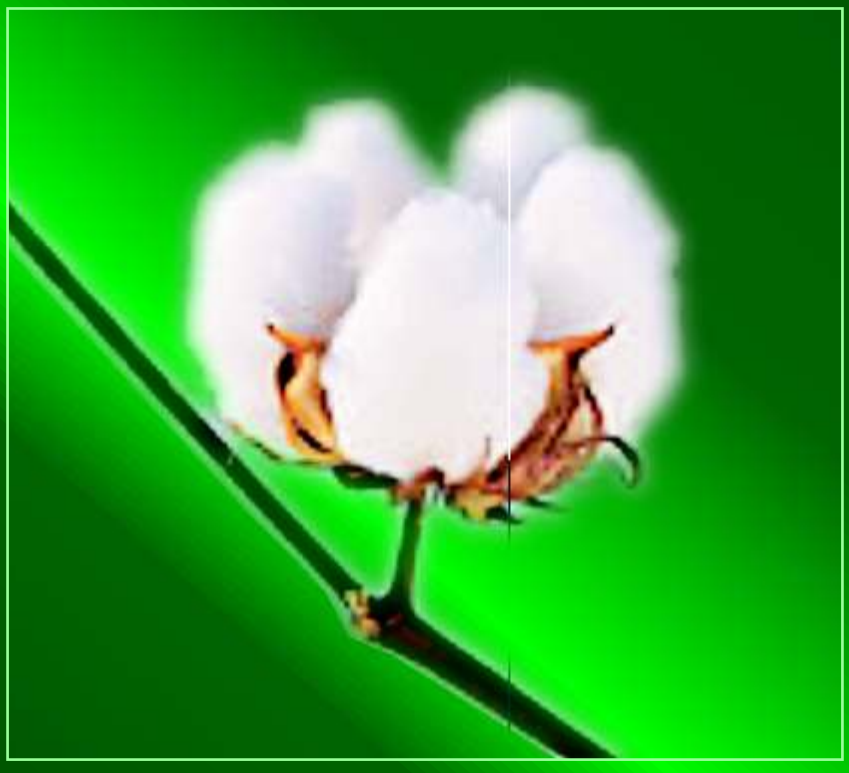
Q & A ON *BT*-COTTON IN INDIA

Answers to more than 70 questions on all aspects

T. M. Manjunath



ALL INDIA CROP BIOTECHNOLOGY ASSOCIATION

Old world bollworm, *Helicoverpa armigera*

Pink bollworm, *Pectinophora gossypiella*

Spotted bollworm, *Earias vittella*

Bt-cotton (Note early bearing and good boll retention) Non *Bt*-cotton

Field photo: Mahyco

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FOREWORD

Bt-cotton, being the very first and until now the only agricultural biotechnology product approved by Govt of India in March 2002 for commercial cultivation, has attracted a great deal of interest, curiosity and controversy right from 1998 when its first regulatory trials were initiated in India. All kinds of allegations were made and doubts raised with regard to its need, utility, efficacy, safety and benefits. The activists who were opposed to this technology, burnt legitimate Bt-cotton trial plots in a few places, staged public demonstrations, moved the courts and delayed the regulatory approval. Their activities and statements received prominent coverage in print and electronic media. This has created a lot of confusion, and even fear, among some farmers and general public about Bt-cotton. I have personally witnessed this situation. Amidst these, what was not realized is the fact that Bt-cotton has undergone and passed all the biosafety tests prescribed by the Indian regulatory authorities prior to its approval. Despite the continued opposition by a small section, the Indian cotton farmers who have been haunted by bollworms for more than three decades, have accepted this technology. This is reflected by the fact that the area under Bt-cotton which was about 29,000 hectares (72,000 acres) in 2002, the first year of approval, has steadily increased from year to year to reach about 3.8 m ha (9.4 m acres) grown by more than 2.3 million farmers in 9 states by 2006. Presently, with the approval of more than 60 Bt-cotton hybrids developed by various Indian seed companies and also newer and improved versions of Bt-cotton, there will be an increasing demand for these transgenic seeds. Of course, the regulatory authorities will continue to monitor their performance.

As the Director of Central Institute for Cotton Research, Nagpur, between 2000 to 2003, I had special interest in all aspects of cotton crop, including transgenics. I had conducted and observed Bt-cotton trials and also closely interacted with farmers and scientists in various places to satisfy myself about its safety and performance. I was convinced that the real cotton farmers were not opposed to this technology and also they were not unduly bothered about its technological details as long as it is beneficial to them. However, Bt-cotton being a new technology, several aspects were/are not clear to many including those whose opinions matter. Therefore, I always felt that there is need for a publication that explains this technology and clarifies all the doubts. I am very glad that this has been fulfilled by Dr. T. M. Manjunath.

Dr. Manjunath is an eminent entomologist who has worked and published extensively on many crop pests, especially cotton bollworms. He was one of the key members of the Mahyco-Monsanto team which was responsible for the introduction of Bt-cotton into India. He has closely interacted with a variety of stakeholders including farmers, activists, policy makers, students, teachers, scientists and media persons. He has pooled all their questions, more than 70, arranged them into convenient sections, and answered them so lucidly that the readers can easily understand the subject. The method he has chosen to provide information in the form of 'Questions & Answers' is commendable. This publication has a lot of educational importance on transgenic crops and should be a constant companion for those interested in this area. I hope it will clear a lot of doubts and enable people to develop more confidence in crop biotechnology which is making rapid progress in India as in other parts of the world. I would like to compliment Dr. Manjunath on his fine contribution.

