cotton was a non-spray."

- Dr. C.D. Mayee, Director, Central Institute of Cotton Research (CICR), Nagpur.[7]

"Bt cotton products could have long term environmental and health effects. It is essential that the Health Ministry was involved more in such decisions."

- Dr. C.P. Thakur, Former Health Minister, Union of India.[8]

On the basis of the field trials by Monsanto and Mahyco, the GEAC had, in its 32nd meeting dated 26.03.2002 given conditional clearance for three years from April 2002 to March 2005, for commercial release of three out of four of Mahyco's transgenic cotton hybrids. The GEAC has given approval for commercial cultivation of Mech-12, Mech-162 and Mech-184 varieties of the transgenic hybrids of the cotton to Mahyco. The clearance was granted on the grounds that the crop had been fully tested in Indian conditions, that it does not require pesticide sprays, that it gives higher yield and farmers earn higher incomes. All the claims on the basis of which the clearance was granted have been proven false by the total failure of Bt cotton in states where it was cleared for planting, including Andhra Pradesh, Maharashtra and Madhya Pradesh.

However, while claiming on the one hand that the Bt varieties had been fully tested for six years, the GEAC tacitly appears to have accepted that the evidence is not complete. The GEAC's conditions for approval include the following:

- Mahyco will monitor annually the susceptibility of boll worms to

Commercial clearance to Bt cotton was given by the GEAC on the grounds that the crop had been fully tested in Indian conditions, does not require pesticide sprays and gives higher yields to farmers. All these claims have been proven false by the failure of Bt cotton in Andhra Pradesh, Maharashtra and Madhya Pradesh, as well as other states where it was cleared for commercial planting.

the Bt gene vis-à-vis baseline susceptibility data and submit data relating to resistance development, if any, to the GEAC.

- Monitoring of susceptibility of bollworms to the Bt gene will also be undertaken by an agency identified by the Ministry of Environment and Forests at applicants' cost.
- Mahyco will also continue to undertake studies on possible impacts on non-target insects and crops and report back to GEAC annually.

In addition to the GEAC's own tacit acceptance of the incompleteness of the Monsanto-Mahyco Indian trials, by 2002 there was enough evidence from independent researchers, and actual experience of farmers worldwide, to conclude that the Indian trials by Monsanto and Mahyco provided "inadequate information" and failed to "err on the side of caution and prevent activities that may cause serious or irreparable harm" to the environment, human health and farmers' income.

An independent study conducted by RFSTE in late October 2002 in the states of Andhra Pradesh, Maharashtra, Madhya Pradesh and Karnataka found that:

- Monsanto-Mahyco have sold almost 105,000 packets of the three varieties of Bt cotton, each packet, priced at Rs. 1,600/-, was meant for one acre and the total weight of the seeds was 570 gm. (450 gm. Bt and 120 gm. of non-Bt of the same hybrid variety). These were sold under Monsanto's brand name Bollgard.
- Bt cotton is not resistant to bollworm, and requires higher pesticide use than non-Bt varieties.
- Bt cotton has been devastated by pest attacks. Pest occurrence on Bt was higher than non-Bt cotton. As the trial data had already indicated there was a 250-300% increase in non-target pests – jassids, aphids and thrips – for Bt cotton in Maharashtra, Andhra Pradesh, Madhya Pradesh and Karnataka. What was shocking was the substantial attack of bollworm in all the states, particularly in Maharashtra and Andhra Pradesh.
- In Maharashtra, in the Boath village in Pandharkawada (Kelapur) tehsil in Yavatmal, Advocate Mr. Ram Krishnapathi has sprayed his 50 acre crop twice for bollworm and seven times for sucking pests. The cost for one bollworm spray is about Rs. 700/- per acre, while the cost for one spray for sucking pests is approximately Rs. 250/- per acre.
- Mr. Raju Ratnakar Gandhewar of the same village has had to spray his fields five times for bollworm and 10 times for sucking pests.
- Mr. Sudhama at the farm of Mr. Purshotam Kushalrao Kakre at the Aloda village in Yawatmal district has sprayed his Bollgard crop seven times, six of them to control the bollworm pest. Each spray cost him about Rs. 700/-.
- The Principal of the Anandwan Agriculture Collage, Prof. Palar Pawar has sprayed the college's field five times for pests and have released about 9,000 Bracons to control pests in their one-acre Bt cotton.
- Mr. Ankur Choudhury of Wani in Yawatmal has sprayed his field of Bt cotton seven times for sucking pests.
- Mr. M. Sammaiah of Chintanekkonda village in Parvatagiri tehsil of Warangal, has sprayed his crop thrice for bollworm and sucking pests, before giving up as the results were not satisfactory.
- The majority of Bt farmers in Warangal have used Traser of Denocil Company for controlling pests (Rs. 1160/- for 100 ml for one acre). According to Mr. Venkateshwaran of Mansa Seeds and Fertilizers, a distributor for Mahyco, about 50-60% of Bt farmers used Traser to control sucking pests.
- Another important aspect of the approved Bt cotton varieties is that its Bt toxin is effective only for a period of 80-100 days. Dr. Mayee, Director, Central Institute for Cotton Research (CICR), confirmed that in the Mech 162 strain, the Bt Gene's efficacy declines after 90 days while in Mech 184 the decline occurs after 120 days. The Bt seeds were treated with Imidacloprid (Goucha) for sucking pests, but this is effective for 35 to 45 days only, beyond which the crop was attacked by sucking pests especially Jassid and Thrips. This has been reported by almost every Bt farmer during RFTSE's study and has been confirmed by almost every scientist met by the team.

