PROJECT PROFILE

ON

BT BIO PESTICIDE

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BACILLUS THURINGIENSIS (BT)
(BIO PESTICIDE)

INTRODUCTION

Bacillus thuringiensis (Bt) is a naturally occurring, soil borne organism that has gained popularity recently for its ability to control certain insect pests in a natural, environmentally friendly manner.

BT is considered ideal for pest management because of its specificity to certain pests. Also it is non toxic to human beings and natural enemies of many crop pests. More than 150 insects, mostly lepidopterous larvae, are known to be susceptible to B.t.var kurstaki BT is effective in controlling insects in their larval stage only. Damage to the crop is maximum during the larval stage of insects. At this stage of life cycle, the larvae or the caterpillars feed on the plant parts voraciously. Hence, if BT enters into its system during this stage, it is most effective in killing the insect.

BT is applied to the foliage of infested plants. Generally application of BT is recommended on the under surface of the leaves for two reasons:

Most larvae feed from the underside of the leaf surface.

BT is broken down faster in sunlight. Application to the underside of the leaf surface prolongs its activity. High temperatures do not have any adverse effect on BT. After Bt spores are ingested by larvae, the bacteria grow and produce crystalline toxins. The crystalline toxin paralyses the digestive tract of larvae causing it to cease further eating. Death of the insect follows in 12 hours to 5 days after ingestion. This depends on the amount of Bt ingested, the size and variety of the larvae. Bt var kurstaki controls Helicoverpa and *other bollworms on cotton, tomato fruit worms, diam*ond back moth, cabbage looper, *Spodoptera* on various crops, chili pod borers, and many other caterpillars. Bt var *israelensis* can control mosquitoes and black flies.

Bt has gained popularity because of its distinct advantages over other pesticides viz:

Bt toxin is active only in alkaline conditions as found in insect guts. It is safe for human beings and higher animals.

Bt can be used right upto harvest unlike other chemical pesticides.

Beneficial and non target insects are not killed by Bt as it is effective only against a certain class of insects (viz. Lepidoptera, Diptera and Coleoptera etc.).

Insects that die from Bt infection do not pose any danger to birds or other animals feeding upon them.

Bt does not pose any danger to crops on which it is sprayed. It also does not harm the surrounding environment.
Little or no resistance has been reported to date.

The Bt History:

Bacillus thuringiensis (or Bt) is a Gram-positive, soil-dwelling bacterium, commonly used as a pesticide. Additionally, B. thuringiensis also occurs naturally in the gut of caterpillars of various types of moths and butterflies, as well as on the dark surface of plants

B. thuringiensis was first discovered in 1901 by Japanese biologist Shigetane Ishiwata. In 1911 it was rediscovered in Germany by Ernst Berliner, who isolated it as the cause of a disease called Schlaffsucht in flour moth caterpillars. In 1976, Zakharyan reported the presence of a plasmid in a strain of B. thuringiensis and suggested its involvement in endospore and crystal formation.

Spores and crystalline insecticidal proteins produced by B. thuringiensis have been used to control insect pests since the 1920s. They are now used as specific insecticides under trade names such as Dipel and Thuricide. Because of their specificity, these pesticides are regarded as environmentally friendly, with little or no effect on humans, wildlife, pollinators, and most other beneficial insects. The Belgian company Plant Genetic Systems was the first company (in