(C.D. Mayee)
Chairman
Agricultural Scientists Recruitment Board
ICAR, New Delhi

PREFACE

Cotton is an important cash crop in India and plays a significant role in the national economy, contributing about Rs.360 billion (US$8 billion) towards export income and 4% of GDP. It is estimated to support about 60 million people, including farmers who cultivate the crop and those involved in the cotton industry for processing and trading. All the four species of cultivated cotton, *Gossypium herbaceum*, *G. arboreum* (both called 'Desi,' meaning local, or Asian cotton), *G. hirsutum* (American cotton) and *G. barbadense* (Egyptian cotton) are grown in India. The cotton area has fluctuated between 8 and 9 million hectares in the last decade of which, in recent years, about 70% constituted hybrid cotton. Among hybrids, *G. hirsutum* represents about 90%. Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh, Punjab, Haryana, Rajasthan, Karnataka and Tamil Nadu are the important cotton growing states in our country.

While India has the largest area under cotton in the world, representing 20 to 25% of the global total, it ranks only third in terms of production next to China and the USA. The yield of cotton in India is one of the lowest with about 300 kg/ha as against the world average of 580 kg/ha. Among the factors responsible for low yields, the losses due to pests are the most important. More than 160 species of insect pests have been reported to attack the cotton crop at various stages of its growth, causing losses up to 60%. Among insect pests, bollworms are the most common and destructive, requiring major efforts to save the crop from them.

The major cotton bollworms in India are the Old World Bollworm or False American Bollworm - *Helicoverpa armigera*, Pink Bollworm - *Pectinophora gossypiella*, Spotted Bollworm - *Earias vittella* and Spiny Bollworm - *Earias insulana*. Of these, *H. armigera* is the most devastating. More than 50% of the total chemical insecticides used for plant protection in India are sprayed on the cotton crop alone, especially to control bollworms. Even so, farmers are unable to get effective control due to various reasons and are desperately looking for alternative measures. In this context, the regulatory approval of Mahyco-Monsanto's *Bt*-cotton by Govt of India in March 2002 for

commercial cultivation against bollworm control is expected to provide the much needed succour to Indian cotton farmers as demonstrated in several other countries. Being a new technology, several doubts have been raised, mostly due to a lack of proper understanding of the technology or vested interests, creating confusion in the minds of farmers and general public. Therefore, there is need for clarifying these based on scientific facts and placing everything in its proper perspective. Based on my interaction with diverse stakeholders and my own experience, I have made an attempt to fulfill this gap. For the sake of convenience, the information on various aspects of *Bt*-cotton has been unfolded in the form of answers to more than 70 questions, divided into several sections such as bollworms, *Bacillus thuringiensis* (*Bt*), development of *Bt*-cotton, efficacy, safety, insect resistance management, field performance and adoption, costs and benefits, opposition to *Bt*-cotton, legal and illegal seeds, regulation etc. While doing so, I have tried to simplify science. The statistics provided in this book may change from year to year, but the basic scientific principles related to the technology would remain more or less the same. I hope this publication will be useful to various scientists, policy makers, seed companies, journalists, NGOs, students, teachers, extension workers and, above all, progressive farmers.

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A C K N O W L E D G E M E N T S

I am grateful to Dr C D Mayee, Chairman, Agricultural Scientists Recruitment Board, New Delhi, and former Director, Central Institute for Cotton Research, Nagpur, for going through the manuscript and writing a very encouraging 'Foreword' to this publication. As he was closely involved in monitoring the *Bt*-cotton trials in various capacities at different stages of its regulatory approval, his candid views are very valuable.

I was associated closely with Mr Sekhar Natarajan, Mr Rajendra Ketkar, Ms Ranjana Smetacek and several others in Monsanto India and with Mr Raju Barwale and Dr M K Sharma in Mahyco during the pre- and post-regulatory approval of *Bt*-cotton in India. We have faced several interesting and intriguing challenges which have been a great learning experience. I have also had opportunities to interact with various scientists, policy makers, industries, farmers, NGOs, media and my colleagues on numerous occasions which were helpful in getting an insight into the various perceptions and realities about *Bt*-cotton. I wish to record my sincere thanks to all of them.

I am very thankful to Dr K S Mohan, Monsanto Research Centre, Bangalore, who was one my closest associates, and to Dr Graham Head, Monsanto, USA, for going through the manuscript and offering very useful suggestions.

This publication has become a reality because of the initiative taken by Mr R K Sinha, Executive Director, and also the members of All-India Crop Biotech Association, New Delhi, to publish it under the aegis of AICBA. Mr. Bhagirath Choudhary, ISAAA, New Delhi, showed keen interest in this publication. My thanks are due to all of them. It is heartening that AICBA has plans to bring out the translation of this book in several regional languages for the benefit of larger readership.

The views expressed in this publication are my own, not influenced by any.

- TMM

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I. ABOUT COTTON BOLLWORMS

- ***What are the major cotton bollworms in India?***

The major cotton bollworms in India are the Old World Bollworm or False American Bollworm - *Helicoverpa armigera*, Pink Bollworm - *Pectinophora gossypiella*, Spotted Bollworm - *Earias vittella* and Spiny Bollworm - *Earias insulana*. All these belong to the insect order Lepidoptera (moths and butterflies). The Tobacco Caterpillar – *Spodoptera litura*, also a Lepidopteran, is a sporadic pest of cotton. Although highly polyphagous and predominantly a defoliator of tobacco, castor, several vegetable and many other crops, in an outbreak situation it can cause serious damage to cotton bolls and other fruiting structures as well. However, although it has the potential, it is not considered as a major or a regular pest of cotton in India.

Old world bollworm - *Helicoverpa armigera*

Spotted bollworm - *Earias vittella*

Pink bollworm - *Pectinophora gossypiella*

Among the bollworms, *H. armigera* is the most dominant and destructive. It has been difficult to control this pest due to its widespread insecticide resistance, multivoltine and prolific pattern of breeding and high polyphagy. Farmers' major efforts are directed towards controlling *H. Armigera*.

