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GM Cotton in Gujarat: General Madness or Genuine Miracle?

Sudarshan Iyengar*
N. Lalitha**

Abstract: Genetically modified crops are the latest contribution to agriculture from modern plant biotechnology. As food security at a reduced cost and the promised of an assured crop has always attracted the attention of farmers and the State, genetically modified cotton or Bt cotton cultivation which meets these expectations is spreading steadily in developing countries. Farmers are willing to adopt this technology to reduce the pest attack and cost of cultivation and thereby improve the yield. India has also approved the commercial cultivation of the Bt cotton since 2002. There are a number of studies carried out by NGOs, independent researchers as well as some that are company sponsored, either for or against the Bt technology. Nevertheless, a uniform conclusion does not emerge from these studies about the performance of Bt cotton. Gujarat was one of the few states where genetically modified cotton was officially introduced in 2002. The unapproved Bt cotton by then had already entered the cultivation scheme of the farmers. A survey conducted in 2002 compared the performance features of the approved and unapproved varieties of cotton among farmers. The study showed that an equal number of acres were under the unapproved variety. While there are unresolved questions about the pest resistance capacity of the approved variety itself, the fast spread of the unapproved variety causes more concern. A detailed regulatory framework has been set up to regulate and monitor the research and open field trials of genetically modified organisms. However, it is evident that the reverse order information flow from the bottom to top layers of the framework is lagging so that this results in a flourishing sale of the unapproved variety and a lack of compliance with the biosafety regulations. This situation would actually lead to the technology loosing its potency sooner than it is expected leaving the farmers to look for a newer way out.

Keywords: Approved Bt, unapproved Bt, farmers, biotechnology, regulation, environment, pesticide

* Vice Chancellor, Gujarat Vidyapith, Ahmedabad, India.
Email: vc@gujaratvidyapith.org

** Associate Professor, Gujarat Institute of Development Research.
Email:Lalitha@gidr.ac.in, lalitha_narayanan@hotmail.com

Introduction

Biotechnology refers to the manipulation of living organisms for scientific or industrial use. The 'modern' biotechnology refers to a set of techniques such as genetic engineering, cell and tissue cultures, protein synthesis and enzymology. This is different from the earlier technologies involved in making bread, vaccines and antibiotics as it involves the manipulation of the original traits or gene of an organism. Such genetic manipulation can be to: (a) alter the genes already functioning within an organism; (b) transfer a gene from one organism to another organism of the same species and (c) transfer a gene from one organism to an organism of a different species. This type of genetic modification is known as resulting in genetically modified organisms (GMO) or *transgenic* because it cuts across species and plants. In agriculture, it can be expected to benefit developing countries by for example (a) increasing productivity; (b) reducing vulnerability due to the whims of nature and on slaughts of pests, and (c) improving the nutritional quality of the food. The area under GM crops is steadily increasing in many parts of the world - from 1.7 million hectares in 1996 to 58 million hectares in 2002.

However, such GMOs in plants have evoked a mixed response from agriculturalists and environmentalists since the concern is not only to improve agricultural productivity but also to sustain the natural resources and protect the environment in the process. In India also, the area under genetically modified cotton crop is increasing in spite of a strong lobby against the entry of GM crops in the country. The protest in India forms part of an international environmental movement against GM crops in general. There have been allegations and counter allegations of suppression of facts that reveal the possible positive and negative impacts. There are questions of economic gains both short-term and long-term and the environmental and ecological sustainability of introducing GM crops. There are two types of argument that are made.

One set deals with the insincerity and inadequacy on the part of the regulatory mechanisms that have been constituted and the working of these. This argument has its basis in the belief that the developing countries are not generally equipped to handle the testing and regulation of innovative technological breakthroughs that claim a tremendous potential to bring revolution in the sector or sub sector. It is thus, implicitly assumed that technological breakthroughs and their potential do not have any intrinsic problem, but the operationalization and regulation of these is problematic and hence such technologies should not be brought in without adequate preparedness. The second set of arguments raise doubts about the potential of the technology to help humanity in reducing poverty and in increasing material welfare. Environmentalists all over the world use both types of arguments to attack the possible propagation of new technologies such as the GM seeds. In India, the commercialization of GM cotton was allowed only in 2002 in a few states, which has raised a series of issues ranging from the validity of the field trials to the performance of GM cotton in the country. While these issues by and large remain unanswered, the unapproved GM cotton is being cultivated in most of the cotton growing states.

This raise issues such as: (a) what kind of regulatory framework do we have in India to monitor such new technologies; (b) the type of intellectual property protection offered to plant varieties and the GM cotton in question; (c) why farmers prefer to use unapproved variety of cotton, and (d) what are the implications of the spread of unapproved variety in India? Some of these issues warrant attention and discussion. We attempt to seek answers to some of these questions in this paper. The paper is organized as follows. In the section that follows the introduction, we discuss the regulatory framework that exists in India for the promotion and monitoring of biotechnology. In the third section we discuss the intellectual property protection offered to plant varieties. In the following section we compare the performance of the approved and unapproved variety with the help of data that were collected from a survey among selected farmers in Gujarat. In the final section, a few comments are made on the present scenario and its likely fall out in future on GM cotton as well for as other GM crops.

Regulatory Framework for Plant Biotechnology in India

Both developed and developing countries have put in place certain guidelines for the research, trials and cultivation of GM crops. India is a signatory to the Convention of Bio diversity and has also signed and ratified the Cartegena Protocol (CP) on biosafety. Therefore, India is committed to establish or maintain means to regulate manage or control the risks associated with the use and release of GMOs, which are likely to have adverse environmental impacts and affect the conservation and sustainable use of biological diversity. Hence a detailed legal and institutional framework governing GM crops has been set up in view of the fact that a number of trials are going on in the private and public sector. It appears that India perhaps adopts the concept of familiarity and a product based approach in approving the commercial release of a GM crop. As per the concept of familiarity, the possible risk characteristics of the GM crop are studied in comparison with the non-GM crop. The product based approach ensures that all plants and the product with new characteristics not previously used in agriculture or production are monitored irrespective of whether they contain a GM trait or not.

GMOs are regulated in India under the purview of Environment Protection Act, 1986. The objective of this Act is to protect the environment, nature and health in connection with the application of genetic engineering in producing GMOs. The 1989 Rules for the 'manufacture, use, import, export and storage of hazardous micro organisms, genetically engineered organisms or cells' were subsequently revised in 1994 and 1998. These rules mandate the creation of six competent authorities that are in charge of lab experiments, field experiments and the commercial release of GMOs as mentioned below:

(i) Recombinant DNA Advisory Committee (RDAC) is mandated to evolve the Recombinant DNA safety guidelines. RDAC also reviews biotechnology developments at the national and international levels and recommends suitable biosafety regulations for India.

(ii) Review Committee on Genetic Manipulation (RCGM) functions under the Department of Biotechnology and includes representatives of: Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR), Indian Council of Agricultural Research (ICAR) and Council of Scientific and Industrial Research (CSIR). Functions of the RCGM include the issuing of guidelines for GMO research, authorizing rDNA projects in high-risk category and controlled field experiments and permitting imports of GMOs for research.