1985) to develop genetically engineered (tobacco) plants with insect tolerance by expressing cry genes from B. thuringiensis. The making of Bt brinjal involves insertion of a gene from the soil bacterium Bacillus thuringiensis into the DNA or genetic code of the vegetable to produce pesticidal toxins in every cell. In 1995, potato plants producing Bt toxin were approved safe by the Environmental Protection Agency, making it the first pesticide producing crop to be approved in the USA. By 1996, Bt Maize, Bt Potato and Bt cotton were being grown by farmers in the USA. Bt crops (in corn and cotton) were planted on 281,500 km^2 in 2006 (165,600 km^2 of Bt corn and 115900 km^2 of Bt cotton). This was equivalent to 11.1% and 33.6% respectively of global plantings of corn and cotton in 2006. Claims of major benefits to farmers, including poor farmers in developing countries, have been made by advocates of the technology, and have been challenged by opponents. The task of isolating impacts of the technology is complicated by the prevalence of biased observers, and by the rarity of controlled comparisons (such as identical seeds, differing only in the presence or absence of the Bt trait, being grown in identical situations). The main Bt crop being grown by small farmers in developing countries is cotton, and a recent exhaustive review of findings on Bt cotton by respected and unbiased agricultural economists concluded that "the overall balance sheet, though promising, is mixed. Economic returns are highly variable over years, farm type, and geographical location" . Environmental impacts appear to be positive during the first ten years of Bt crop use (1996–2005). One study concluded that insecticide use on cotton and corn during this period fell by 35.6 million kg of insecticide active ingredient which is roughly equal to the amount of pesticide applied to arable crops in the EU in one year. Using the Environmental Impact Quotient (EIQ) measure of the impact of pesticide use on the environment, the adoption of Bt technology over this ten year period resulted in 24.3% and 4.6% reduction respectively in the environmental impact associated with insecticide use on the cotton and corn area using the technology.

Insects Controlled by Bt

Kurstaki strain (Biobit, Dipel, MVP, Steward, Thuricide, etc.):

Vegetable insects

Cabbage worm (cabbage looper, imported cabbageworm, diamondback moth, etc.).

Tomato and tobacco hornworm.

Field and forage crop insects

European corn borer (granular formulations have given good control of first generation corn borers).

Alfalfa caterpillar, alfalfa webworm.

Fruit crop insects

Leafroller.

Achemon sphinx.

Tree and shrub insects

Tent caterpillar.

Fall webworm.

Leafroller.

Red-humped caterpillar.

Spiny elm caterpillar.

Western spruce budworm.

Pine budworm.

Pine butterfly.

Israelensis strains (Vectobac, Mosquito Dunks, Gnatrol, Bactimos, etc.)

Mosquito.

Black fly.

Fungus gnat.

San diego/tenebrionis strains (Trident, M-One, M-Trak, Foil, Novodor, etc.)

Colorado potato beetle.

Elm leaf beetle.

Cottonwood leaf beetle.

The Bt protein has been used safely since 1950s by organic gardeners and farmers worldwide as biological insecticide.

- Bt is shorthand for common soil-inhabiting bacteria called *Bacillus thuringiensis*. Bt also refers to insecticide products made from these bacteria.

- Bt is widely distributed. In addition to being found in many soils around the world, it is also found on the leaves of plants and in stored grain.

- Some strains of Bt kill insects with toxins called *insecticidal crystal proteins or delta endotoxins*. This group of toxins is considered relatively harmless to humans and most non-pest species. However, other toxins produced by Bt have a broader spectrum of toxicity.

- Delta endotoxins are stomach poisons that must be eaten by the insect in order to be effective. After ingestion, the toxin is activated in the highly alkaline insect midgut.
- Delta endotoxins rapidly paralyze the insect's digestive system, so damage to the plant stops soon after the insect is exposed to the crystals. Mortality may take several days, so the effects of delta endotoxins are very different from what we expect from conventional insecticides.
- Another type of Bt toxins are called vegetative insecticidal proteins, or VIPs. VIPs are also considered relatively safe for non-pest species; however, other classes of toxins produced by Bt have a broader spectrum of toxicity.

- Different strains (about 280 are known) of *Bacillus thuringiensis* produce different forms of delta endotoxins—many are toxic to caterpillars (e.g., European corn borer), while others are toxic to flies (e.g., mosquitoes) or beetles (e.g., corn rootworm).

- Bt insecticides, consisting of dormant Bt and delta endotoxin, have been available commercially and used in agriculture for more than 30 years (e.g., Bactimos, Biobit, Dipel, Javelin, Teknar, Vectobac). These are used primarily for control of caterpillar pests of various crops, as well as mosquito and black fly larvae.

- The delta endotoxins are considered to be much more selective and safer for humans and non-target organisms than most conventional insecticides because they attack sites that are found only in a few groups of insects. Commercial Bt insecticides are classified as Generally Regarded as Safe (GRAS) by the EPA, and are approved for most organic certification programs.

- Production of delta endotoxin is controlled by a single gene in the bacteria. A modified version of this gene can be placed in corn plants. Corn plants containing this gene can produce delta endotoxin and therefore be toxic to insects that are susceptible to that form of the protein.