Pesticide free cultivation – A False Claim

Other institutions and experts have also conducted studies on the performance of Bt cotton. A study conducted by Dr. Abdul Qayoom, formerly Joint Director, Agriculture, Government of Andhra

Cost Benefit Analysis of Bt. cotton vs other cotton in one acre in Maharashtra and Andhra Pradesh			
	Bt. Cotton	**Non-Bt. Hybrids**	**AKA 5 & 7 (Growing in ZARC, Yawatmal)**
A. Expenditure on Inputs (Seeds, fertilisers, pesticides, irrigation)	Rs. 8100/-	Rs. 5750/-	Zero Expenditure
B. Expected Total Yield	4 quintals	10 quintals	5 quintals
Output Value	Rs. 6600 (Rs. 1650/- qtl)	**Rs. 16500** (Rs. 1650/- qt)	**Rs. 8250** (Rs. 1650/- qtl)
C – A	**Loss of Rs. 1500/ acre**	**Profit of Rs. 10750/-acre**	**Profit of Rs. 8250/- acre**

Cost Benefit Analysis of Bt. cotton vs other cotton in one acre in Madhya Pradesh		
	Bt. Cotton	**Non-Bt. varieties**
A. Expenditure on Inputs (Seeds, fertilisers, pesticides, irrigation, labour)	Rs. 6675/-	Rs. 7005/-
B. Expected Total Yield	4.01 quintals	7.05 quintals
C. Output Value	**Rs.7218** (Rs. 1800/- quintal)	**Rs.13320** (Rs.1800/- per quintal)
C – A	**Income of Rs. 543/- acre**	**Profit of Rs. 6315/- acre.**

Cost Benefit Analysis of Bt. cotton vs other cotton in one acre in Karnataka		
	Bt. Cotton	**Non-Bt. varieties**
A. Expenditure on Inputs (Seeds, fertilizers, pesticides, irrigation, labour)	Rs. 8925/-	Rs. 10250/-
B. Expected Total Yield	3.82 quintals	7 quintals
C. Output Value	Rs.7640 (Rs. 2000/- quintal)	Rs.14000 (Rs. 2000/- per quintal)
C – A	**Loss of Rs. 1285/ acre**	**Profit of Rs. 3750/ acre**

Pradesh, Mr. Sakkari Kiran, an agricultural scientist and Dr G.V. Ramanjaneyaloo, among 21 individual farmers and farmers groups in 11 villages of Warangal District, found that there was only a marginal difference in the quantity of pesticide used on Bt and non-Bt cotton. While farmers sprayed Bt cotton 4-6 times this season, they sprayed non-Bt cotton only 5-7 times, just one more spray!

Mahyco has said in its promotional cassette (given along with Bt seeds) that if the Economic Threshold Limit (ETL) level in Bt Cotton, defined as 20 bollworms in one acre, is crossed, farmers have to spray to control pests. Their own promotional material proves that they knew their claim of pest resistance was false and they made this false claim only to get commercial clearance on false grounds to misguide farmers and to make illegitimate profits at the cost of innocent farmers.

Bt cotton has also been attacked by wilt *(fusarium oxysporum fsp. Vasinfectum)* and root-rot *(Rhizoctoria bactaticola)* in Maharashtra, Andhra Pradesh, Madhya Pradesh and Karnataka. This has also been confirmed by the Dr. S.W. Khodke, Assistant Professor and Plant Pathologist at the Zonal Agriculture Research Center (ZARC) in Yawatmal, A.M. Ingle, Agriculture Development Officer of Yawatmal as well as Dr. Jalapathi Rao, Principal Scientist and Head of the Agriculture Research Centre in Warangal. These diseases were limited to Bt cotton varieties.

No higher yields

Bt cotton was sold with the claim that it would yield 15 quintals per acre. However yields have been as low as 20 kg. per acre. The average total yield per acre expected by Bt cotton growers was 3-4 quintals per acre in Maharashtra and Andhra Pradesh.

In Badwani, Khargaon, Dhar and Khandwa districts in MP, almost half the 42 farmers surveyed reported that their crop had failed. The farmers of Khargaon were devastated by a total crop failure. In the other districts, only one expected a yield of 12.5 quintals, the average yield expected by other farmers was 4.01 quintals, as compared to the 15 quintals promised by Monsanto-Mahyco.

In Karnataka, 15 of the 40 farmers visited in Bellary, Sirippupa and Haveri/Dharwad districts, expected a total failure of their crops. The average yield expected by the remaining farmers was 3.82 quintals per ha. Even the CICR is expecting a maximum yield of 4 quintals per acre in 10 acres of Bt cotton being grown under the Institute Village Linkage Programme (IVLP) in Maharashtra.

In most of the fields visited in the month of October 2002, the Bt cotton plants were in a stage of maturity with the leaves turning red prior to falling. The non-Bt on the fringes looked far healthier, taller and a bit greener than the Bt plants. The early maturity of the Bt crop is probably caused by the toxin gene, as it could not be due to environmental conditions as non Bt and hybrid cotton varieties were healthy and lush green.