(iii) Genetic Engineering Approval Committee (GEAC) functions as a body under the Department of Environment, Forests and Wildlife and comprises of: (a) Chairman-Additional Secretary, Ministry of

Environment and Forests, (b) Co-chairman – a representative from the Department of Biotechnology, (c) Representatives from the Ministry of Industrial Development, (d) Departments of Biotechnology and Atomic Energy, (e) Indian Council of Medical Research, (f) Council of Scientific and Industrial Research, (g) Directorate of Plant Protection, and (h) Central Pollution Control Board (CPCB). The functions of this Committee are to: authorize commercial use (including import) of GMOs or their products; authorize large scale production and release of GMOs and their products into the environment; and mandate restrictions or prohibitions on production, sale, import or use of GMOs, if necessary.

iv) State Biotechnology Coordination Committee (SBCC) should be established as per the guidelines, in states where research or experiments with GMOs is going on. The Committee comprises of: the Chief Secretary of the State Government; Secretaries from the Departments of Environment, Health, Agriculture, Commerce and Forests, Public Works, Public Health; Chairman, State Pollution Control Board; and state microbiologists and pathologists. The functions of the SBCC is to: periodically review safety and control measures in institutions handling GMOs; inspect and take punitive action in case of violations through the State Pollution Control Board or Directorate of Health; act as nodal agency at the state level to assess damage if any from the release of GMOs and to take on-sight control measures.

(v) District-level Committee (DLC) is required to be established in the districts wherever GMO trials or research is going on. The DLC should comprise of: District Collector, Factory Inspector, Pollution Control Board Representative, Chief Medical Officer, District Agricultural Officer, Public Health Department Representative, district microbiologists/pathologists, Municipal Corporation Commissioner. The functions of the DLC are to: monitor safety regulations in installations; investigate compliance with rDNA guidelines and report violations to SBCC or GEAC; act as nodal agency at the district level to assess damage if any from release of GMOs.

(vi) Institutional Bio safety Committee (IBSC) should be established by every institution engaged in GMO research. This should consist of the head of: the organization, scientists engaged in rDNA work, the biosafety or Medical Officer and a nominee from the Department of Biotechnology. The functions of this committee are to: oversee rDNA research activities; seek approval of the RCGM for category III risk experiments- experiments on transgenic traits which on release into the environment may cause significant alterations to the biosphere, ecosystem, plants and animals; ensure adherence with bio safety guidelines; prepare an emergency plan for exigencies that could arise; and keep the District Level Committee, State Level Biotechnology Co-ordination Committee and GEAC informed about relevant experiments.

The above framework shows that regulatory authorities have been set up with specific responsibilities at the central, state and district level indicating a top down approach. Such an approach necessitates that after the commercial release of the GM crops, the reverse order flow of information from the district to the central government has to be there to ensure that regulating guidelines are complied with and for monitoring of GM crops. This is very essential to ensure that the appropriate procedures are followed prior to and after the open release of GMOs.

Intellectual Property Protection for Plants

Traditionally most biological research in the field of agriculture was kept outside the arena of intellectual protection because, these biological entities have the ability to reproduce themselves, which made it difficult to enforce property protection. But providing intellectual property rights was in practice for plant species like flowers, fruits and vegetables that could be bred and do not reproduce by conventional and natural methods. In the recent past, there has been huge investment-intensive research in agricultural crops as well in the private sector of the developed countries. According to an estimate, private investment in biotechnology research ($5billion) is far ahead of the public investment in developed countries. In comparison to this, there is hardly any private investment in the developing countries and the public investment in biotechnology is around $125 million. The western countries, particularly the US, lead the rest of the world in plant biotechnology followed by Europe and Japan. The business and research environment prevailing in these countries supported by strong intellectual property protection has enabled these countries to march ahead of other countries.

Patents, plant breeders' rights, trademarks, geographical indications and trade secrets can protect innovations in agriculture. Besides this the Union Internationale pour la protections des Obtentions vegetables (UPOV), a multilateral treaty which is administered in cooperation with the World Intellectual Property Organization (WIPO), is also adopted by several countries.

India has however developed a *sui generis* system, which is weaker than the patent system after nearly a yearlong debate on the draft bill on Indian Plant Varieties and Farmer's Rights Bill in 2001. The highlights of this IPVRB are: (a) Varieties will be granted protection on the basis of novelty, distinctness, uniformity and stability. (b) The distinctness of a variety is recognized if the said variety is distinguishable by at least one essential characteristic from any other variety whose existence is common knowledge in any country at the time of filing the application. (c) Registration under this Act shall confer an exclusive right on the breeder or his successor, his agent or licensee to produce, sell, market, distribute, import or export the variety. (d) A farmer shall be deemed to be entitled to save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act in the same manner as he was entitled before the coming into force of this Act. However, a farmer will not be entitled to sell branded seed of a variety protected under this Act. A protected variety can be used for conducting experiment or research. But if an initial source of a registered variety is repeatedly used for the purpose of creating other varieties for commercial production, then authorization of the breeder of the registered variety is required.

The important aspects in which the Indian Act scores merit over UPOV or patent protection is that the distinctiveness criterion requires that the variety seeking protection is to be distinguishable from other variety by at least one essential characteristic. Second, the extent of protection provided to the breeder stops at the right to produce, sell, market, distribute, import or export the variety and does not extend to harvested material and other products obtained from material of the variety. That is, for instance, Monsanto cannot claim right over the harvest from the protected seed, which can be used by the farmer for subsequent cultivation. It may be noted that most non-European legislation including that of the US allows farmers to save seeds of protected varieties. However, European legislation is more stringent on this. Under arrangements between EU farmers and breeders all farmers have to pay royalty even when they use farm-saved seed of protected varieties, though the royalties are lower than those for commercial seed. This restriction greatly increases the revenue a breeder can derive from marketing a new protected variety.[1]

In India, the IPVRB will be implemented by the Plant Varieties and Farmer's Rights Protection Authority. Whereas the original Bt gene of Monsanto is protected in the US, companies seeking introduction of this gene have to obtain a license from Monsanto and get an approval from the GEAC for introducing the same in India. It may be noted that though it is not possible to get a plant patent in India, 'patents are possible for many aspects of a plant and its utilization except the plant per se. Inventors have to look for multiple protection and not just think in terms of protecting plant per se' (*IPR Bulletin*. September 5, 2004).

'In India, 484 applications have been filed specifically referring to plants since November 1994 till December 2003. Of these 484 applications, 221 are convention applications and 265 are non-convention applications. The convention applications also include 132 PCT applications out of which 72 relate to plant extracts and 60 relate to various compositions from plant products. The major applicants are CSIR, Avestha Gengraine Tech (19), JB Chemicals and Pharmaceuticals Ltd (11) and Synit Drugs Pvt. Ltd (10). 109 applications were filed in 2001 and 70 were filed in 2002' (*IPR Bulletin*, Sept, 2004).

This Bulletin also reports that the CSIR obtained a plant patent from the USPTO in August 2001 for a new hybrid variety of mint or mentha claiming priority from June 03 1998. The invention relates to a new and distinct interspecific hybrid mint plant called 'Neerkalka' which is developed by asexual crossing between improved Mentha arvensis and pollen plant mentha spicata. Nevertheless, the research that is going on in both the private and public sector in India (Tables 1 and 2) necessitates an appropriate plant protection system in place for India.