- ***How do bollworms damage the cotton crop?***

The bollworm moths lay their eggs on tender parts of the plant. The most preferred site for egg laying is leaves, especially the upper canopy. Eggs hatch in 2 to 3 days and most of the newly hatched larvae initially feed by scraping the chlorophyll in tender leaves and

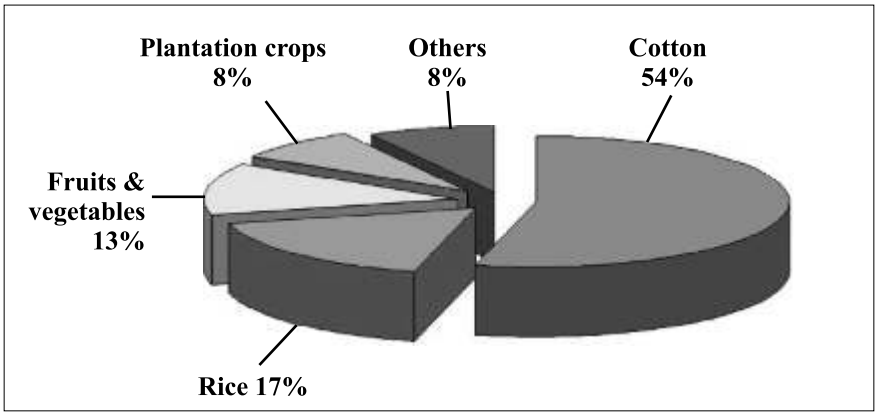
other tender parts for a day or two. As the larvae grow and moult, they move over to flowers, squares and green bolls, the most preferred food, by boring into these plant parts. Hence they are called 'bollworms.' *H. armigera* is a highly destructive feeder, meaning the larvae destroy more squares and bolls than what is actually required for nutrition. The larval period lasts for about 3 weeks after which they typically pupate in the soil or on plants, and moths emerge in 7-10 days under normal conditions. Those squares and bolls that are damaged by the larvae become useless, dry or may drop off. Such destructive and wasteful feeding habit results in heavy yield losses.

Helicoverpa and *Earias* start their activities when the crop is very young (about 6 weeks old) and may complete one or two generations while the crop is still in its vegetative phase. Their feeding and reproductive activities intensify as the crop enters the reproductive phase when plenty of squares and bolls become available. *Pectinophora* appears around the blooming stage. All these pests remain active almost throughout the crop season.

- ***What are the major control measures adopted by the farmers?***

Chemical control is the most widely adopted practice as, when successful, its results are quick and visible. The number of sprays given may range from 5 to 20 with an all-India average of seven sprays per crop. It is estimated that insecticides worth about Rs. 30 billion (US$ 660 million) are used annually in Indian agriculture

CROP-WISE CONSUMPTION OF INSECTICIDES IN INDIA



of which about Rs.16 billion are spent for the control of cotton pests and of this Rs.12 billion (Rs.1200 crores or US$ 26 million) against bollworms alone! In terms of volume, about 54% of the total insecticides used in Indian agriculture is applied on cotton crops. This indicates the economic importance of bollworms in general and *Helicoverpa armigera*, the major bollworm, in particular. Despite such repeated sprays, bollworms continue to cause yield losses up to about 60%. Among the factors responsible for such unsatisfactory control are the abuse of insecticides, spurious products and, most importantly, *H. armigera* has developed resistance to most of the recommended insecticides including the synthetic pyrethroids. Therefore, farmers, scientists and policy makers have been frustrated and desperately looking for alternative methods for bollworm control.

- ***What are the alternative control methods?***

There are several individual approaches, but integrated pest management (IPM) where several options are judiciously integrated, has been considered a suitable alternative. IPM aims at sequential or simultaneous use of non-chemical methods like sex pheromone traps, biological control agents and botanical insecticides as a top priority while chemical insecticides are applied only as a last resort. There are a few reports indicating the success of IPM when it was strictly followed. However, in general, in a cotton eco-system where regular spraying has become a habit with the farmers, IPM did not infuse enough confidence as it could not match the temporal efficacy of chemicals and provide consistent and visible results. Therefore, farmers are perhaps left with no option but to "Spray and Pray." In such a challenging scenario, based on its widespread adoption and demonstrated success in other countries, bollworm resistant *Bt*-cotton which has been approved by Govt of India in March 2002, brought a ray of hope to our cotton farmers.

Selected References:

Armes et al., 1996; Barwale et al., 2004; Kranthi et al., 2001; Manjunath, 2004; Manjunath et al., 1989; Mohan & Manjunath, 2002; Patel et al., 1974; Puri et al. 1999; Ramasubramanyam, 2004

II. WHAT IS *BT* *(BACILLUS THURINGIENSIS)?*

- ***What is Bt?***

Bt is the popular abbreviation for *Bacillus thuringiensis*, a bacterium commonly found in soil with ubiquitous distribution. Hence it is popularly called a 'soil bacterium', but it is also quite common in other habitats like dead insects, water, dead plants, grain dust etc. The insecticidal property of *Bt* was first discovered in 1901 in Japan by Ishiwata and later in 1911 in Germany by Berliner who described this species and gave the present name. More than 80 varieties or sub-species of *Bt* have been described so far.