In the Pattipakkam village in Shampet Mandel in Warangal, Venkat Reddy's Bt crop matured completely in October. Unlike other hybrid cotton varieties, which yield up to March, Bt cotton farmers could not get any yield after November-December 2002.

This maturity factor could be caused by the genetic engineering processes through which Bt cotton has been developed. It could also be because of the toxic gene itself in the Bt cotton plants.

There is no doubt that Bt cotton has disappointed its growers and the yield has been much below expectations.

Bt cotton does not increase farmers' income

The failure of Bt cotton has completely exposed the companies trying to market their GE seeds at the cost of farmers and calls into question the GEAC clearance given to unreliable, untested hazardous seed varieties. This has devastated cotton farmers, many of whom are now faced with penury. Mala Rao Krishna Rao Thakre of the Boath village in Yawatmal suffered a major heart attack when his 27 acres of Bt cotton were devastated by diseases and pests.

The incomes of Bt cotton farmers suffered not just because of low yields, but also because of staple size. Monsanto-Mahyco claimed a staple size ranging from 26-29 mm. In actuality, it is hardly 15-20 mm, and fetched the same rate as a short staple cotton (around Rs. 1,500 per quintal), while the normal rate offered for the best quality cotton is Rs. 2,000 to 2,200 per quintal. One of the buyers in the Warangal Cotton Market, Mr. Sarangpani of K.N.R. Enterprises said that Bt cotton staples are only 6-7 mm long while the staples of good quality non-Bt cotton is 32 mm. long! Good quality varieties such as Banni, Brahma, RCH-2 and Mech-1 cotton staples also fetch high prices.

Contrary to the GEAC's statements that they would earn an additional income of Rs. 10,000 per acre with Bt cotton, farmers have actually lost more than this amount. Not only is the cost of the seed higher than of non-Bt varieties, Monsanto's varieties also need more inputs in terms of fertilisers and water.

Bt cotton's failure could create a repeat of the situation in Warangal in December 1997, when hundreds of cotton farmers committed suicide due to crop failure.

In comparison to Bt, some of the non-Bt hybrid farmers have used a maximum of 4 sprays while many are not using sprays at all because they are ineffective. The non-Bt seed costs only Rs. 350 to Rs. 450 per packet (450 gm.). Though the irrigation cost was more or less the same for both Bt and non-Bt fields, Bt cotton requires more moisture and some farmers had to irrigate their Bt field more than non-Bt fields. The input cost was nil for those who grew indigenous varieties of cotton (desi cotton) e.g. AKA-5 and AKA-7. This cotton was found at ZARC in Yawatmal (see table above).

The only study that bolsters Monsanto's claims vis-a-vis Bollgard is by Matin Qaim (University of Bonn's Centre for Development Research) and David Zilberman (Professor at the University of California in Berkeley), published in the journal *Science*. This paper states that the Indian experience with Bt is positive and yields have increased by 80%. Qaim and Zilberman have used data provided by Mahyco-Monsanto, which is still not in the public domain, to substantiate their claims. These claims have been rebutted by internationally renowned scientists and experts. Shanthu Shantharam, a scientist who has worked as a regulator with the USDA and is an authority on 'pest-resistant genes in managed ecosystems' states that such increase cannot be attributed to a single Bt gene, calling it a "preposterous idea".[9]

Qaim's study is also rebutted by Dr. Suman Sahai of Gene Campaign, who said that the paper is based exclusively on data supplied by the company that owns Bt cotton, Mahyco-Monsanto, and as such will be biased. Yet the data presented in this 'sensational' paper is not based on the harvest that year, as one would expect, but on a few select trial plots belonging to the company! No data from farmers' fields or from the All India Coordinated Variety trials conducted by the Indian Council of Agricultural Research have been included.[10]

This amounts to manipulating data since trial plots are experimental fields with optimal conditions, whereas performance in real fields under normal cultivation conditions can be, and usually is, very different. The kind of results quoted by Qaim have not been seen anywhere else in the world where Bt cotton is being cultivated. In the US and China, a 10 to 15 percent yield increase has been recorded. Such sensational data has led to a spate of media reports about the 'superlative' performance of Bt cotton, both nationally and internationally. Such misleading reports end up influencing policy makers in a direction that could ultimately be detrimental to farmers.

Contrary to the GEAC's statements that they would earn an additional income of Rs. 10,000 per acre with Bt cotton, farmers have actually lost more than this amount. Not only is the cost of the seed higher than of non-Bt varieties, Monsanto's varieties also need more inputs in terms of fertilisers and water.

The Indian experience with Bt cotton shows that it neither gives higher yields nor does it increase farmers' incomes. This finding is in keeping with the USDA report on the economics of GM crops.[11]

Yield drag in transgenic plants, affecting farmers' incomes have been reported in numerous other studies. A study based on 8,200 trials of soya varieties in US universities in 1998 reports yield drags between top Roundup Ready (RR) varieties and top conventional varieties averaging 6.7%. In some areas, best conventional varieties produced yields on average 10% higher than RR varieties sold by the same seed companies [Benbrook, C.M. (1999), *Evidence of the magnitude and consequences of the Roundup Ready soybean yield drag from university-based varietal trials in 1998;* AgBioTech InfoNet Technical Paper Number 1].