Table 1: Major Developments in Transgenic Research and Application in Public Sector

Institute	Plants/Crops	Transgene(s) inserted	Aim of the project
AAU, Johat, Assam	Chickpea	Bean alpha AI	To generate plants resistant to bruchids
Bose Institution Kolkata	Rice	S-adenosylmetbinine decarboxylase	To generate plants tolerant to stress
Central Institute for Cotton Research, Nagpur	Cotton	Bt. Cry gene(s)	To generate plants resistant to lepidopteron pests
Central Potato Research Institute, Simla	Potato	Bt. Cry1A(b)	To generate plants resistant to lepidopteron pests
Central Tobacco Research Institute, Rajahmundry	Tobacco	Bt. CrylA(b) and cry IC	To generate plants resistant to Helicoverpa armiger and Spodoptera litura
Centre for Cellular and Molecular Biology, Hyderabad	Rice	Bar	To generate herbicide-tolerant plants
Central Rice Research Institute, Cuttack	Rice	Bt. CryIA(b) Xa21	To develop plants resistant to lepidopteron pests, bacterial blight/disease
Delhi University, South Campus, New Delhi	Mustard/ rapeseed	Bar, barmase, borstar	To generate herbicide-tolerant plants, male-sterile and restorer lines for hybrid seed production
	Rice	Pyruvate decarboxylase and alcohol dehydrogenase	To generate plants tolerant to flooding
	Tomato	Ctx-B and Tep antigens of Vibrio cholerae	Edible vaccine development

Table 1 continued

Table 1 continued

Institute	Plants/Crops	Transgene(s) inserted	Aim of the project
	Brinjal	Chitinase, glucanase and thaumatin encoding genes	To generate plants resistant to diseases
	Cabbage	Bt. CryIA(b)	To generate plants resistant to lepidopteron pests
	Wheat	Bar, HVAI, PIN2	Resistance against biotic and abiotic stresses
	Rice Pusa basmati	Cod A, Cor 47,	Resistance against biotic and abiotic stresses
Directorate of Rice Research, Hyderabad	Rice	Xa-21, cry 1 A (b)	To generate plants resistant to lepidopteran pests and bacterial and fungal diseases
Indian Agricultural Research, Institute, New Delhi	Brinjal	Bt. CryIA(b)	To generate plants resistant tolepidopteron pests
	Cauliflower	Bt. CryIA(b)	To generate plants resistant to Pluella scylostella
	Tomato	Bt. CryIA(b)	To generate plants resistant tolepidopteron pests
	Cabbage	Bt. CryIA(b)	To generate plants resistant to P scylostella
	Rice	Bt cry 1A(b), Chitinase	To generate plants resistant tolepidopteron pests
	Mustard/ rapeseed	Arabidopsis annexin gene	To generate stress-tolerant plants
	Mustard/ rapeseed	Choline dehydrogenase	To generate abiotic stress-tolerant plants

Table 1 continued

Table 1 continued

Institute	Plants/Crops	Transgene(s) inserted	Aim of the project
	Potato	ACC synthase	To control fruit ripening
	Tomato	ACC synthase	To control fruit ripening
	Banana	ACC synthase	To control fruit ripening
	Tobacco	Chitinase, glucanase and RIP	To generate plants resistant to fungal attack
	Brassica	Chitinase, glucanase and RIP	To generate plants resistant to fungal attack
	Pigeonpea	Protease inhibitor and lectin genes	To generate plants resistant to boll worms and aphids
IARI sub-station, Shillong	Rice	Bt. Cry1A(b)	To generate plants resistant to yellow stern borer
International Centre for Genetic Engineering Bio-technology, New Delhi	Tobacco	Bt.cryIla5	To generate plants resistant to Spodop eratlitura
	Rice	Gm2	To generate plants resistant to gall midge
International Crop Research Institute for Semi-Arid Tropics, Hyderabad	Chickpea	PGIP	To generate plants resistant to fungal pathogens
Indian Institute of Horticulutral Research, Bangalore	Muskmelon	Rabies glycoprotein gene	To develop edible vaccines
	Tomato	Leaf curl virus sequence	To generate plants resistant to leaf curl virus
	Tomato	Chitinase and glucanase	To generate plants resistant to fungal diseases

Table 1 continued

Table 1 continued

Institute	Plants/Crops	Transgene(s) inserted	Aim of the project
	Citrus	Coat protein gene of citrus triesteza virus	To develop transgenic citrus plants resistant to cirus triesteza
Jawaharlal Nehru University, New Delhi	Potato	Ama-1*	To generate nutritionally enriched plants
	Tomato	OXDC*	To generate plants resistant to fungal infection
Madurai Kamaraj University, Madurai	Blackgram	Dianhin and barmase gene or Bar	Development of insect resistant and herbicide-tolerant plants
	Blackgram	Coat protein and replicase genes of Vigna mungo yellow mosaic virus	To develop viral-resistant plants
	Rice	Chitinase, B-1,3 glucanase and osmotin genes	To develop plants resistant to fungal infection
	Coffee	Chitinase, B-1,3 glucanase and osmotin genes	To develop plants resistant to fungal infection
Narendra Dev University of Agriculture, Faridabad	Rice	Cry1A(b)gene	To generate plants resistant to lepidopteron pests, bacterial and fungal diseases
National Botanical Research Institute, Lucknow	Cotton	Cry1E and CryIC with terminal altered at C-end	To develop transgenic resistant to Spodopotera litura and Helothisis armigera
Punjab Agricultural University, Ludhiana	Rice Pusa basmati	Cry1Ab, Cry1Ac	For resistance against yellow stem borer

Table 1 continued

Table 1 continued

Institute	Plants/Crops	Transgene(s) inserted	Aim of the project
Tata Energy Research Institute, New Delhi	Mustard	Ssu-maize Psy and Ssu-tpCrt1 gene	To generate plants containing high levels of b-carotene
Tamil Nadu Agricultural University, Coimbatore	Rice	GNA gene	To generate plants resistant to pests gall midge
University of Agricultural Sciences, Bangalore	Muskmelon	Rabies glycoprotein gene	To develop edible vaccines

* Genes isolated in India. In most of the viral work, sequences for pest-derived resistance (PDR) have been isolated from the viral strains predominant in India

Source: www.iisc.ernet.in/currsci/feb102003/297.pdf

Table 2: Transgenic Lines in Advanced Stage of Development for Field Trials in Private Sector

Ankur Seeds Ltd., Nagpur	Cotton*	Cry1A (C)	To generate plants resistant tolepidopteron pests
Hybrid Rice International, Gurgaon	Rice	Cry1A(b), cry9(c) and bar genes	To develop plants resistant to lepidopteron pests and herbicide tolerance
Indo-American Hybrid Seeds, Bangalore	Tomato	Alfalfa glucomase and Tomato leaf curl virus genes	To generate plants resistant to viral and fungal attacks
MAHYCO, Mumbai	Cotton*	Cry1A©	To generate plants resistant to lepidopteron pests
	Cotton*	CP4ESPS	To generate plants for resistance to herbicide glyphousie
	Cotton*	CryX gene	To generate plants resistant lepidopteron pests
	Corn*	CrylA(b)	To generate plants resistant lepidopteron pests
	Pigeonpea	GUS	For transformation work
	Rice	CrylA©, Xa21 and GNA genes	To generate plants resistant to lepidopteron pests, bacterial blight and sucking pests
	Mustard	CP4 EPSPS	To generate plants tolerant to herbicide
MAHYCO Research Foundation, Hyderabad	Rice	Xa-21	To generate plants resistant to bacterial blight
Progo PGS (India) Ltd. Gurgaon	Brasical mustard	Bar, banase, barstar	To develop superior hybrid cultivars
	Tomato	CrylA(b)	To generate plants resistant to lepidopteron pests

Table 2 continued

Table 2 continued

	Brinjal	CrylA(b)	To generate plants resistant to lepidopteron pests
	Cauliflower	CrylH/Cry9C lepidopteron pests	To generate plants resistant to
	Cauliflower	Bar, Barmase, Barstar	To develop superior hybrid cultivars
	Cabbage*	Cryl 9C lepidopteron pests	To generate plants resistant to
Syngenta India Ltd., Pune	Cotton*	Vip 3 gene lepidopteron pests	To generate plants resistant to
	Maize*	CrylA(b) lepidopteron pests	To generate plants resistant to