- ***What is unique about Bt?***

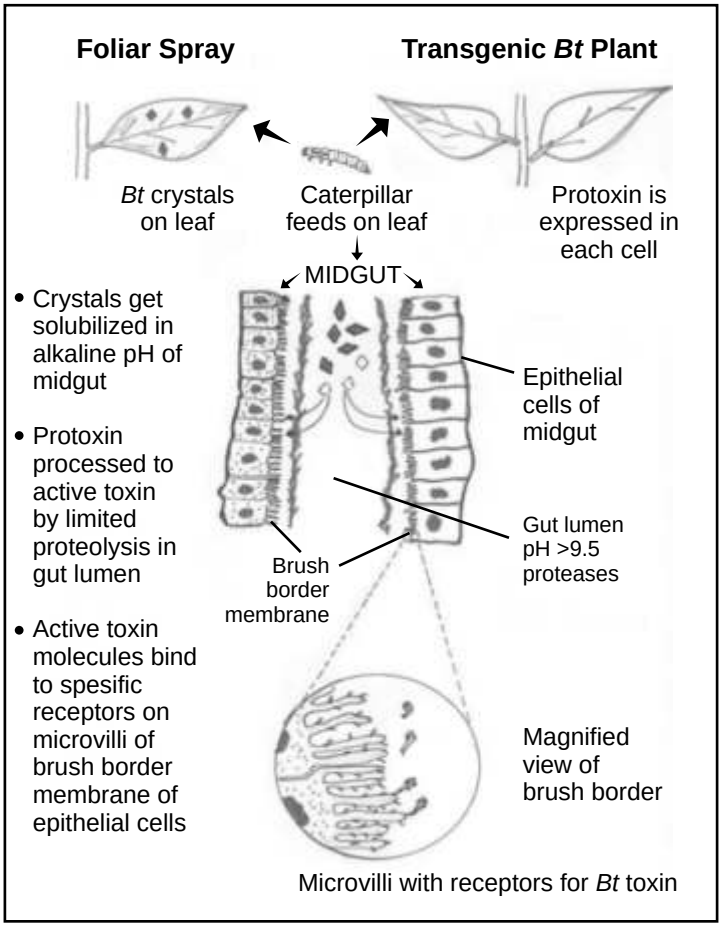
A unique feature of *B. thuringiensis* is that it is a gram-positive, endospore-forming bacterium characterized by the presence of Cry (acronym for 'crystal' protein as the insecticidal proteins aggregate to form insoluble crystals in the bacterium) protein within the cytoplasm of the sporulating cells. Different varieties or sub-species of *Bt* produce different insecticidal proteins. Currently about 250 Cry proteins, sourced from about 80 sub-species of *Bt*, have been characterized. Each of these proteins affects only a narrow range of insects belonging to a particular group. Thus, there are *Bt* proteins that can selectively kill certain larvae of only Lepidoptera (moths and butterflies), Coleoptera (beetles), Hemiptera (bugs), Diptera (flies and mosquitoes) and so on. A particular *Bt* protein active on one group of insects does not affect other insects or other organisms. Such host specificity is also a unique feature of *Bt*.

- ***How does Bt act?***

Bt-proteins require certain specific conditions for them to be active against the insect.

- In the first place, the concerned *Bt* protein has to be ingested by the susceptible insects as it has no contact effects. In the case of *Bt*-plants, this happens when the larvae feed on plant tissues.
- The protein requires an alkaline gut with a suitable pH (9.5 and above) for its activation.
- There should be specific receptors in the insect mid-gut epithelial cells for protein-binding before it can kill the insect.

_BT_ INSECTICIDAL PROTEINS MODE OF ACTION

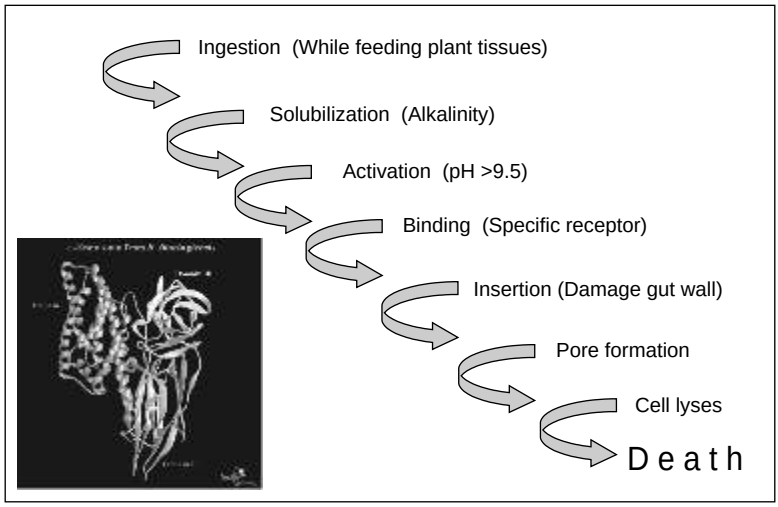


All these conditions are available only in the susceptible insects and therefore they succumb when they feed on *Bt*-plants.

- ***How exactly are the bollworms affected by Bt-cotton?***

In the commercialized transgenic *Bt*-cotton plants, the expression of *Bt* protein is constitutive i.e., the protein is expressed in all parts of the plant. When the larvae feed on *Bt* plants, they ingest *Bt* protein along with the plant tissues. If it is a susceptible insect like bollworms, the *Bt* protein gets activated in the mid-gut and the activated molecules bind themselves to certain receptors present on the gut membrane, very much like a specific key fitting into a lock. Such a specific interaction between the activated *Bt* protein and receptor results in 'holes' being formed in the insect intestine, causing destruction of the gut lining. The haemolymph (insect blood) carrying ions and vital nutrients leak into the intestine. This leads to paralysis of the insect gut as a result the insect stops feeding. This sequence of events can take place within a few hours. The affected larvae may die after a day or two, but since it stops feeding, any further damage to plants is prevented (see figure).

SELECTIVE ACTIONS OF *BT* IN INSECTS



Bt proteins can affect only those insect species possessing the specific receptors and conditions for toxin activation and, therefore, pose no threat to higher order organisms as they lack such specific conditions in their gut. This includes warm blooded animals.

- ***Since when is Bt used for insect control?***

Bt proteins have served as the principal active ingredient of a number of commercial bacterial insecticides and these have been used as spray formulations (a mixture of endospores and insecticidal crystals) for control of various insect pests since the mid-1950s in several countries. The pests targeted included various caterpillars (Lepidoptera) and beetles (Coleoptera) attacking several crops as also mosquito and blackfly (Diptera) vectors of human and animal diseases. However, the concept of transgenic plants, including *Bt*-cotton, was as recent as the 1980s.