BT COTTON

While BT cotton is followed and compared with Non-BT cotton the economics will be as follows.

Partial Budgeting form of Bt and Non-Bt cotton

a) Increase in costs in Rs./acre

I) Seed cost = 1364.52-256.48=1108.04

II) Fertilizer cost=1739.49-915.13=824.36

III) Irrigation cost=1256.24-734.45=521.79

IV) Picking cost = 2468.75-1846.25=622.50

Sub total =1108.04+824.36+521.79+622.50=3076.69

b) Decrease in cost in Rs.

Insecticide cost=1690.29-867.28=823.01

Sub total = 823.01

c) Decrease in Returns in Rs.: nil

d) Total Increase in Returns in Rs.: 22328.13 - 14799.25 =7528.88

Comparing Net return with Bt cotton = (b+ d)-(a+c) = (823.01+7528.88) – 3076.69 = 5275.20 Rs.

With Bt cotton, cost mainly increased in seed, fertilizer, irrigation and picking which is Rs. 3076.69 per acre. On the other hand, farmers reduced the insecticide cost which is near about 26 per cent cost of total increased cost with Bt cotton. But Bt farmers had higher yield, thus they had near about 50 per cent more return than non-Bt cotton which compensate all increased cost. Thus with Bt cotton farmers got higher net return i.e. Rs.5275.20 per acre.

In Northern India, Bt cotton was approved for commercial cultivation in 2005. Some of the farmers adopt Bt cotton first year, many other farmers adopted after see the Bt cotton in the farm of their neighbour farmer or village farmers. The following figure 1. shows their adoption pathway. In adopter major group of early majority and another major group is from early adopters. Mostly farmers want to watch the seed variety in their neighbourhood then they will adopt. In northern India, farmers adopted Bt cotton mainly in third year of Bt cotton approval.

BT Cotton impacts

Cotton the most important commercial crop of India, often referred as the White Gold, consumes more than 45% of the total pesticides used in our country. The most important insect pests that affect cotton production are jassids, white fly, aphids and thrips among the sap sucking pests and boll worms (American, Pink and Spotted) and *Spodoptera* among the leaf eating caterpillars. Of these cotton pests, the American boll worms alone cause yield reduction upto 40 – 70 % under severe incidence. The genetic resistance, one of the important pest management strategies, is available in cotton gene pool against the sap sucking pests, whereas such resistance is not available against the bollworms. Hence, an alternate strategy is explored to circumvent this problem by cloning and transferring the genes encoding the toxic crystal δ - endo toxin protein from the soil bacterium *Bacillus thuringiensis*. The Bt transgenic cotton (Bollgard of Monsanto) has thus been developed successfully in USA, which has the ability to control the bollworms during crop growth effectively.

Ever since three Bt cotton hybrids have been approved for commercial cultivation in India during 2002, there was a sharp increase in area under cultivation of such hybrids from a mere 72,000 ac in 2002-03 to 30,00,000 ha in 2006-07. So far, 59 Bt hybrids have been approved in different cotton growing zones by GEAC (Genetic Engineering Approval Committee, Government of India) after extensive field trials by All India Coordinated Cotton

Improvement Project centres and RCGM trials in farmers' fields. Bt cotton hybrids exhibited excellent control of American Boll worm and reduced the use of insecticides leading to create eco-friendly environment without compromising on profitable yield. As compared to insecticide mediated control of bollworms, Bt cotton technology does not harm non-target beneficial insects; besides reduction in production cost, increase in profit, reduced farming risk and improved economic outlook for cotton are the highlights of this novel technology. Use of this technology is also helpful in improving wild life population, reduced run-off of insecticides, reduced air pollution and improved safety to farm workers and neighbourhood.

Large scale cultivation of Bt cotton has resulted in the significant reduction of insecticide use to the tune of 40 to

60% less than the intensity on the corresponding non-transgenic varieties. Several studies have evaluated the economic benefits accrued due to the cultivation of Bt transgenic cotton versus the corresponding non-transgenic cultivar. Apart from causing a reduction in the usage of insecticides all over the world Bt-cotton has significantly contributed to enhanced yields. Hence it has become very popular in all cotton growing countries of the world. One important advantage of Bt-cotton is that farmers rarely resort to prophylactic spray applications, which they do otherwise, in the absence of Bt-technology. In some regions of the country 7-10 prophylactic sprays per season are common on cotton. The total number of sprays averaged at 16-20 in some districts of Andhra Pradesh and Punjab during 1986-2001. The problem of pest management had become more complex due to bollworm resistance to insecticides, thereby causing enormous wastage of insecticide and subsequent environment pollution.