Transgenics developed elsewhere are being backcrossed to inbred lines to develop commercially viable hybrids that can be grown in different agroclimatic regions of the country
Source: www.iisc.ernet.in/currsci/feb102003/297.pdf

Performance of GM Cotton in Gujarat

Cotton is an important commercial crop in Gujarat and farmers readily adopt hybrid cotton. A larger percentage of cotton falls under the unirrigated area. Like the rest of the cotton growing parts, frequent and intensive pest attacks have caused a severe set back to the cotton crop in Gujarat and farmers became indebted. Hence, any technological breakthrough promising lower pest attack and improved yield levels would be welcomed by the farmers of Gujarat. Table 3 reports that cotton cultivation on an average accounts for 15 per cent of the total area under cultivation in Gujarat. Whereas the area under cotton crop in the state increased from 1566 in 1980-81 (000 hectares) to 1750 in 2002, production declined from 1738 to 1703 followed by the declining trend in yield from 189 to 165. Moving averages indicate that whereas the area under cotton has stagnated after 1996-97, production has been inconsistent. The late 1990s is also the period when the cotton crop all over the country failed due to severe pests attack contributed by unseasonal rainfall in several places. This was the scenario at the time of introduction of GM cotton in Gujarat.

Chronology of Events Preceding Introduction of Bt Cotton

It may be useful to go through the chronology of events in the introduction of Bt cotton in India and Gujarat. In March 1995, the Department of Biotechnology, Government of India permitted an import of 100 grams of Transgenic Cocker - 312 variety of cottonseeds by Mahyco from the US. In April 1998, Monsanto entered into collaboration with Mahyco and got permission for undertaking small trials of 100 gm Bt per trial. In November 1998, thousands of farmers in Karnataka burnt down the Bt cotton trial field protesting against Monsanto. In January 1999, the Research Foundation for Science, Technology and Ecology (RFSTE) of New Delhi challenged the legality of the field trial permission granted by the Department of Biotechnology. In July 2000, permission was granted to undertake large-scale field trials including seed production at 40 sites in six states. The data, because of which the permission was granted, was kept confidential. However, it was inferred that the small trials showed that Bt Cotton was 'safe'. In January 2001, a ten member team from the US comprising of judges and scientists came and educated the Chief Justice of the Supreme Court of India on biotechnology. In June 2001, an

Table 3: Area, Production and Yield of Cotton in Gujarat 1980-81 – 2001-02

Year	Area in 000 Hectares	3 years Moving Average	Production in 000 tonnes	3 years Moving Average	Yield in 000 Bales of 170 Kg. each	3 years Moving Average	Area under Cotton as Percentage to total area under crops
1980-81	1566	-	1738	-	189	-	13.45
1985-86	1451	-	2122	-	249	-	13.16
1990-91	1042	-	1531	-	250	-	9.85
1991-92	1135	1109	1181	1567	177	240	16.08
1992-93	1151	1137	1988	1597	294	239	15.46
1993-94	1126	1197	1623	2044	245	289	10.74
1994-95	1313	1319	2522	2184	327	281	11.72
1995-96	1517	1457	2408	2583	270	303	13.86
1996-97	1542	1552	2819	2881	311	315	14.16
1997-98	1598	1604	3417	3413	364	361	14.55
1998-99	1672	1672	4004	3169	407	334	15.27
1999-00*	1539	1539	2086	2417	230	253	15.89
2000-01*	1615	1615	1161	1650	122	172	17.43
2001-02*	1750	-	1703	-	165	-	17.49

Source: Socio Economic Review Gujarat State, 2002-03.

open dialogue was held between Monsanto and Greenpeace to discuss Bt cotton with scientists, representatives of the Ministry of Environment and Forest and farmers. Field data was not shared in this meeting. In the same month, that is in June 2001, the GEAC approved large-scale trials and Mahyco conducted trials in 100 hectares in seven states.

Around September 2001, scientists from Mahyco observed that transgenic cotton was being grown at nearly 10,000 acres of Gujarat. It was reported that these farmers had purchased the seeds from Navbharat, a seed company, which is thought to have developed the seed as a hybrid from the transgenic seed, imported from the US. Since this large-scale plantation was done without GEACs permission, GEAC ordered the destruction of the crop.

In November 2001, Gene Campaign filed a case in Delhi High Court challenging the government with negligence in allowing large scale field trials conducted without appropriate monitoring, regulation and safety precautions. In February 2002, the Indian Council of Agricultural Research (ICAR) submitted a positive report to the MoEF on the field trials of Bt cotton. On 26 March 2002, India joined the GM community by giving a green signal for the commercial cultivation of GM crops. Three varieties of cotton using Monsanto's Bt technology got the approval. Two seasons have passed since and the third is in progress. Farmers in Andhra Pradesh, Maharashtra, Madhya Pradesh, Karnataka, and Gujarat have grown Mahyco-Monsanto Bt cotton during Kharif 2002, 2003 and 2004. Full studies containing detailed data on various claims and doubts are yet to come out in the open. In April 2003, the GEAC denied the commercial clearance to Monsanto's Bt cotton for the north Indian states. In May 2004, GEAC has granted permission to Rasi Seeds to sell Bt cottonseeds in central and south India.

Performance of Bt Cotton in India: Recent Experiences

The legal introduction of GM crops in India began with genetically modified cotton that are resistant to bollworm attack and was introduced by the Maharashtra Hybrid Seed Company (Mahyco), which has a 50:50 partnership with Monsanto.[2] So far, cotton remains as the single GM crop that has been allowed for sale in India.[3] The company's claim with respect to the GM variety is that: (a) Bt Cotton will reduce pesticides use considerably; (b) cultivation costs will come down drastically; and (c) profits for farmers will increase.

Mixed reports are available on the performance of Bt cotton from different places. Qaim's study (2001) using the field trial data of Mahyco-Monsanto clearly brings out the cost advantages of Bt cotton cultivation particularly in pesticide reduction over hybrids and the conventional cotton variety. However, studies conducted by independent research agencies and the non-governmental organisations show a different trend, which is presented, in the following paragraph. The AC Neilson ORG_MARG study conducted in 2003 in Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka among the bollgard cultivators (1672 farmers) and the conventional cotton cultivators (1391 farmers) reports that the bollgard growers experienced better yield, reduction in pesticide use and a net gain which is provided in Table 4.

Table 4: Performance of Bt Cotton in Selected States

State Bollworm pesticide	Reduction in Increase		Yield net profit		Increase in	
	%	Rs.	%	Quintal per acre	%	Rs. Per acre
Andhra Pradesh	58	1856	24	1.98	92	5138
Karnataka	51	1184	31	1.36	120	2514
Maharashtra	71	1047	26	1.48	66	2388
Gujarat	70	1392	18	1.20	164	3460
MP	52	889	40	2.2	68	3876
All India Weighted average	60	1294	29	1.72	78	3126

Source: AC Neilson survey 2004.

As evident from this table the performance of Bt cotton in these states has been better as compared to the conventional variety. However, the study conducted by the Andhra Pradesh Coalition in Defence for Diversity (APCIDD) showed a different result. According to APCIDD study, in Kharif 2002 about 1200 farmers cultivated Bt cotton in Warangal district alone. Warangal district is the highest cotton-growing district as well as the highest Bt cotton grower in the state. More than 90 per cent cultivated Bt Mech 162 and the variety was a miserable failure according to the APCIDD study. The Monsanto study on the other hand showed good results and the failure was attributed to the bad monsoon and a dry year.