In May 2000, the results of a two-year study by Nebraska University's Institute of Agriculture and Natural Resources showed RR soya yielded 6% less than their closest non-GM relatives and 11% less than high-yielding non-GM varieties. The yield penalty was attributed to the gene insertion process [University of Nebraska (2000) #145, *Research shows Roundup Ready soybeans yield less;* IANR News Service].

The University of Wisconsin found GM soya yields from the 1998 harvest lower than non-modified varieties in over 80% of cases in trials across nine US states. A review of 40 trials of soya varieties in the north central region of the US in 1999 found a mean 4% yield drag in RR soya [Oplinger, E.S., M.J. Martinka, and K.A. Schmitz (1999), *Performance of transgenetic soybeans-Northern US*, presented to the ASTA Meetings, Chicago, cited in Clark, E.A. (1999) *10 reasons why farmers should think twice before growing GE crops*].

In the UK, reports of crop trials from the National Institute of Agricultural Botany show yields from GM winter oilseed rape and sugar beet 5-8% less than high-yielding conventional varieties [Reported in Farmers Weekly (UK), 4th December 1998].

In summary, yield losses, not yield gains, are more commonly associated with transgenic crops compared to the best available conventionally-bred cultivars and hybrids [Clark, E.A. (1999) '10 reasons why farmers should think twice before growing GE crops'].

Yield drag in soya is associated with problems in root development, nodulation and nitrogen fixation, particularly in drought or infertile conditions, as the bacterial symbiont responsible for nitrogen fixation is sensitive to both Roundup and drought [Benbrook, C.M. (2001), *Troubled times amid commercial success for Roundup Ready soybeans: glyphosate efficacy is slipping and unstable transgene expression erodes plant defenses and yields;* AgBioTech InfoNet Technical Paper Number 4]. Furthermore, there is a metabolic cost to expressing herbicide-resistance or the Bt-endotoxin. For example, levels of proteins responsible for plant defense responses are depressed following Roundup application. Although these are eventually restored to normal, pathogens quickly infect the plants in sub-optimal growing conditions. This forces a diversion of energy to repair damage, resulting in an essentially irreversible tax on yields.

University of Minnesota economist Vernon W. Ruttan sums it up: "Thus far, biotechnology has not raised the yield potential of crops" ['*Economist: Biotech has not made impact yet*'; Farm Progress, 21 November 2000].

The present international scientific knowledge, information and experience on GE crops and on crops engineered to contain the Bt gene in particular, emphasises the unpredictable, hazardous and unforeseen changes that can take place in the characteristics and behaviour of that organism itself; the unforeseen effects that it can have on other species if the gene is transferred to other species; the possibility of the creation and emergence of weed like characteristics and the creation of superweeds; the kind of potentially harmful impact that it can have on the environment and the ecology in general and in particular, the build-up of resistance in the target pest, *Helicoverpa armigera* (American bollworm) and other pests, which for cotton in India include *Pectinomorpha gossypiella* (pink boll worm), *Spodoptera litura* (army worm) and *Bemisia tabaci* (white fly).

The varieties of genetically engineered Bt cotton in India contain the Cry1Ac gene, of which Bharathan has stated "Cry1Ac is not the best gene for Indian conditions' (Bharathan, G 2000, *Bt-cotton in India: anatomy of a controversy;* Current Science 79:1067-1075). It is a known fact that *H. armigera* and *Spodoptera*, are less susceptible to Bt toxin than is *Heliothis,* the major US pest against which Bollgard gene was developed in the first place. Susceptibility is highly variable and resistance evolves rapidly in the laboratory [Kranthi, K.R., Kranthi, S., Alis, S., and Banerjee, S.K.; 2000; Resistance to CrylAc delta-endotoxin of *Bacillus thuringiensis* in a laboratory selected strain of *Helicoverpa armigera* (Huebner). Current Science 78:1001-1004.].

Buildup of resistance in American Bollworm to Bt

Studies conducted from the mid-90s onwards have shown that the target pest *Helicoverpa armigera* is increasingly becoming resistant to genetically engineered Bt varieties of corn and cotton. Bt cotton extensively grown in Arizona has shown that the decrease in non-Bt refuges increases chances of evolution of resistance in *Pectinomorpha*, a major pest of cotton in both Arizona and India [*Genetically modified pest protected plants: science and regulation;* 2000; National Research Council, National Academy Press, Washington, DC. USA].

The same study has shown that low toxin levels late in the season lead to relatively low susceptibility, which, combined with high intraspecific variation, increase chances of evolution of resistance in *Helicoverpa. [Genetically modified Pest protected plants: science and regulation*, 2000, National Research Council, National Academy Press. Washington, DC. USA.]

A 1998 study by Shen-Jin Liang *et al* from the Department of Plant Protection, Nanjing Agriculture University in China confirms the early build up of such resistance. The study indicated that populations of *H. armigera* from Yanggu (Shadong), Handan (Hebei), Xinxian (Henan), Xiaoxian (Anhui) and Fengxian (Jiangsu) provinces in China showed clear resistance to Bt. The effects of transgenic cotton lines expressing Bt toxin on various populations of *H. armigera* were also determined. The average mortality of newly hatched larvae of *H. armigera* (Yanggu and Xinxiang) with early resistance to Bt declined significantly (16-29%) compared with those of the susceptible strain. It is suggested that populations of *H. armigera* from Yanggu and Xinxiang were resistant to Bt and transgenic cotton expressing the Bt toxin.