Yield increased substantially by adopting Bt-cotton and farmers in India were able to reduce at least 2-3 insecticide applications. Over the past four years bollworm infestation in India was low, thus reducing the need for insecticide applications. However, the benefits of Bt-cotton were more in other countries where bollworm infestation was high. Insecticide applications on Bt-cotton varieties were reduced up to 14 applications in China, 7 in South Africa and 5-6 in Indonesia and Australia (Table 5).

Biosafety tests and assessment of toxicity to non-target organisms

Biosafety tests indicated absolute safety to goats, cows, buffaloes, fish and poultry. Feed-safety studies with Bt cottonseed meal were carried out with goats, buffalos, cows, rabbits, birds and fish. The results revealed that the animals fed with Bt-cotton seed meal were comparable to the control animals in various tests and showed no ill-effects. These studies were carried out by the National Dairy Research Institute, Karnal; Central Avian Research Institute, Bareily; Industrial Toxicological Research Centre, Lucknow; National Institute of Nutrition, Hyderabad; Central Institute of Fisheries Education, Mumbai and GB Pant University for Agriculture and Technology, Pantnagar.

The Cry1Ac is mainly toxic to the bollworms (cotton bollworm, pink bollworm and spotted bollworm), semiloopers and hairy caterpillars. Bt-cotton expressing Cry1Ac is absolutely non-toxic to all other non-target organisms such as beneficial insects, birds, fish, animals and human beings. Laboratory and field studies carried out in India showed that the Cry1Ac protein deployed in Bt-cotton did not have any direct effect on any of the non-target beneficial insects. Work carried out elsewhere in the world also showed similar results. There was some evidence of a reduction in numbers of predators and parasitoids which specialise on the Bt controlled bollworms, but also of increases in numbers and diversity of generalist predators such as spiders. Generally the decrease in the parasitoid and predator populations were associated with decrease in the densities of the pest populations on account of Bt-cotton. Due to these changes in pest complex, farmers had to spray 3-5 times on bollgard as compared to 6-8 times on non-Bt cottons. Any effects could be assigned to the decrease in prey quality – for example with stunted *Spodoptera litura* caterpillars which had fed on Bt cotton. In the field situation, partial life studies broadly confirmed this finding. There was no increase in green vegetable bug numbers, aphid or whitefly numbers on Bt cotton. In general, such adverse effects as have been measured are very small when compared with the side effects of the spraying of conventional insecticides.

Post release field performance and enhanced economic benefits

Results from extensive Bt cotton trials under farmer field conditions, conducted from 1998 to 2001 confirmed that Bt cotton with the Cry1 Ac gene provides effective and safe control of bollworm and related pests. Field trials have confirmed that, compared to conventional hybrids, Bt cotton can increase yields by up to at least 40%, reduce insecticide sprays by at least 50 % or more (decrease from 7 to 2 or 3 sprays on average) equivalent to savings of Rs 2500/hectare, and increase overall farmer income from Bt cotton from Rs 3500 to Rs 10,000 or more per hectare.

Mahyco commissioned a nationwide survey by ACNeilsen-ORG MARG in 2003. The survey covered 3,063 from Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Gujarat (Table 6). The data showed that a yield increase by about 29% (range 18 to 40%) due to effective control of bollworms, a reduction in chemical sprays by 60% (range 51 to 71%) and an increase in net profit by 78% (range 66 to 164%) as compared to non-Bt cotton. The net profit was estimated to an average of Rs.7,724 (range Rs. 5,900 to 12,696) per hectare. Mahyco conducted an independent survey during 2003 to assess the performance of Bt-cotton in fields of 3000 farmers. Results showed an average net profit of Rs 18,325 (range 15,854 to 20,196) per hectare.