In the next season of Kharif 2003, APCIDD continued its season-long study and added two more districts Adilabad and Kurnool. Twenty eight villages and 164 farmers were selected and were visited every fortnightly by 11 NGO volunteers and the APCIDD technical team members. Monsanto also contracted AC Nielsen for the study. The comparative results are given in Table 5.

Table 5: Comparative Results for Andhra Pradesh

	Characteristics	Monsanto Neilsen Study	APCIDD Study
1.	Bollworm Pesticide Reduction		
	Quantity	58 per cent	14 per cent
	Cost	Rs. 1856	Rs. 321
2.	Yield Increase		
	Percentage	24	2
	Quantity	1.98 qu/ac	0.09 qu/ac
3.	Increase in Net Profit		
	Percentage	92	-9
	Monetary	5138	-750

Source: Compiled by Authors.

Working out the economics of cotton cultivation, Suman Sahai (2002) observes that the farmers in Maharashtra perceived that they need about 1 kg of seed per acre, which works out to a cost of Rs. 700 to Rs. 900 per acre depending on the variety. All available hybrid seeds cost between Rs. 300 and Rs. 450 per each 450 gms bag. For the sake of calculations, she has considered the seed cost to be an average of Rs. 800 per acre. Pesticide sprayings work out to another Rs. 1000 per acre. Wardha and almost all of Vidarbha is rainfed so the yields are lower compared to the irrigated areas in Punjab and Haryana. The average cotton yields are around 3 quintals per acre in this region. In this situation, two new varieties of cotton, one legal and the other illegal have become available to farmers. The Mahyco-Monsanto varieties are priced at Rs. 1600 per bag. The economics in this case will be: cst of seed per acre will go up to Rs 3200. If pesticide use is reduced because of the Bt toxin, say even by as much as a dramatic 60 per cent, savings on pesticide will work out to Rs. 600 per acre. The yield will not be affected much since Bt cotton has not been bred to confer a yield advantage but has the advantage of disease resistance. Also the lack of irrigation facilities will work against the yield increase. Therefore, the economics of Mahyco-Monsanto's Bt cotton look very unfavourable for the farmer. A total outlay of Rs 3600 (3200 for seed + 400 for pesticide) as against Rs 1800 per acre in the old system (800 for seed + 1000 for pesticide) is worked out. This means an increased outlay of Rs 1800, which is double. The cost advantage in case of Bt thus appears doubtful according to her study.

Gupta and Chandak's study (2004) was conducted in various parts of Gujarat except Kutchch where 363 farmers were surveyed in 2001-02, the year when Navbharat was formally selling seeds. The survey revealed that farmers who had used Mahyco seeds experienced higher yield with higher costs. Navbharat and its derivatives provided higher yields than normal hybrids at a much lesser cost.

GEAC's own study also observes that the Bt cotton did not perform well. Following widespread complaints of failure of Bt cotton in Madhya Pradesh in early last year, GEAC commissioned a seven-member team of scientists to evaluate the performance of the crop. This study reported that Bt cotton failed in Madhya Pradesh due to wilting and large scale drying of the crop at the peak bolling stage accompanied by leaf dropping and shedding as also the forced bursting of immaculate bolls. According to the study non-bt plants performed much better[4] (Krishnakumar, 2004). The panel set up by the Gujarat government also said that 'it is unfit for cultivation and should be banned in the state[5] (Krishnakumar, 2004).

Thus, while the company-sponsored studies present a positive picture, the other studies emphasize that the Bt variety neither has cost advantage nor yield advantage. While the above mentioned studies have compared the performance of Bt cotton and the conventional cotton, Jatan, a network of farmers and organizations propagating organic farming in Gujarat in collaboration with the Gujarat Institute of Development Research, Ahmedabad undertook a study of selected farmers in Gujarat who had grown Bt during the 2002-03 agricultural season. The objectives of the study were to: (a) understand the impact of Bt cultivation; (b) analyse the experience of farmers cultivating approved Bt cotton; (c) understand the farmer's awareness about cultivating approved Bt cotton; (d) identify whether the conditions set forth for the cultivation of approved Bt cotton had been followed; and (e) compare the performance between approved Bt cotton and unapproved Bt cotton in the agricultural year 2002-03. In ten districts of Gujarat, 410 farmers were surveyed for the study. The chosen districts were Kutchch, Sabarkanta, Gandhinagar, Bhavnagar, Rajkot, Bharuch, Vadodara, Surendranagar, Amreli and Narmada which are all traditionally cotton growing areas. The sample is purposive and covered only those farmers cultivating Bt cotton (approved and unapproved variety) and the survey was carried out by Jatan volunteers. In subsequent paragraphs we discuss the performance of the approved and unapproved variety in Gujarat. Table 6 gives details on the sample farmers' distribution in the state.

Table 6: Distribution of Sample Farmers in Gujarat Growing Approved and Unapproved variety in 2003-04

Districts	Total farmers selected	Farmers growing Bt Cotton	Farmers growing Bt. Like and Non Bt Cotton	Percentage growing Bt Cotton
Kachchh	115	38	77	33.04
Sabarkantha	46	40	6	86.96
Bhavnagar	178	88	90	49.44
Bharuch	26	15	11	57.69
Others	45	15	30	33.33
Gujarat	410	196	214	47.80

Source: Field Study.

It should be noted that three out of four districts that find a place in the table are dry and drought prone and Bharuch is not prone to drought and has black cotton soil that is well-suited for cotton crop. Surendranagar is another district that is semi arid and has a substantial area under cotton, but the study has not been able to cover a significant size of farmers from this district. It may be noted from the table that the Sabarkantha and Bhavnagar farmers have gone in for the Bt variety of cotton a big way. Both groups of farmers have experienced frequent failures in growing hybrid cotton. Since all the farmers reported growing Bt cotton, we used the price criterion to distinguish the approved and unapproved variety cultivators. Thus, all those farmers who reported paying a price of Rs.1600 per packet of seed were classified as Bt growers and the others as unapproved Bt growers. The price of the unapproved variety ranged from Rs.50 to 1100. Generally the F2 (second generation) seeds do not have any fixed price level and are priced much lower than the F1 (first generation) varieties.

Most of the farmers in the study reported their main occupation as agriculture. In all six out of 410 cotton growers reported their main occupation as service (4), business (1) and labour (1). With regard to formal educational levels, the sample distribution was interesting. The details are contained in Table 7, which reports that relatively formally literate farmers have chosen Bt. cotton. Of all farmers, 68 per cent who reported growing Bt cotton were educated at least up to 10^{th} standard, whereas among the unapproved cotton growers the percentage was 31. It may be said, therefore, that literate farmers are more likely to experiment with newer varieties such as GM crops as and when they are released.

Table 7: Educational Levels of Farmers among Cotton Growers

Educational Level	Percentage of farmers in approved Bt. Cotton category	Percentage of farmers in unapproved Bt. Cotton category	All farmers
Illiterate	7.14	14.48	10.97
Can read and write	35.20	54.21	45.12
Up to 10^{th} standard	28.06	19.63	23.66
Up to 12^{th} Standard	14.80	7.48	10.98
Graduation	11.73	3.74	7.56
Post Graduation	3.07	-	1.47
Others	-	0.46	0.24
All	100.00196	100.00214	100.00410

Source: Field survey.