Studies in China have been conducted on the impact of Monsanto's Bt cotton following its introduction and popularisation in 1997. In 2000, Bt cotton was grown on up to 1 million hectares, accounting for 30% of China's cotton production. It is estimated that the area planted for Bt cotton increased to 1.5 million hectares in 2001, 35% of the total cotton area. Monsanto's Bt cotton accounts for approximately two thirds of the Bt cotton grown, while several domestically developed varieties account for the remainder.

> *Studies conducted from the mid-90s onwards have shown that the target pest* Helicoverpa armigera *is increasingly becoming resistant to genetically engineered Bt varieties of corn and cotton.*

Bt cotton's environmental impacts

Research conducted during the past few years at four domestic academic institutions shows that Bt cotton is effective in controlling cotton's primary pest – bollworm (*Helicoverpa armigera Hbner*) – especially in the cotton's seedling stage. However, lab experiments and field research also demonstrate that there are adverse environmental impacts associated with the cultivation of Bt cotton:.

i. Although the Chinese studies fail to show significant impacts on natural predators associated with Bt cotton, there are associated adverse impacts on natural parasitic enemies of the cotton bollworm. Researchers have shown a decrease in the ratios of parasitisation and eclosion and reduction in the weights of cocoon and adult. The populations of parasitic natural enemies in Bt cotton fields are significantly reduced.

ii. Bt cotton is not effective in controlling many secondary pests, especially sucking pests. Field experiments showed that the populations of secondary pests such as cotton aphids, cotton spider mites, thrips, lygus bugs, cotton whitefly, cotton leaf hopper and beet armyworm increased in Bt cotton fields after the target pest – bollworm – had been controlled. Some pests replaced bollworm as the primary pests and damaged cotton growth.

iii. The diversity indices of the insect community, the pest subcommunity and the pest-natural enemies subcommunity, as well as the evenness index of Bt cotton fields are all lower than those in conventional cotton fields. However, the pest dominant concentration in Bt cotton fields is higher than in the conventional cotton fields. Therefore, the stabilities of insect community, pest subcommunity and pest-natural enemies subcommunity in Bt cotton fields may be less than those in conventional cotton fields, and the possibility of outbreaks of certain pests in Bt cotton is much higher.

iv. Both laboratory tests and field monitoring have verified that cotton bollworm can develop resistance to Bt cotton. Laboratory tests for selection of Bt-resistant bollworm indicated that the susceptibility of bollworm to Bt cotton fell to 30% after 17 generations under continuous selection with a diet of Bt cotton leaves. The resistance index of the bollworm increased 1,000 times when the selection was continued to the 40th generation. Based on these results, the scientists concluded that Bt cotton would probably lose its resistance to bollworm after it had been planted for 8-10 years continuously.

v. Bt cotton demonstrates excellent resistance to the second-generation bollworm and chemical control is not generally needed for the seedling period of Bt cotton.

vi. However, the resistance of Bt cotton to the bollworm decreases over time, and control is not complete in the third and fourth generations. It is now recognised in China that farmers must use two to three times the amount of chemicals to control the bollworm, particularly from mid-July to end-August. Despite this, there are not yet effective measures to postpone resistance development or otherwise resolve the resistance problem.[12]

Joanne Daly and Karen Olsen of CSIRO Entomology, GPO 1700 Canberra, ACT Australian Cotton Cooperative Research Centre state that resistance is an ongoing concern with the management of *Helicoverpa armigera* in the Australian cotton industry. In response, resistance management strategies (RMS) are in place to either prevent or retard further development of resistance to either chemical insecticides or to the Cry1Ac protein in transgenic plants. While these strategies have been successful at slowing down the rate at which resistance has developed to insecticides, they have neither prevented the ultimate spread of resistance to most field populations nor the evolution of new mechanisms of resistance that make resistance increasingly difficult to manage.[13]

Farmers in Australia are now being advised to spray additional insecticide on Monsanto's GM Bt cotton, INGARD, "under conditions of reduced INGARD plant efficacy".[14] The latest official guidance makes it clear that Bt cotton is in some circumstances failing to control the principal target pest it was introduced for, *Helicoverpa armigera*.

Rigorous field studies of teams led by Bruce Tabashnik (University of Arizona) and Fred Gould (North Carolina State University), both reported in recent years in the Proceedings of the National Academy of Sciences, U.S., provide solid evidence of insect resistance to Bt cotton.

The other big claim for GM crops is of a reduction in pesticide use. In reality, herbicide tolerant and Bt-transgenic varieties of GM crops are trapping farmers into a cycle of increased reliance on pesticides. Recently, hundreds of hectares of GM cotton fields in Bulukumba, South Sulawesi, were destroyed by pests.[15] Officials said that there was "nothing to worry about", and a spokesperson from Monsanto (the GM Bollgard cotton seed supplier) asserted that "they are just larva which eat the leaves, but will not disrupt cotton production". But local farmers complained, pointing out that the supplier had claimed the cotton variety was resistant to all kinds of pests.

Even when GM crops express pest resistance, there is little evidence of reduced pesticide use. This is borne out by data on transgenic cotton. Although to date one fourth of American cotton is produced with genetically engineered Bt varieties, no significant reductions in the overall use of insecticides were achieved [Thalmann, P. & V. Kung (2000), *No reduction of pesticides use with genetically engineered cotton*, for WWF International; and Thalmann, P. & V. Kung, (2000), *Transgenic cotton: Are there benefits for conservation? A case study of GMOs in agriculture, with special emphasis on freshwater*]. In fact, those insecticides that could be replaced by Bt cotton make up a minor proportion of insecticides used.