Field trials conducted by Mahyco during 2001, in 157 farms in 25 districts of Madhya Pradesh, Maharashtra and Tamilnadu showed that there were no changes in the insecticide use for sucking pest control, but at least three sprayings meant for bollworm control were saved due to the Bt-technology. Thus, insecticide use of cotton bollworm was reported to have been reduced by 83% and yield increase by a staggering 80%. Global estimates show that, Bt cotton caused an average net income increase of $ US 50/hectare in the USA, $357/hectare to $549/hectare in China and $25-51/hectare in South Africa.

Opportunities for the future

Keeping in mind the development of resistance to Cry 1Ac protein in insects, notable progress has already been made to diversify the transgene and to pyramid genes which are having different mode of action so that development of resistance is delayed. The genes available for exploitation include Bollgard II of Monsanto (Cry 1Ac + Cry 2Ab), VIP COT of Syngenta (VIP 3A) and Wide Strike of Dow Agro Sciences (Cry 1Ac + Cry 1F). The problem with regard to fibre quality of Bt hybrid as noted in MECH. 12 and MECH. 184 may be circumvented by involving a proper combination of parents to produce superior Bt cotton hybrid for both yield as well as fibre quality.

Table 1. Area, Production and Productivity of cotton in India

Year	Area (lakh ha)	Production (lakh bales)	Productivity (kg lint/ha)
2000-01	81.5	167	319
2001-02	85.9	153	309
2002-	73.9	158	322

03			
2003-04	76.3	179	399
2004-05	89.2	243	463
2005-06	88.2	243	465

Table 2. Bt-cotton area (ha) in India, based on the number of packets (450 g) sold

S. No.	State	2002	2003	2004	2005
1	Andhra Pradesh	3,792	5,199	73,890	226,684
2	Madhya Pradesh	1,482	12,968	87,894	142,062
3	Gujarat	9,104	42,097	134,034	147,335
4	Maharashtra	12,379	18,711	208,715	621,111
5	Karnataka	2,178	3,547	20,443	28,888
6	Tamilnadu	373	3,404	9,756	18,409
7	Haryana	0	0	0	13,309
8	Punjab	0	0	0	51,425
9	Rajasthan	0	0	0	1,610
Total		**29,307**	**85,927**	**53,4731**	**1250,833**

Source: DBT, Government of India

Area under Bt cotton hybrids in 2006-07 (Lakh hectares)

State	Total State Area	Bt cotton hybrid Area	% of Bt cotton Area

Punjab	6.18	2.81	45.5
Haryana	5.33	0.42	7.9
Rajasthan	3.08	0.05	1.6
Gujarat	23.90	4.07	17.0
Maharashtra	31.24	16.55	53.0
Madhya Pradesh	6.66	3.02	45.3
Andhra Pradesh	9.48	6.57	69.3
Karnataka	3.56	0.80	22.5
Tamil Nadu	0.94	0.32	34.0
Total	91.37	34.61	37.9

Source : DOCD, Mumbai

Table 3. List of Bt cotton hybrids approved for commercial cultivation in India.

Name of the company	North Zone	Central Zone	South Zone
M/s. MAHYCO Seeds	MRC 6301 [2005] MRC 6304 [2005] MRC 6025 (2006) MRC 6029 (2006)	MECH. 12 [(2002], MECH. 162 [2002], MECH. 184 [2002], MRC 6301 [2005] MRC 7301 BG II	MECH. 12 (2002) MECH. 162 (2002) MECH. 184 (2002) MRC 6918 (HxB) (2005) MRC 6322 (2005)

		(2006) MRC 7326 BG II (2006) MRC 7347 BG II (2006)	MRC 7351 BG II(2006) MRC 7201 BG II (2006)
M/s. Rasi Seeds	RCH 134 [2005] RCH 317 [2005] RCH 308 (2006) RCH 314 (2006)	RCH 2 [2004], RCH 118 [2005] RCH 138 [2005], RCH 144 [2005] RCH 377 (2006)	RCH 2 (2004) RCH 20 (2005) RCH 368 (2005) RCH 111 (2006) RCH 371(2006) RCHB 708 (HxB) (2006)
M/s. Ankur Seeds	Ankur 651 [2005] Ankur 2534 [2005]	Ankur 651 [2005] Ankur 09 [2005]	--------
M/s. Nuziveedu Seeds	NCS 913 (2006) NCS 138 (2006)	Bunny [2005] Mallika [2005] NCS 913 (2006)	Bunny (2005) Mallika (2005) NCS 913 (2006)
M/S Ganga Kaveri Seeds	--------	GK 204 (2006) GK 205 (2006)	GK 209 (2006) GK 207 (2006)
M/S Emergent	--------	Brahma (2006)	Brahma (2006)