Selected References:

Beegle & Yamamoto, 1992; Crickmore et al., 1998; Fred et al., 2000; Kameswara Rao, 2005; Manjunath, 2005(a); Mohan & Manjunath, 2002.

III. DEVELOPMENT OF *BT*-COTTON

- ***What is a Bt-plant?***

Depending upon the type of pests to be controlled - whether it is Lepidoptera, Coleoptera etc. - the relevant genes from the soil bacterium, *Bacillus thuringiensis (Bt),* are isolated, studied, suitably modified and introduced into the desired plant species by genetic engineering. The new *Bt*-gene gets stably integrated in the host genome and becomes an inheritable trait. Such transgenic plants containing the *Bt*-gene(s) are popularly called '*Bt*-plants.' For example, *Bt*-cotton is incorporated with the lepidopteran specific gene(s) as it is designed to control bollworms which belong to this insect order. Similarly we have *Bt*-corn, *Bt*-potato, *Bt*-brinjal (egg-plant), *Bt*-rice etc. with their encoded proteins providing insect control.

- ***When were the first Bt plants commercialized?***

The first genes encoding the insecticidal *Bt* proteins were cloned in the early 1980s. This paved the way for constructing recombinant bacterial insecticides containing novel combinations of these proteins and to the development of *Bt*-plants. The first *Bt*-cotton plants were developed by the Chinese Academy of Agricultural Sciences (CAAS) in China and by Monsanto Company in the USA in the early 1990s. However, regulatory approval and large scale commercial cultivation of *Bt*-crops which included *Bt*-cotton along with *Bt*-corn and *Bt*-potato developed by Monsanto, took place in the USA in 1996. Thus, 1996 marked the beginning of commercialization of transgenic crops.

- ***How exactly can an ordinary cotton plant be converted into a Bt Cotton plant?***

It can be accomplished by introducing the required *Bt* gene into the desired cotton cultivars by genetic engineering. For example, the

cry1Ac gene encoding the insecticidal protein Cry1Ac is first isolated from the soil bacterium, *Bacillus thuringiensis*. The gene is then modified to be more similar to a plant gene and combined with the 35-S promoter (derived from cauliflower mosaic virus) to achieve the expression of Cry1Ac protein in all parts of the plant (i.e., constitutive expression). In order to identify plant cells that contain this new gene, a selectable marker is needed. In this case, the *npt II* gene which encodes the enzyme neomycin phosphotransferace II (NPT II) is used. Plant cells containing these new genes are isolated on a medium containing the antibiotic kanamycin. The *aad* gene is a bacterial selectable marker 3"(9)-0-aminoglycoside adenyltransferace (AAD) which allows selection of bacteria containing the Cry1Ac plasmid on a medium containing spectinomycin or streptomycin. Cotton transformation is achieved through tissue culture (starting with the American cotton variety Coker 312) technique that allows the soil bacterium, *Agrobacterium tumefaciens*, to transfer the DNA contained on the plasmid with the above sequences. The transformed cotton lines were screened to identity those with these genes inserted into the cotton genome in the most favorable position to achieve the desired insect control and agronomic performance.

- ***How were our Indian cotton cultivars converted into Bt-cotton?***

Monsanto provided the *Bt*-gene, *cry1Ac (Bollgard®)*, incorporated in the seeds of the American cotton variety called Coker 312, to its Indian licensee Maharashtra Hybrid Seed Company (Mahyco) along with the technology. Through routine back-crossing with the parental lines of Mahyco's proprietary hybrids, the gene was transferred from Coker 312 into them. Thus the native hybrids are incorporated with the *Bt*-gene. Hybrid seeds were then produced in the usual manner. All the current *Bt*-cotton hybrids are *Gossypium hirsutum* (American cotton).

- ***How long did it take to get the approval of Bt-cotton in India?***

It took 6 to 7 years for Mahyco to complete all the regulatory trials related to biosafety and agronomic impact and get the official approval of the first batch of three *Bt*-cotton hybrids in India in March 2002. The chronology of events is summarized in the table:

Chronology of Development and Approval of *Bt*-Cotton in India

1995	Mahyco applied to DBT for permission to import a small stock of Bollgard® (*Bt*-cotton) seeds from Monsanto Company, USA. DBT gave permission.
1996	A nucleus stock of 100 gms of cotton seeds of the American variety Coker 312 containing the Bollgard® *Bt* gene, *cry1Ac*, was received by Mahyco from Monsanto, USA. Mahyco initiated crossing Coker 312 with the Indian cotton breeding lines to introgress *cry1Ac* gene. 40 elite Indian parental lines were converted for *Bt* trait.
1996-1998	Risk-Assessment Studies were conducted, using Indian *Bt*-cotton hybrids, in laboratories and fields designated by RCGM/GEAC. These included pollen escape, aggressiveness and persistence, biochemical analysis, toxicity and allergenicity.
1998-1999	Multi-location field trials at 40 locations in 9 states to assess agronomic benefits and safety. Data submitted to RCGM.
1999-2000	Field trials repeated at 10 locations in 6 states. Data submitted to RCGM
2000	July 2000 – Based on the recommendations of RCGM, the GEAC gave permission for large scale field trials in 85 ha and seed production in 150 ha.
2001	*Kharif* 2001 – Large scale field trials covering 100 ha. Field trials were also conducted by All India Coordinated Cotton Improvement Project of the Indian Council of Agricultural Research (ICAR).
2002	On 26 March 2002, GEAC approved Mahyco's three *Bt*-cotton hybrids, viz. MECH 12*Bt*, MECH 162*Bt* and MECH 184*Bt*, for commercial cultivation in India. This approval was initially valid for three years and it came with certain conditions. **It was a landmark decision as *Bt*-cotton is the first-ever transgenic crop to receive such a regulatory approval in India.**