How long have the farmers been cultivating cotton and Bt. cotton? In answer to this question we learnt that more than 58 per cent farmers have more than seven years experience in growing cotton. Interestingly, there are also first time growers and out of the 26 first time growers 18 or about 70 per cent chose to grow Bt cotton. Table 8 contains details on the experience of farmers in growing cotton under Bt and other than Bt category. A large chunk of farmers with more than seven years of experience in cotton cultivation have gone in for both the approved and unapproved variety of cultivation, perhaps in the hope of recovering from their loss.

Table 8: Number of Farmers by Years of Experience in Cultivating Cotton

Years of experience cultivating cotton	Approved Bt	Unapproved Bt	Totali n
First time	19(9.7)	27(12.7)	46
Less than 4 years	47(24)	28(13.1)	75
4 to 7 years	27(14.5)	19(8.9)	46
Above 7 years	103(52.5)	139(65.3)	242
Total	196	213	409

Note: Figures in parentheses are percentages to column total
Source: field survey.

Interestingly, of the 194 approved cotton cultivators 150 or 77 per cent of farmers have 5 or less than 5 acres of land. Similarly, of the 208 farmers cultivating unapproved varieties 141 farmers or 68 per cent of farmers have less than 5 acres of land. Of the three approved varieties of Bt cotton (Mech 12, Mech 162, and Mech 184), Mech 162 and Mech 184 were more popular among the farmers, where out of the 157 farmers cultivating Bt cotton, 72 and 69 farmers had chosen Mech 162 and Mech 184 respectively. Farmers have purchased both approved and unapproved Bt seeds by paying cash. Farmers have chosen cultivation of Bt to avoid pest's attack and to get a good yield. Eighty per cent of the farmers have bought seeds from the recognized seed agents. Since, the majority of the approved Bt cotton cultivators have bought the seeds from approved agents, we expect the farmers to have received appropriate information about the technology and the precautions that they should take while cultivating the new variety of the seeds.

Table 9 provides details about the information provided to the farmers about approved Bt cotton. Thirty nine per cent of the farmers have confirmed that they were informed about the requirement of cultivating non-Bt cotton variety in the Bt cotton field. Only 10 per cent of the farmers reported receiving information regarding the nature of the Bt cotton and its impact on pests. Most importantly, a negligible percentage of farmers have reported awareness regarding the fact that the approved variety has been given conditional approval for three years.

Table 9: Distribution of Farmers According to the Awareness of Information on Bt Cultivation

Type of Information Given About Bt Cotton	Approved Bt	Type of Seed Unapproved Bt	Total
Do not cultivate in less than one acre	59(38)	2	61
20% for refuge crops	61(39)	4	65
Pesticides requirement for other pests	15(9.7)	1	16
Bt. Cotton approval for 3 years	2	-	2
None of the above	17(11)	5	22
Others	-	-	-
Total	154	12	166

Source: Field survey.

When new varieties like the transgenic seeds are available, the role of diffusion agencies like the approved seed sellers and the extension workers in the private and public sector become very essential. They will have to play an active role in educating the farmers about the salient features of the seed, the nature of planting, requirement of fertilizer, timing of pesticides, etc. Adoption of new technology will be easy only if the farmers have adequate information about the new technology. However, only 11 per cent of the farmers have received information about Bt cultivation practices from the company propaganda, while 54 per cent of the farmers have received information from friends and neighbours. The role of the government agriculture department or the media in providing information about this technology to the farmers has been nil. In spite of this, 81.3 per cent of the approved Bt cotton cultivators have stuck to the refuge schedule perhaps due to the information provided by the neighbour farmers. A negligible percentage of unapproved variety cultivators have also stuck to the refuge criteria.

Frequent visits by approved agents or extension workers help the farmers in getting appropriate advise about the new technology and also in ascertaining the actual area under Bt cultivation, stages of pest attack, amount of pesticide used, impact of pollination, etc. Further, in the case of Bt technology, the performance of the crop in the field would be useful for the company/government. We expected that since the farmers have bought their seeds from the authorized sources, the role of the extension workers would be substantial. However, as evident from Table 10, out of the 155 responses for this question, 43 per cent have confirmed visits by some supervisors. But 52 per cent have responded negatively.

Table 10: Number of Farmers Confirming visit of Supervisors

Confirming visit of supervisors	Type of Seed	
	Approved Bt	Unapproved Bt
Yes	66(43)	3
No	80(51.6)	7
Don't Know	9	-
Total	155	10

Source: Field survey.

It is very interesting to observe that in terms of yield, the unapproved variety has done better than the approved variety. Specifically, farmers have obtained 4.8 quintals and 5.32 quintals per acre from the approved and unapproved variety, respectively. Table 11 reports the average yield obtained by the approved and unapproved Bt cultivators by different size of landholders. The overall outlook suggests that the yield from approved Bt cotton at 522.04 Kgs per unit of acre is higher than the 506.25 Kg per unit of acre yield from unapproved Bt cotton. Interestingly, whereas the yield from smaller size classes of approved Bt is higher than the unapproved Bt, in land holding exceeding 5 acres, unapproved Bt has yielded 451.02 kgs compared to 353.34 kgs of approved Bt.

The entire purpose of introducing Bt cotton is to save the crop from the bollworm pest attack. In India, though cotton cultivation accounts for only 5 per cent of the land, it nevertheless accounts for 50 per cent of pesticide consumption. Hence, it is of interest to see, whether there is difference in the use of pesticides between approved Bt and unapproved Bt and thereby the difference in the expenditures. Interestingly, while the approved Bt cultivators with lower size groups of land have incurred higher pesticide expenditure, the unapproved Bt cultivators have spent comparatively less. To elaborate, whereas

Table 11: Average Yield and Pesticide Expenditure

Size of land acre	Average yield in KG in approved Bt	Average Yield in KG unapproved Bt means of yield	't' values Of difference between the approved Bt	Average pesticide exp in Rs. in Bt	Average pesticide expin Rs. in unapproved pesticide expenditure	't'values of in diference between the means of
< 1	696.07 (14)	559.28 (5)	0.814	1017.14	885.44	0.281
1.1-3	717.83 (42)	695.27 (39)	0.161	859.96	686.08	0.952
3.01-5	643.57 (40)	487.59 (62)	1.73**	712.84	458.05	1.84**
5+	353.34 (92)	451.02 (99)	-1.814**	294.04	429.91	-1.999*
Total	522.04 (188)	506.25 (207)	0.335	563.42	493.45	1.049

Source: Field Survey
Note: * and ** denote significance at 10 per cent and 5 per cent level respectively. Figures in parentheses are the number of farmers.

unapproved Bt cultivators have incurred Rs.493.45 per unit of acre on pesticides in order to get 506.25 kgs of yield, the approved Bt cultivators have spent Rs. 563.43 per unit of acre on pesticides and have obtained a yield of 522.04 kgs. It should be noted that while the difference in the pesticide expenditure incurred by approved Bt cultivators is higher than that of the unapproved Bt cultivators, in the land classes exceeding 5 acres, unapproved Bt cultivators have spent Rs. 429.91 on pesticides, while the approved Bt cultivators have spent only Rs. 294.04.

Interestingly, in land size classes less than 3 acres, the difference in yield and pesticide expenditure is not statistically significant. But in the size class of 3 to 5 acres, the difference between yield and pesticide expenditure between the approved and unapproved variety is statistically significant indicating that though approved Bt has better yield performance, the pesticide expenditure is also high. In the higher land holdings, yield performance of unapproved cotton is higher than the approved cotton variety and it is statistically significant. Also, the difference in the pesticide expenditure of the approved and unapproved variety is negative and significant which implies that in order to get a higher yield, farmers with large size classes of land incur more expenditure on pesticides. But overall, there is no significant difference between the approved and unapproved varieties either in terms of yield or in terms of pesticide expenditure.