genetics			
M/s Nath Seeds	NCEH 6 (2006)	NCEH 2 (2006)	NCEH 3 (2006)
JK Seeds	JKCH 1947 (2006)	JK Varun (2006)	JK Durga (2006) JKCH 99 (2006)
Ajeet Seeds	--------	ACH 33-1 (2006) ACH 155-1(2006) ACH 11-2 BG II (2006)	ACH 33-1(2006) ACH 155-1 (2006)
Prabhat Seeds Ltd	--------	NPH 2171 (2006)	PCH 2270 (2006) NPH 2171 (2006)
Krishidhan Seeds	--------	KDCHH 441 BG II (2006) KDCHH 9810 (2006) KDCHH 9632 (2006) KDCHH 9821 (2006)	KDCHH 9632 (2006) KDCHH 9810 (2006)
Vikram Seeds	--------	VICH 5 (2006) VICH 9 (2006)	VICH 5 (2006) VICH 9 (2006)
Tulasi Seeds	--------	Tulasi 4 (2006) Tulasi 117 (2006)	Tulasi 4 (2006) Tulasi 117 (2006)
Vikki's Agro Tech	--------	VCH 111 (2006)	--------

Pravardhan Seeds	--------	PRCH 102 (2006)	--------

Table 4. Economics of Bt-cotton cultivation in ICAR trials 2001.

Hybrid	**Yield Q/ha**	**Gross income Rs./ha**	**Insecticide cost Rs./ha**	**Net income Rs./ha**
MECH-12 Bt	11.67	21,006	1,727	16,854
MECH-12 Bt	13.67	24,606	1,413	20,768
MECH-12 Bt	14.00	25,200	1,413	21,362
Local check	8.37	15,066	2,845	12,221
National check	7.31	13,158	2,001	11,157

Table5. Spray application reduction on Bt cotton during 2002-2003

	Year of	**Total**	**Area under**	**No. of**

Country	introduction	cotton area (lakh ha)	Bt-cotton		insecticide sprays	
			Lakh ha	%	Non-Bt	Bt-cotton
USA	1996	62.0	20.0	33	5	2
Mexico	1996	0.8	0.3	35	4	2
China	1997	48.0	15.0	31	20	7
Australia	1997	4.0	1.5	36	11	6
Argentine	1998	1.7	0.1	5	5	2
S. Africa	1998	0.4	0.2	45	11	4
Indonesia	2001	0.2	0.1	18	9	3
Colombia	2002	0.4	0.1	10	6	2
India	2002	85.0	2.8	3	5	2

Table 6. Results of the ACNeilsen-ORG MARG, 2003

State	Pesticide reduction		Yield increase		Net profit	
	Rs/ha	%	Q/ha	%	Rs./ha	%
Andhra Pradesh	4,594	58	4.9	24	12,717	92
Karnataka	2,930	51	3.3	31	6,222	120
Maharashtra	2,591	71	3.6	26	5,910	66
Gujarat	3,445	70	2.9	18	8,564	164
Madhya Pradesh	2,200	52	5.4	40	9,594	68

Average	3,202	60	4.2	29	7,737	78

Source:

BT BRINJAL

Introduction: Bt brinjal, popularly known as Bacillus Thuringiensis Brinjal is at the centre of a major controversy in India.The debate over its introduction is hotting up. Environment minister Jairam Ramesh's sudden recourse to public consultations, after Bt Brinjal was cleared as India's first genetically modified food crop, has also raised questiones over the differences among the policy makers at the highest level. The issue over Bt brinjal gets worse with central government ministers contradicting each other.

The Agriculture Minister has reportedly said the committee's decision was final. Meanwhile, Environment Minister said that "the Genetic Engineering Approval Committee may well be a statutory body but when crucial issues of human safety are concerned, the government has every right . . . to take the final decision." Science and Technology Minister said that he stood by the committee's findings.

The Genetic Engineering Approval Committee (GEAC) announced approval for large scale field trials for Bt brinjal6 in September 2007, and probably its commercialization by early 2009. It also cleared proposals for biosafety studies for other food crops such as okra (lady's finger), rice, and tomatoes.