- ***What are the differences between using Bt as a spray and Bt in transgenic plants for insect control?***

The major differences are:

- In order to spray, *Bt* formulation has to be purchased separately whereas in transgenic *Bt*-plants, *Bt* is incorporated in the seed itself.
- During spray, *Bt* is applied externally on the plants whereas in transgenic plants, *Bt* protein is produced within the plant.
- When sprayed, it is difficult to get uniform coverage of the entire plant/crop and also there is wastage of spray fluid whereas in transgenic plants, *Bt* protein is present in all the plants, in all the parts and all the time.
- When sprayed, *Bt* may get rapidly degraded if exposed directly to solar radiation or washed off by rain whereas in transgenic plants, as *Bt* is present within the plant, it is not greatly affected by external conditions.
- One needs to monitor the pests closely so as to appropriately time effective sprays, whereas in transgenic plants, since the control measure is in-built, the insecticidal activity is always present, providing protection day and night.
- Spray formulations can be applied, as and when required, on any crop which may be considered as an advantage whereas in the case of transgenics, the advantage is restricted only to those crops that have been transformed into *Bt*-plants.

- ***Was there a need to introduce Bt-cotton from America when we have our own cotton cultivars?***

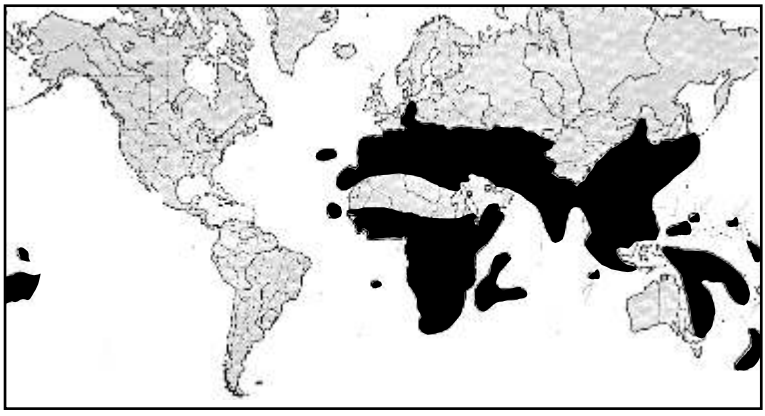
Bt-cotton plants as such were not introduced into our country. It should be clearly understood that *Bt* is an insecticidal trait, not a cultivar. Mahyco has obtained license from Monsanto to use their

Bollgard® *Bt*-gene to develop *Bt*-cotton in India. This gene has been deployed by Mahyco in the cotton hybrids that have been developed by them. In fact, these hybrids which bear the Indian germplasm, were already under commercial cultivation in India even before the incorporation of *Bt*-gene in them. The *Bt*-gene has empowered such hybrids to express a particular protein that can kill bollworm larvae and derive protection. The gene can be introduced into any desired cotton cultivars as has been accomplished by Mahyco and subsequently by Rasi, Ankur, Nuziveedu and several other seed companies.

- ***It is accused that, in the first place, the 'American Bollworm' was introduced into our country from America and now the Bt-cotton technology, also from America, is offered as a remedy against the same pest! How far is it true?***

This accusation defies facts. The so-called 'American Bollworm', *Helicoverpa armigera,* does not occur in America at all! The distribution of this species is limited only to the Old World (India, Pakistan, China, Australia, Africa etc) (see distribution map below). Therefore, it is more appropriate to call *H. armigera* the 'Old World Bollworm' or 'False American Bollworm' to remove such confusion.

DISTRIBUTION MAP OF
OLD WORLD BOLLWORM, *HELICOVERPA ARMIGERA*



- Host plants : Cotton, tomato, chickpea, pigeonpea, tobacco, sunflower etc. Highly polyphagous with more than 180 recorded host plants.
- Distribution : Europe, Asia, Russia, Africa, Australasia and Pacific Islands

Source : CIE Map No.15 (revised) & Manjunath (1989)

H. armigera was primarily a pest of tomato (it was popularly called the 'Tomato Fruit Borer') in India before it switched to cotton, chickpea, pigeon pea and a large number of other crops (more than 80 plant species). Two closely related species, *Helicoverpa zea* (Cotton Bollworm) and *Heliothis virescens* (Tobacco Budworm) have been serious pests of cotton in the USA for a long time. When *H. armigera* was first noticed on cotton in India in a serious form in the early 1970s, perhaps it was mistaken as an accidental introduction of the American species and hence earned the misnomer 'American Bollworm.' The fact that India had earlier introduced the American cotton (*Gossypium hirsutum*) varieties to enlarge the genetic base of cotton in our country had further added to this suspicion. However, this confusion was cleared long ago and it is a well-established fact that *H. armigera* is a native species. Therefore, the above allegation is not valid. It is important to note that *Bt*-cotton is effective against the bollworm species found in the USA as well as those found in India. Thus, this technology is useful to us.

- ***What are the advantages of Bt-cotton?***

Bt-cotton has several advantages. Some of these are:

- *Bt*-technology for control of bollworms is made available in the seed itself. Farmers have to just sow the *Bt*-cotton seeds as they do with conventional seeds. The resulting plants have the in-built ability to produce *Bt*-protein within their body and defend themselves from bollworms. No extra efforts or equipment are needed to utilize this technology.

- *Bt* protein is expressed in all parts of the plant (i.e., constitutive expression), providing bollworm control day and night, almost throughout the plant life. No need to monitor the bollworms to initiate control measures.

- The newly hatched larvae feeding on any part of the plant will ingest *Bt*-protein and die within one or two days, thereby preventing any potential serious damage to the crop.