While only 9 per cent of the farmers cultivating Bt have not used any pesticides, this percentage is smaller (6 per cent) for the non-Bt cultivating farmers. Pesticides use up to 3-4 times appear to be a common norm for both approved Bt (40 per cent) and unapproved Bt cultivators (48 per cent) (see Table 12).

It was also observed that 27 and 18 per cent of the approved and unapproved cultivators have been using the residual of cotton as cattle feed and thus the Bt cotton has entered the human chain. Farmers have not observed any adverse impact on health. The limited information that we have provided here shows that there is indeed a difference in the yield performance of the unapproved variety compared to the approved variety. This coupled with the fact that the price of the unapproved variety is relatively lesser than the approved Bt has prompted the farmers to adopt th e unapproved variety.

Table 12: Use of Pesticides by Approved Bt and Unapproved Bt Cultivators

Pesticides Use	Approved	Unapproved	Total
Not even once	18 (9%)	13 (6%)	31
1-2 time	49	45	94
3-4 time	78 (40%)	102 (48%)	180
5-6 time	24	28	52
7-8 time	15	17	32
9-10 time	10	3	13
11-15 time	2	2	4
>15 time	0	2	2
Total	196	212	408

Source: Field survey.

Implications and Issues in Bt cultivation

Presently, there are two kinds of problems facing the government. One pertains to the uncertain and the mixed performance reports on Bt cotton while the second and more serious is the spread of the unapproved variety in various parts of the country, which cannot be withdrawn. In fact, this is one of the problems with GMOs that once they are released in the open, it is very difficult to recall or rectify the damage.

It is true that the promise of less pesticide expenditure and thereby better yield has attracted a number of farmers to Bt cultivation and particularly more towards the unapproved variety in Gujarat which according to the farmers is better suited to the Gujarat soil. A survey done by GIDR showed that the Mech 12 variety did not yield at all and between Mech 184 and 162 Mech 162, performed better. But the realization came only after farmers tried the variety in their field. This survey also highlighted that certain traditional varieties such as Gujarat 23, Gettu or the Digvijay variety released by the State Seed Corporation have not been affected by the pests at all and these farmers have not incurred any expenditure on pesticides. It suggests that only the hybrids and the high yielding varieties have been prone to pest's attack. Similarly, the Vagad Kapas and Varahlakshmi varieties that were popular in the dry regions of Saurashtra and Kachchh, had lesser pest problems and low but assured yields. The emphasis shifted from drought and pest resistant varieties that had become well acclimatized over decades and centuries to hybrid varieties that yielded better but had a high fluctuation rate. High mean-high variation became the name of the game and low mean-low variation lost out. The Bt game is about the same high mean –high variation trend.

The spray of Bt or Bacillus thuringiensis, a common soil bacterium, is one of the most important biological pest control techniques in use worldwide. The genetic engineers have done a marvelous thing by developing transgenic crops containing the insecticide gene of Bt, so that the plant itself makes the protein necessary for protection against pests. This is being adjudged as the single biggest commercial application of r-DNA technology in the world so far. However, it makes a lot of difference when Bt is used as a spray and the plant itself acts as a pesticide. In fact, there is a growing concern that the very effectiveness of Bt as a bio-pesticide could be irrevocably endangered if the use of Bt-transgenic plant varieties is not stopped immediately. 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, US, evidence of insect resistance to Bt cotton.[6]

Interestingly, the North Carolina State University's research study reported that 1 in 350 tobacco budworms carried resistance to the Bt toxin. This estimate forewarns: (a) of a swift evolution of resistant insect populations, and (b) that with 4 per cent refuge, the Bt cotton could remain effective against tobacco budworm for 10 years. However, Bt cotton has less resistance to other pests such as cotton bollworm and European corn borer and hence this study predicts a boom cycle of only 3-4 years for Bt.[7] Bt cotton is not effective against other pests like boll weevil and whitefly.

A recent study[8] by a scientist from Indian Agricultural Research Institute found that the bollworm developed resistance to the toxin CRY 1AC within six generations. Earlier the Central Institute for Cotton Research in Nagpur also showed that the bollworm could develop resistance within 10 generations. According to scientists this article states that there are two strategies to counter this resistance. One is the expensive strategy to introduce a dual gene system where if one toxin fails the other one would act. The second consist in planting adequate amounts of refuge where the resistant insects breed with the counterparts surviving on the non-Bt crops so that the resistant trait gets diluted in the next generations. However, the GIDR survey shows that increasingly farmers are ignoring the refuge, though the Mahyco seed packet does contain a 150 gram packet of non Bt seeds. The reason for ignoring this is that this non-bt attracts a lot of bollworm and the farmers do not want to risk their Bt crop by exposing them to these bollworms. This only explains that the farmers have not been adequately informed either by the company or by the government officials about the role of the refuge in the cultivation of Bt cotton. Critics such as Suman Sahai have argued that in a country like India where the holdings are small and hardly enough to feed the family on the land that is operated, farmers will have hardly any incentive to provide 20 per cent of the acreage for non Bt cotton. Keeping the issue of scientific validity of ensuring 20 per cent refuge a side for a while, a question that begs the answer is: has Mahyco-Monsanto strictly monitored the refuge plantation? The company-sponsored studies are silent on this aspect.

These resistance arguments pose the specter of a scenario in which that Bt seeds become useless. Can farmers in this case go back to their original seeds? If yes, what will be the intensity of the bollworm attack? Would the situation be worse than that of a cultivation scenario without Bt gene or would it be the same?

The other concern is the spread of the unapproved variety in several parts of the country. This should be fully attributed to the lack of monitoring and regulation, which has resulted in farmers indiscriminately crossing any variety of cottonseed. The impact of such crossing is likely to create disasters in the future. This is because, farmers are developing Bt cotton hybrids in their own fields without adopting any standard protocols that are needed in producing seeds like separation of the field to check for pollination from other variety and so on. Basically farmers cross the male line of unapproved Bt gene with the locally acceptable female line. Such crossings may result in a progeny, which has just one copy of the Bt gene or none depending on the number of copies of the Bt gene in the unapproved Bt. In subsequent generations the number of seeds having the Bt gene would decrease. This will result in the growing of Bt and non-Bt crops together. This would lead to the insects developing resistance to the toxin much faster than would happen with exposure to the ones containing Bt genes alone. This is because there is a possibility of the insects that have fed on the Bt crops to jump over to the neighbouring non-Bt crop and thus survive from the toxic effects of the gene and slowly develop immunity to the Bt gene. Bt gene expression could be different in different cultivars it is inserted in, which means that the quantity of toxins produced could also differ. The implications of such indiscriminate crossing of the varieties are faster resistance to pests that will shorten the period that the farmers could exploit this gene. There is also the possibility of the bollworm being more tolerant to the pesticides being sprayed than before because of the new characteristics that it has acquired in the process of developing immunity towards the Bt toxin. Further, there is also the possibility of the gene transferring into other sexually compatible plants and wild relatives and because of the selective advantage of the gene, the ones without this gene may become extinct and affect the genetic resources available.