In February 2008, the apex legislative body in India, the Supreme Court, revoked the ban it had earlier placed on the approval of large scale field trials of transgenic crops. Following this announcement, Bt brinjal became a hotly debated topic among activists, scientists, farmers and Multi National Companies (MNCs).

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

Bt brinjal, a genetically modified strain created by India's number one seeds company Mahyco in collaboration with American multinational Monsanto.

The key benefits promised are:

Bt brinjal is resistant to pests and therefore will need less use of pesticides and insecticides, reducing the cost of production

It improves yields and helps the agriculture sector.

Why it is a debate: Bt cotton was the first transgenic crop to be released in India. Introduced into the country in the year 2002, Bt cotton became the subject of many a controversy.

Its performance, sale of illegal seeds, its impact on the environment, biodiversity, and health of livestock were all hotly debated.

The debate was further fuelled by the fact that there were wide differences in the performance results obtained by studies sponsored by the company, independent researchers, and NGOs.

The GEAC announcement regarding Bt brinjal, a food crop that originated in India, served to intensify the biosafety debate

Bt Brinjal is being developed in India by M/s Mahyco [Maharashtra Hybrid Seeds Company]. Now, the company was cleared by GEAC to take up large scale field trials with the permission of the GEAC in 2006-07. The importance of this development can be understood from the fact that no GM Brinjal has been released for an advanced stage of field trials in open conditions anywhere in the world and that this is the first time that GEAC could be giving permission for large scale open trials for a food crop in India Needless to say, a vegetable, more than other food items, goes through very little processing and is directly consumed through cooking and therefore requires great caution in decision-making.

Bt brinjal was the second GM crop to be cleared by the GEAC, this one at the instance of Monsanto's Indian associate, Maharashtra Hybrid Seeds Company (Mahyco). And this is just the beginning of what could be a biotech revolution, for better or for worse, as many more crops, including cash crops, vegetables, fruits, cereals and pulses, are in the regulatory pipeline.

In October 2009, the Indian biotechnology regulator, Genetic Engineering Approval Committee which is an 30-member committee comprising mainly bureaucrats and scientists, gave its approval for introduction of Bt brinjal, the first genetically modified food crop to be allowed in India.

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B. thuringiensis was first discovered in 1901 by Japanese biologist Shigetane Ishiwata. In 1911 it was rediscovered in Germany by Ernst Berliner, who isolated it as the cause of a disease called Schlaffsucht in flour moth caterpillars. In 1976, Zakharyan reported the presence of a plasmid in a strain of B. thuringiensis and suggested its involvement in endospore and crystal formation.

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They are now used as specific insecticides under trade names such as Dipel and Thuricide. Because of their specificity, these pesticides are regarded as
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The making of Bt brinjal involves insertion of a gene from the soil bacterium Bacillus thuringiensis into the DNA or genetic code of the vegetable to produce pesticidal toxins in every cell.

The Evolution of Bt in India: Background

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

Cultivation in 11 locations. While the ICAR second year trials continued for these five hybrids in 2005, three more new hybrids were assessed by the company [MHB-11 Bt Brinjal, MHB-39 Bt Brinjal and MHB-112 Bt Brinjal] and ICAR in the same year in eleven centres.

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

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

The promises and claims

It is reported that the average shoot damage in Bt Brinjal hybrids ranged from 0.04% to 0.3% as compared to 0.12% to 2.5% in non-Bt Brinjal hybrids.

The% age of damaged fruits reportedly ranged from 2.5% to 20% in Bt Brinjal to 24% to 58% in non-Bt counterparts

This will help small and marginal farmers from having to use 25-80 sprays of pesticides which are ineffective, says the company

The company claims that human health concerns due to pesticide use can be addressed with this transgenic Brinjal with its in-built tolerance

Company promises that through this in-built tolerance, there would be substantial increase in marketable yields. Higher yields would result in higher incomes for farmers, it is expected

The pricing of the seeds will be based on a cost-recovery model, making it affordable for all farmers, whether the seed comes from the private sector or the public sector, it is promised

Farmers will be able to continue to save and re-use their seed for the hybrids and varieties because of this arrangement, it is reported.