- *Bt*-proteins, being lepidopteran specific, affect only the bollworms and are safe to biological control agents and other non-target beneficial organisms, higher animals and plants.
- *Bt*-cotton is compatible with other control measures such as biological control, pheromones, botanical insecticides and also chemicals that are recommended for Integrated Pest Management. In fact, *Bt*-cotton can serve as a major component of IPM in cotton crops.
- *Bt*-cotton helps to avoid or minimize chemical sprays, thus contributing to cleaner environment and conservation of biological control agents and biodiversity.
- *Bt*-cotton offers protection from bollworms right from the early days of the crop, leading to a healthy crop, better boll retention, greater harvest and more profit.
- The *Bt*-farmers experience a far lower tension and are certainly better off than the earlier scenario of "spray & pray."

- ***Are there any limitations of this technology?***

It is important to know that *Bt*-cotton offers protection only against bollworms, not sucking pests and other non-lepidopteran pests. Therefore, separate control measures have to be taken against such pests as and when required. Another factor is that the expression of *Bt*-protein in cotton plants may decline after 90 -100 days, calling for supplementary control measures on rare occasions if warranted. It is also a fact that the expenditure on the *Bt*-trait cannot be de-linked from the seeds even if there is no serious bollworm infestation. *Bt* should be always treated as an insurance against bollworms. Further, enforcing 'refuge' crop on farmers poses several practical challenges. It is always necessary to understand clearly the scope of a technology for its proper utilization.

Selected References:

APCoAb, 2006; Barwale et al., 1999, 2004; James,2002; Jayaraman, 2002; Kranthi et al., 2005; Manjunath, 2004, 2005 (a); Manjunath et al., 1989; Mohan & Manjunath, 2002; Perlak et al., 1990, 2001; Pray et al., 2001; Mangala Rai & Prasanna, 2000

IV. EFFICACY OF *BT*-COTTON

- ***Will Bt-cotton control all pests?***

The *Bt*-genes that are currently incorporated in the commercialized cotton plants are lepidopteran specific. They are primarily targeted against bollworms which have been the most destructive and difficult pests to control. Besides bollworms, *Bt*-cotton is effective against secondary lepidopteran pests like the semilooper (*Anomis flava*) and leaf roller (*Sylepta derogata*). However, it is not designed to offer protection against sucking pests (whiteflies, aphids, thrips, jassids) and other non-lepidopteran pests, or against diseases and adverse environmental conditions like drought, cold, salinity etc. Appropriate remedial measures will have to be taken against these as and when warranted.

- ***Since Bt-cotton controls only the bollworms, it provides only a partial remedy. Is it not possible to develop a technology that can take care of all the problems in the cotton crop?***

Yes, such a cure-all technology is the dream of everyone! But, it is easier imagined than achieved. However, by introducing multiple genes with different traits, scientists have already made some progress in solving more than one problem in a single crop. For example, the same cotton cultivar resistant to bollworms as well as certain herbicide has already been developed. Similarly, corn plants with combined resistance to European corn borer, rootworm and herbicide have also been successfully developed. These are already under commercial cultivation in other countries. More research is underway. However, it may not be possible to answer all the problems with any single technology. We should try to integrate and take advantage of several technologies. Science should not discriminate between one technology and the other as long as it is safe and beneficial.

- ***What is the fate of the non-Bt farmers in the neighborhood of Bt-cotton? Will their crops suffer more pest damage?***

There need not be such a fear. *Bt*-cotton and non-*Bt* cotton plants look alike with very little phenotypic differences between them. The bollworm moths lay their eggs on both the cottons without discrimination. However, the subsequent results would be different. The tiny larvae hatching from the eggs laid on *Bt*-cotton will perish within one or two days as they ingest *Bt*-protein while feeding on the plant tissues. On the other hand, the larvae hatching on non-*Bt*-cotton continue to feed and grow and cause serious damage if appropriate control measures are not taken. Merely the presence of *Bt*-cotton in the vicinity, therefore, does not influence the bollworm populations in the non-*Bt* crops. However, if *Bt*-cotton becomes very broadly planted in India, it is possible that it will lead to a decrease in bollworm populations, thereby reducing damage to non-*Bt* crops as well.

- ***Will Bt-cotton be effective against bollworm larvae of any age?***

Bt-cotton is most effective against young larvae that are in the first or second instar. They get killed within one or two days after ingesting the *Bt* protein while feeding on the plant. The older larvae may not die, but they suffer a setback in their overall health and vigour. Such sick larvae feed far less. Since *Bt* protein is constitutively expressed in *Bt*-cotton and the neonates ingest the protein as soon as they take the first bite of the plant, the chances of larvae escaping and surviving beyond first or second instar are rare.

- ***What about the chances of older larvae migrating from the adjacent non-Bt fields and damaging the Bt-plants?***

The larvae of *Helicoverpa armigera* generally have a tendency to feed on the same or a few adjacent plants. Plot-to-plot *en mass* larval movement generally does not occur. Only the adult moths are highly migrant and known to travel long distances. In the case of Spotted Bollworm (*Earias vittella*) and Spiny Bollworm (*E. insulana*) and more so with Pink Bollworm (*Pectinophora gossypiella*), the larval

movement is even more limited. Therefore, one need not be unduly worried about the presence of non-*Bt* crops in the adjacent fields.

- ***Does the expression of Bt-protein remain at the same level in all parts of the plant and throughout the plant life to ensure effective bollworm control?***

The expression of *Bt* protein is more in tender leaves as compared to squares, bolls, flowers and pollen. The optimum expression in leaves is most critical as a greater number of bollworm eggs are laid on leaves and the newly hatched larvae, while feeding on chlorophyll in the leaves, ingest *Bt* protein and perish. High protein expression in fruiting parts will add to further efficacy. The extreme temperature and other environmental factors may also play a role.