There is no independent evidence of a reduction in overall pesticide applications on Bt corn, despite industry claims. Nor is there an economic advantage in using Bt corn except in areas with very high pest infestation. Insecticide use on US Bt corn has in fact slightly increased.

Similarly, with Bt corn, there is no independent evidence of a reduction in overall pesticide applications despite industry claims. Nor is there economic advantage in using Bt corn except in areas with very high pest infestation. Insecticide use on US Bt corn has in fact slightly increased, with insecticides targeting European corn borer rising from about 4% of acres treated in 1995 to about 5% in 2000 [Benbrook, C.M. (2001), *Do GM crops mean less pesticide use?*; Pesticide Outlook, October 2001].

Since resistance has become a major worry, companies now insist that farmers follow resistance management plans (RMPs), which include "refugia" (keeping a certain proportion of fields free of Bt seeds and insecticides). These fields are to be the refuge of susceptible insects, thus slowing down the evolution of resistance. However, Tabashnik's team has questioned two fundamental assumptions behind all Bt RMPs – that resistance to Bt is a rare recessive trait and that cross-resistance to Bt endo-toxins is uncommon. The idea that resistance could be delayed through the use of two or more endo-toxins has, thus, been seriously undermined.

Further, field data show that expression of toxins in Bt-transgenic crops can develop unevenly in different parts of the plant. In one report, Bt toxin expression was found to be 90-95 per cent in the top part of the plant but only 20-25 per cent in the lower nodes, making them more susceptible. Since the lower nodes often produce the highest quality cotton, their loss is even more significant. Bt toxin expression also typically starts out high in the early part of the season but tapers off over time.[16]

It is also inadequate in harsh environmental conditions such as drought. This 'sub-lethal dose' of the toxin can facilitate the development of resistance over time, just as happens with pathogenic bacteria when we fail to complete a necessary course of antibiotics. Uneven expression of Bt in the crop could also accelerate the emergence of 'behavioural resistance' (M. Harris, Science, 1996), because insects may sense which parts of the plant to avoid. In India, with so many different agro-ecological conditions and millions of poor farmers, Bt-transgenic crops are likely to grow unevenly across farms leading to many cases of sub-lethal doses of the Bt toxin and, therefore, resistance might be engendered at an even faster rate. Estimates of how long resistance can be delayed vary, but the average figure in most research, even in relatively favourable circumstances in the U.S., is not more than five years. So powerful demands are being made that the Environment Protection Agency (EPA) should delay any further approval of Bt-transgenic plant varieties, and that previous approvals should be reversed when evidence points to imminent failure of an RMP. In any case, the EPA had granted only conditional registration to

Bt crops in 1995, mainly due to fears that pest resistance could develop.[17]

A study conducted in Alaska to see if targeted insect pests will evolve resistance to Bt showed that several species have evolved such resistance in the field, and many other species have been shown capable of evolving resistance based on lab selection experiments. IPM of Alaska has documented Bt resistant Indian meal moths in the Mat-Su Valley and Anchorage area in 2000 and 2001. The USDA tested Bt resistant strains of the moth at their Agriculture Research Service Biological Control laboratory in Nebraska. One strain developed resistance to the CryIAc toxin by a mechanism that gave it broad resistance to many diverse Bt toxins, including CryIIA, which is extremely different from the CryIAc toxin. This finding indicates that although there are many Bt toxins, if resistance evolves to one of them, we may not be able to just substitute a different Bt toxin.

The EPA has stated that one strain of the tobacco budworm that was selected to adapt to the CryIAc toxin developed a more specific mechanism for resistance. This strain now has over 5,000-fold resistance to CryIAc, which means it takes 5,000 times more toxin to kill the resistant strain than it takes to kill normal strains. The resistant strain also has high resistance to a number of other Bt toxins such as CryIF. Interestingly, this strain is not highly resistant to CryIIA. It has been estimated that one in a thousand tobacco budworms carries a gene for Bt resistance. This is a higher frequency than expected for conventional pesticides and may be related to the fact that Bt toxins are so species specific.[18]

Unlike risks of conventional pesticides that are typically limited to specific circumstances of use and location, and can be conceivably tackled, risks following Bt-transgenic resistance are essentially irrevocable. Once resistance genes emerge and gain a foothold in populations, they cannot be recalled.