COMMERCIAL MANUFACTURING OF BT

The training for manufacturing on commercial scale is provided by the following institution namely Directorate of Oil Seeds Research, Hyderabad.

1. Directorate of Oil Seeds Research, Hyderabad

Hands on Training on Mass Production and Quality

Testing of Various Bio-pesticides/Bio-agents by Directorate of Oil Seeds Research, Hyderabad**.**

The approach to insect pest and disease management has seen a significant change over

the years from chemical control to integrated pest management (IPM) with emphasis currently on Biointensive integrated pest management (BIPM). The shift in this paradigm is an outcome of the continuing search for eco-friendly pest management strategies driven by the impact of the ill-effects of injudicious use of chemical pesticides on human health and environment. The immediate need for sustainable, eco-friendly pest management has been felt very strongly providing an impetus to research and development of microbial pesticides. Majority of the microbial pesticides can be easily multiplied on artificial media with an immense scope for ensuring their timely availability - a pre-requisite for their effective integration into the BIPM modules. It is in this context that expertise development for effective handling and exploitation of the potential microbial agents gains utmost importance.

Brief of technology developed by Oil seeds Research.

Production of Bacillus thuringiensis (Bt) was standardized on wheat bran based media in 250 ml Erlenmeyer flasks. Scale-up of Bt production on the best medium in plastic tubs with aeration at 8 h intervals starting 16 h after incubation yielded a significant increase in spore count and toxin content of the product. Maximum lysis of Bt cells was obtained by 60 h of incubation at 30 degrees C. This protocol was suitable for production of Bt strains and local isolates. The Bt produced proved highly effective at 0.1% concentration against larvae of castor semilooper, Achaea janata L, resulting in complete mortality by three days in laboratory bioassays. In field trials, the population of castor semilooper larvae on the castor bean crop was reduced significantly by three days after application. The cost for material production of 1 kg of Bt was approximately US dollars 0.70.

2. National Research Development Corporation (NRDC),
New Delhi

Vector Control Research Centre (VCRC),
Puducherry
Biocontrol Agents for Mosquitoes
Bacillus thuringiensis
Product/Process: Slow release and wettable powder formulations from Bacillus thuringiensis serotype H14 and process thereof.
Application/Uses: These products containing serotype H14 (VCRC B17) have been used for the control of vector mosquitoes. The WDP (40%) at 2.5-5 kg/ha for clear and 5-15 kg/ha for polluted habitats was found to have residual activity for about a week against Culex quinquefasciatus. The Controlled Release Formulation (CRF) at 10 kg/ha was found

to have a residual activity for 15 weeks in disused wells against Culex quinquefasciatus.

Salient Technical Features: Bacillus thuringiensis var. israelensis (Bti), a naturally occurring bacterial pathogen of mosquito larvae was isolated from the paddy fields of Puducherry (strain VCRC B17).

Scale of Development: Technology has been developed up to pilot scale and assigned to National Research Development Corporation (NRDC), New Delhi, for commercialization.

Status of Commercialization: The technology has been licensed to six firms namely:

i) M/s Tuticorin Alkali Chemicals, Chennai

ii) M/s Revathi Agrifood Industries Pvt. Ltd., Chennai

iii) M/s R.K.Biotech Product Private Ltd., Chennai

iv) M/s Bacto Power Pvt. Ltd., Coimbatore

v) M/s Coromandal Biotech Industries (India) Ltd. Hyderabad

vi) M/s Neelagriva Biosciences Pvt. Ltd. Mysore

vii)M/s Amit Biotech Ltd., Kolkata

An Indian process patent (no. 192055) has been granted for this larvicidal preparation. Product patent application (no. 650/DEL/2003) has also been filed.

FINANCIAL ASPECTS

Installed capacity	120 MTs per annum
Total project cost	Rs.100.00 lakhs
Selling price per MT	Rs.50000 per MT
Net profit	Rs.20000 per MT

The actual cost of raising and cultivation details area available form the following institutions. They provide the technology also.

1. Project Director
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Rajendra Nagar
Hyderabad- 5000030
Phone: 040-24015222
director@dor-icar.org

2. Tamil Nadu Agricultural University
Coimbatore - 641 003
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E-Mail: info@tnau.ac.in

3. National Research Development Corporation (NRDC)
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