Concluding Remarks

Following the Bt cotton debate in India, it becomes clear that all is not well with the Bt cotton case in the country. Bt or GM crops are not like the seed transfers that took place in distant past when some travelers brought experimental seeds and planted them in native soils and if it took root it did; if it failed, it was forgotten. Science has tried to intervene in this process first by creating an artificial environment for the foreign crops and then it eventually tried to alter genes so that the plants are born with some characteristics that help increase the material welfare of the human being. However, scientists have been tentative as they have always been and therefore have always prescribed some dos and don'ts for the science and technological wonders they introduce and try to propagate. In the case of GM crops too it appears that the seeds cannot be simply brought and sown in the fields. They have to be tested for their scientific claims including health and yield assurance, for cost and for their negative fallouts on human health and the general environment. Some of the ill effects may be devastating.

Obviously, as we have noted in the chronology of events in introducing Bt cotton in India the players to introduce the game namely, the government and the seed company know the rules and have tried to play within the rules. Since the onus of taking the technology to farmers is on the government, its role has to be examined more critically. Government has to play two roles; one is to ensure the feasibility, viability and safety of the technology, and two, to protect farmers and breeders rights. In the second section, we have discussed the arrangements that the Government of India has made to facilitate the introduction of the GM technology. The details are about on the institutional arrangements. The issue is, do the arrangements work as they are mandated? The answer unfortunately is the negative.

In the case of Bt cotton the final regulating authority, the GEAC granted its approval to Mahyco-Monsanto to sell Bt seeds to farmers in selected states. The GEAC while approving laid down the following conditions:

1. Bt cotton will be grown with an insect refuge of 20 per cent non-Bt cotton.
2. Mahyco-Monsanto company which has developed the varieties, will 'monitor annually the susceptibility of bollworms to Bt gene vis-à-vis baseline susceptibility data and submit data relating to resistance development, if any, to GEAC'.
3. GEAC has also appointed the company 'to undertake studies on possible impacts on non-target insects and crops, and report back to GEAC annually'.

The environmentalists who form the major group of critics have come down heavily on the way in which the regulation has been implemented particularly, in entrusting the job of monitoring to the company itself. Critics have argued that the agency, which has a business and profit motive, would have a natural inclination to either ignore monitoring and would feed wrong and/or manipulated reports. According to them it was perhaps the first instance in which a company that was producing and selling the GM seed was entrusted with monitoring.[9] In the same vein there is also a related question. Four years of Bt cotton cultivation have passed. Has the company provided any feedback data to the GEAC? If so, has this been discussed in public? The following specific questions are relevant in the context of the debate.

1. How many farmers as per the Mahyco-Monsanto records followed the refuge criteria?

2. Where and what type of testing arrangements have been made to examine field level susceptibility of bollworm against the baseline data?
3. What tests have been set up and what are the findings (preliminary, intermediary or final) that have been documented and reported by the company with regard to impact on non-target insects and crops?
4. What is GEAC's assessment about the two year's experience of growing Bt cotton in the country and what are the basis or grounds on which the clearance to northern states have been withheld?

The government needs to answer at least some vital questions with respect to the process of approval followed. We have noted that the Government granted approvals to the company to undertake small and big trials on farmers' fields. However, at the time of the approval, the government did not accept the results of the company's trials that went on for a few years and later accepted the trials that were done for a year under the supervision of ICAR. The results of the trials and the report of the ICAR have not been made public for the purpose of an open debate about the technology and its impact. Since the decision is likely to impact thousands of farmers in the country, the results of trials pertaining to feasibility, viability and possible environmental effects should be made public. Transparency is vital in introducing technologies where uncertainty looms large. Going back to the process of granting clearance, the government should also make public its decision to burn the Bt - like cotton standing on the field in October 2001. Was it because it was dangerous and likely to cause serious irreversible environmental damages? And when it faced a lot of resistance from the farmers and the fields could not be burnt what corrective measures were taken? What stand has government taken on the court case challenging the Navbharat Seeds' move to introduce cotton seed containing GM material without permission vis-à-vis the Mahyco-Monsanto claims? What would be the responsibility of the company wherever the crop has failed?

Now let us turn our attention to the most important argument of the whole debate and that is the economic viability from the farmers' viewpoint. Unfortunately, the evidence is thin on both the sides. The proponents of the technology have also not come with detailed sample studies of farmers who have cultivated Bt cotton for two seasons now. Ideally, there should have been some cohort studies launched by the Company that is interested in selling more seeds, or by the agricultural universities in all the states or at the initiative of the ICAR as an all-India coordinated research project. Of course, NGOs and 'concerned scientists' should also have undertaken such a study of farmers' cohorts. There have been some cross-sectional studies in some states.

Bt is not for yield advantage. Higher yields are linked to irrigation. Hence, the comparative advantage has to be analysed based on the cost and investment and not with the output side. Profitability increase is due to decreased cost by means of savings in pesticides sprays that have become very expensive. The claim is that spray technology has become expensive and is relatively ineffective while seed technology is more effective. The industry's claims regarding the reduction in cost and increased profitability of Bt cotton growing enterprise appears to raise serious questions. As pointed out earlier, it is necessary to undertake a longitudinal study of selected farmers for controlling physical factors, land holding and the educational levels of farmers. The thin and scattered evidence that one comes across is inconclusive.

Now let us turn our attention to the third aspect that relates to environmental/ecological impact of GM crops with particular reference to the experience of Bt cotton in India. We have noted that the international scientific community has raised concern to do with the resistance issue. We are perhaps yet to record any resistance or will the resistance build up late? How late? What will the farmers do then? If the successful generations of seed lose potency in some way even of the pest toxin, the farmer's dependence for seeds will become total on one or two seed companies. The companies and the scientists promoting this in the private sector and regulating it can be negligent, collusive and profits oriented and mass keep playing this game till it pays. So in case of failures where do the poor farmers to in that case? Do they have clear rights to claim compensations?

Spread of the unapproved variety in different parts of India is a mockery of the regulatory mechanism. It also signals that farmers are willing to take risks for short-term gains. The Government of India is not averse to the technology as evident from the field trials that are going on in the public and private sector. In such a situation it is only necessary that the government in the interests of the farmers should provide adequate information about the positive and negative impact of the technology. Unchecked spread of the unapproved variety will lead to companies bringing in terminator genes or some other technology to protect their interests which will nullify the rights of the farmers to 'save, use and sell' the seeds of the protected varieties in future. This also forewarns that technological breakthroughs in this field will not be diffused adequately to benefit the farmers in developing countries, if adequate intellectual property protection is not provided.

Even when all these issues remain unanswered, the government has approved another transgenic Bt cotton RCH 2 for commercial cultivation in the central and southern parts of the country. Our field observations suggest that farmers are not fully informed about the technology either by the company or by the government. It is not clear whether the company should be held responsible for not providing adequate information or whether the government should in the overall interest of the farmers and society contribute to their awareness through extension workers even though the technology is diffused by the private sector. Further, the elaborate institutional framework to regulate and monitor this technology should function efficiently which requires capacity building and the information from the bottom should reach the top. The questions and issues that we have raised in this paper should be considered when the conditional approval is reviewed in 2005 by the regulatory agencies. In the absence of this, an important breakthrough in science would loose its advantage in the maddening rush to make quick gains.

Endnotes

1 Srinivasan (2004).

2 A short account of the approval process for the commercialization of the Bt cotton in India is detailed in Iyengar and Lalitha, 2002.

3 Commercialization of Bt mustard has been stalled due to the absence of information on the economic viability of the crop to the farmers.

4 *Fronline*, May 21, 2004.

5 *ibid.*

6 Shiva and Jafri (2003).

7 Prakash (1997)

[8] This paragraph draws upon the article published in Frontline, May 21, 2004.

[9] Again the field observations from the GIDR survey confirm that neither the company nor any government officials contacted the farmers regarding the performance of Bt cotton or for any impact of the seeds.

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