Other environmental impacts

Numerous studies have shown that genetic pollution with the introduced gene can cause weedy relatives of the GM plant to become superweeds. Researchers have shown that a Bt gene can migrate to weeds in a natural environment, making them stronger. Scientists studied sunflowers engineered with a gene that produces a chemical toxic to certain insects to see what happened when transgenes were inadvertently passed along to weedy relatives. Bt sunflowers are not in commercial cultivation. The resulting hybrid sunflowers that contained the transgene had 50% more seeds than control hybrids without the gene. The researchers also found that the addition of this gene didn't harm the weeds' physical fitness, even when the sunflowers were deprived of water and nutrients. "A plant with a transgene may have to divert more energy to handle this new compound it's making," Snow said. "Doing so could reduce the plant's ability to reproduce. But that certainly wasn't the case here".[19]

There are also numerous studies by international scientists published in leading scientific journals showing hazardous impacts on non-target species as well as essential pollinators such as the monarch butterfly. Studies conducted by the U.S. Department of Agriculture's Agricultural Research Service (USDA-ARS), Corn Insects and Crop Genetics Research Unit, and the Department of Entomology, Iowa State University; Department of Entomology, University of Nebraska; Department of Environmental Biology, University of Guelph, Canada and Department of Statistics, Iowa State University, on the toxicity of various Bt proteins, confirmed the earlier findings of Losey *et al*, that Cry1Ab and Cry1Ac are toxic to monarch larvae. Losey's study was criticised on the grounds that there was no quantitative assessment of the protein consumed by the larvae. The latter study admits that in field conditions, the toxicity depends upon the amount of pollen consumed by the larvae.[20]

The insecticidal *Bt*-toxins, isolated from *Bacillus thuringiensis* are often engineered into plants in a pre-activated form, and are already known to be harmful to bees directly, and to lacewings further up the food chain. A recent study in Switzerland found that lacewings, which prey on corn pests, suffered mal-development and increased mortality when fed corn borers raised on Bt crops. [A Hilbech, W.J. Moar, M. Prisztai - Carey A. Fillppin and F. Zigler, Toxicity of Bt to the Predator *Chrysoperla carnea*, Environmental Entomology, Vol. 27, No 4, August 1998].

Research at the Scottish Crop Research Institute showed that lady birds fed on aphids which were fed on transgenic potatoes laid fewer eggs and lived half as long as lady birds on a normal diet [A.N.E. Brich et al *Interactions between plant resistance genes, pest aphid populations and beneficial aphids predators*, Scottish Crop Research Institute, Dundee, Annual Report 1996/97 p 68-71].

Evidences of the effects of GE-pollen on non-target species is increasingly coming to the fore. For example, a study on the phenomena of gene jumping done by Professor Hans-Hinrich Kaatz, a respected German zoologist at the University of Jena in Germany, found that the alien gene from genetically modified rape seed had transferred to bacteria living inside the guts of honey bees. This research suggests that all types of bacteria could become contaminated by genes used in genetically modified technologies, including those that live inside the human digestive system [The Observer, New Delhi, October 16, 1999].

One of the chief concerns with genetically engineered crops is that they may become weeds in agricultural and non-agricultural settings. There is potential for herbicide resistant varieties to become serious weeds in other crops. Plants by nature are not weeds, but due to physiological and structural traits these plants are allowed to persist in environments managed or otherwise influenced by humans. Some of these traits allow them to compete with cultivated crops or plants. Scientists have suggested that some transgenes may confer or enhance the presence of weedy characteristics in some crops, i.e., transgenes may enhance the crop's capacity to persist in a field, invade new habitats or both. It is possible that Bt plants do not show development of weedy character today, but there is no guarantee that it would not show such characteristics in the future. Weedy and invasive traits are not observed in one year or two and in some cases, show up only decades later. The lantana plant, brought into India by the British initially did not show any weedy character, but today it has totally invaded all of India's forests, destroying biodiversity and hindering regeneration.

Illegal Clearance and Illegal Trials

The conditional clearance by the GEAC dated 26.03.2002 for commercial release of transgenic Bt cotton seeds was based upon information obtained from previous tests and trials (open field trials) which were cleared by an authority without the jurisdiction required to grant such approval. The GEAC's decision needs to be seriously scrutinised as the permission granted to Monsanto for the open field trials was in violation of existing biosafety rules!

Under the *Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989* framed under the *EPA, 1986*, permission for the release of organisms into the environment and permission for conducting open field trials (which leads to release into the environment) as well as permission for import can only be given by the GEAC, which is part of the MoEF. However, in this case, such permission was given by the Department of Biotechnology, which is under the Ministry of Science and Technology, through the Review Committee on Genetic Manipulation (RCGM). Thus the permissions for large-scale field trials at 25 locations in 9 states dated 27.7.98 and 5.8.98, granted by the RCGM, and the proceedings that culminated in such permissions, were in violation of the 1989 Rules.

The 'permission' given by RCGM for import of transgenic material and the permission to conduct multicentric trials is blatantly illegal as it violates the Rules as well as the provisions of the EPA, 1986. As per Rule 4(4) the GEAC "*shall function as a body under the Department of Environment, Forests and Wildlife for approval of activities involving large-scale use of hazardous micro-organisms and recombinants in research and industrial production from the environmental angle. The Committee shall also be responsible for approval of proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials.*" Moreover, the law as contained in Rule 8 clearly states that "*production in which genetically engineered organisms are generated or used shall not be commenced without the consent of GEAC.*"

Rule 9(1) states that "*deliberate or intentional release of genetically engineered organisms including deliberate release for the purpose of experiment shall not be allowed.*" The introduction and trials of Bt cotton by Monsanto-Mahyco and 'approval' by the RCGM was hence in violation of all the above-mentioned Rules. This was the basis of the RFTSE's ongoing Public Interest Litigation filed in the Supreme Court of India in 1999. The case has now been shifted to the Appellate Authority formed under Rule 19 of the 1989 Rules.

The GEAC's haste in granting conditional clearance to Mahyco for commercial sale of its transgenic varieties is even more questionable when one considers the GEAC's exceedingly strict directions in the case of Navbharat-151, a transgenic cotton seed being sold without requisite statutory bio-safety clearance. Vide an order dated 18.10.2001, the GEAC directed that the entire standing crop of Navbharat-151 be uprooted and destroyed by burning. GEAC also ordered the recovery and destruction of the cotton and seeds harvested by the farmers from Navbharat-151 plants, the seed production plots and the breeding lines, hybrids, and segregating material, including any plucked cotton bolls or any breeding material and seed material available with the Navbharat Seeds company.

The transgene concerned in the GEAC's October 2001 decision on Navbharat is similar to that involved in the April 5, 2002 order (to Mahyco for commercial planting). So five months after ordering the destruction of Navbharat's seeds, the same GEAC granted conditional clearance to Mahyco for commercial sale of its transgenic varieties, when no new independent and impartial data was available!

Clearly, India does not have a proper set of guidelines, rules and systems for evaluating the biosafety and ecological and environmental impacts of genetically modified organisms used in crops. The Indian government itself admitted in recent meetings that the capacities, infrastructure and mechanisms for monitoring are yet to be built. It is absolutely essential that proper guidelines be in place with an independent monitoring and evaluation agency to ensure that 'open trials' and 'commercial release' of GMOs are safe for human health and ecology before they are permitted to be released into the environment.

Conclusion

Numerous independent field studies, by RFSTE and others, have disproved the claims made by Monsanto and Mahyco about Bt cotton as an effective pest resistant commercial crop. The Research Foundation had also conducted a field study during the first large scale field trails in 1998-1999 and went to the Supreme Court to challenge the false claims by the companies concerned. So far Monsanto and Mahyco have not submitted any data in the public domain. Despite this, the government accepted their claims and cleared Bt cotton for commercial planting. Now thousands of Bt cotton growers are facing hardships because of the failure of their Bt crops. Through its irresponsible and questionable haste in clearing an untested technology, the GEAC is responsible for the losses suffered by Bt cotton growers. Similarly, the powerful corporations involved are liable to immediately compensate the thousands of farmers in India who have been affected.

The concerns expressed, especially over the safety of GM foods, by a large number of healthcare and medical professionals, nutritional experts, social activists and environmentalists, in addition to many farmers' groups and consumers' groups, have not been addressed in a systematic or satisfactory way. Given the fact that India is a signatory to the Biosafety Protocol which is now very close to coming into force, it is necessary for India to respect the Precautionary Principle, also enshrined in the Protocol.

The Government of India must fulfill its obligation towards Indian farmers, Indian consumers, our environment, our diversity and our very agriculture by immediately imposing a 10-year moratorium on the irreversible release of GMOs in this country.

The authors work with the Research Foundation for Science, Technology and Ecology and can be contacted at rfste@vsnl.com.

References:

1. *Bt Cotton Will Not Spin Punjab's Yarn;* The Statesman, India, 15 April 2003
2. *Bt cotton proves a failure in Andhra Pradesh*; www.ndtv.com, 3rd March 2003
3. Letter from Joint Director Agriculture, Mehboobnagar to the Commissioner & Director of Agriculture, Andhra Pradesh; Letter No. E3/BT/AO.T/2002 dated 2.01.2003
4. *Bt cotton an official write off*; The Hindu, 26/01/2003; http://www.thehindu.com/2003/01/26/stories/2003012601690500.htm
5. *Government lies on Bt cotton performance*; www.greenpeaceindia.org
6. The Business Standard, New Delhi, 21st October 2002
7. The Hindu Business Line, New Delhi, 25.05.2002
8. The Hindu, New Delhi, 09.04.2002
9. *A Study claims the yield from Bt cotton is 80% higher. AP says it is below normal*; The Business World, 31st March 2003, page 26-28.
10. *Bt cotton: Seeds of Plenty; Empty Promise*, The Times of India, New Delhi, 12th March 2003
11. *USDA Report Exposes GM Crop Economics Myth*, 22nd August 2002, www.btinternet.com/~nlpwessex/Documents/usdagmeconomics.htm
12. *A Summary of research on the environment impact of Bt cotton in China*, Bt cotton in China – Summary of Research; Norfolk Genetic Information Network, 6th June 2002; http://ngin.tripod.com/060602a.htm
13. Joanne Daly and Karen Olsen, *Genetics of Bt Resistance;* http://www.cotton.pi.csiro.au/Publicat/Conf/coconf00/AREAWIDE/23/23.htm
14. http://www.biotech-info.net/Aussie_bt_cotton_problems.html
15. *Pests attack genetically modified cotton*, 29 June 2001, http://www.thejakartapost.com/yesterdaydetail.asp?fileid=20010629.A06
16. *Why Bt Cotton Should be Banned; The Hindu, September 6, 2001; http://www.organicconsumers.org/patent/cottonban091001.cfm*
17. ibid
18. *Pest Resistance to Bt*; Integrated Pest Management of Alaska; http://www.ipmofalaska.com/files/B_t_resistance.html
19. *GM Insect Resistance Could Pass to Weeds*; Http://www.agbiotechnet/topics/Database/newsarticles.asp?id=1722&name
20. *Monarch larvae sensitivity to Bacillus Thuringiensis – purified proteins and pollen*; http://www.biotech-info.net/PNAS-Hellmich_abstract.html