The protein expression remains more or less consistent up to about 100 days, but gradually declines as the plants age. Keeping such factors in mind, an 'Optimum Dose' strategy is deployed in *Bt*-plants so that they express far greater quantity of proteins (>25 times) than actually required for causing larval mortality. Thus, in the later stages of crop growth, even if the protein level has dropped, the remaining protein is adequate to bring about larval mortality, thereby ensuring satisfactory bollworm control throughout the season. Another objective of this strategy is to ensure that all susceptible larvae and even those which are heterozygous for resistance (i.e., likely to develop resistance with constant exposure to *Bt*-crops) are killed so that there is a very low probability of insects gaining resistance to *Bt* protein.

The bollworm populations from different geographical regions as well as from the same region vary considerably in their susceptibility to *Bt* proteins and occasionally, especially later in the growing season, some larvae may survive, although at a greatly reduced level. Necessary alternative control measures have to be taken on such occasions if warranted. *Bt*-cotton should not be treated as a silver bullet.

- ***Is the expression of Bt-protein uniform in all hybrids?***

Bt protein expression varies with different cultivars depending upon their genetic background. Therefore, it is necessary to choose the right hybrids to derive optimum benefit from this technology.

- ***Will the sucking pests become more serious consequent to the control of bollworms by Bt-cotton?***

The mode of feeding by sucking pests and bollworms is different. Sucking pests like aphids, whiteflies, thrips and jassids feed by sucking the sap whereas bollworms feed by chewing the plant parts. They do not compete for the same source of food within the same plant. Therefore, control of bollworms need not necessarily result in encouraging sucking pests, but certain environmental factors like dry spells may do so. On the other hand, due to very limited or no application of chemical pesticides for bollworm control in *Bt*-cotton, the natural enemies of various pests are conserved and these contribute to keeping them in check. However, to get the full benefit of *Bt*-technology, it is always better to be watchful and take appropriate control measures to protect the crop from sucking and other pests as also from diseases and environmental factors that are not controlled by *Bt*-cotton. The ideal approach is integrated pest management (IPM) with *Bt*-cotton as the major thrust.

Selected References:

Arunachalam & Bala Ravi, 2003; Barwale et al., 1999; Deeba et al., 2003; Greenplate, 1999; Jalali et al.,2004; James, 2002; Kameswara Rao, 2005; Kranthi et al., 2005; Manjunath, 2005 (a), 2006; Morse et al., 2005

V. SAFETY TO NON-TARGET ORGANISMS

- ***It is feared that the health of humans and animals exposed to Bt cry proteins may be affected in some way. What safeguards have been taken?***

DNA (deoxyribonucleic acid) is present in all living organisms such as plants, animals and microorganisms and is eaten by human beings and animals in one form or the other with every meal. Most of it is broken down into more basic molecules during the digestive process while the remaining amount is either absorbed into the blood stream or excreted. Nevertheless, tests are carried out with each newly introduced DNA into the plant. This applies to cry proteins as well.

A large number of experiments, as prescribed by the regulatory authorities in each country, have been carried out to examine the safety of cry proteins. Experimental animals like mice, rats, rabbits and sheep fed with unusually high doses (500, 1,000 and 4,300 mg/kg body weight) of cry protein showed no acute toxic effect on their health. These animals were found to be equivalent to those not fed with cry proteins with respect to body weight, food consumption and other respects. The U.S. Environmental Protection Agency (EPA) has concluded "toxicity and infectivity risks of cry proteins to non-target organisms like avian, freshwater fish, freshwater aquatic invertebrates, estuarine and marine animals, arthropod predators/parasitoids, honey bees, annelids and mammalian wildlife will be minimal to non-existent at the recommended rates of registered *B. thuringiensis* active ingredients." This provides confidence that cry proteins produced in *Bt*-crops would pose little risk to non-target organisms.

- ***Have such biosafety studies been carried out in India?***

Yes, biosafety and risk assessment studies have been carried out on *Bt*-cotton in India in the laboratories and fields designated by RCGM/GEAC as a part of the regulatory requirements, prior to its approval. Feed-safety studies using *Bt*-cotton seed-meal were

conducted on goats, buffaloes, cows, rabbits, birds and fish by competent scientists at various institutions like the Industrial Toxicological Research Centre, Lucknow; National Dairy Research Institute, Karnal; Central Institute of Fisheries Education, Mumbai; Central Avian Research Institute, Izatnagar; National Institute of Nutrition, Hyderabad; and G. B. Pant University of Agriculture and Technology, Pantnagar. The results revealed that the animals fed with *Bt*-cotton seed-meal showed no ill-effects and were comparable to control animals in the various tests. In other words, *Bt*-cotton seed-meal was substantially equivalent to its non-*Bt* counterpart. Based on such scientific data, the regulatory authorities considered *Bt*-cotton as safe.

- ***What is the fate of Bt protein in the soil? Will it affect the soil organisms?***

Studies have been conducted to determine the amount of *Bt*-protein leached by roots as also from other plant parts incorporated in the soil and its effect on soil rhizosphere and non-rhizosphere microflora, soil Collembola, earthworms etc. It was found that there was no adverse effect. In fact, there was no difference between the soils obtained from the *Bt* and non-*Bt* plots in this respect. It was also found that *Bt* insecticidal proteins are readily susceptible to metabolic, microbial and abiotic degradation once they are ingested or excreted into soil. The half-life of the Cry1Ac protein in plant tissues has been found to be to be a maximum of 41 days. Therefore, it cannot bio-accumulate causing delayed effects.

- ***Will Bt-transgenic plants affect biodiversity?***

Except for the presence of *Bt*-gene, which has been introduced for the specific purpose of controlling the target pests, *Bt*-plants are substantially equivalent to their non-*Bt* counterparts in terms of protein, carbohydrate, ash and moisture content as well as other acid contents in the foliage. In other words, the impact of *Bt*-plants on other plants or non-target organisms is no different from that of their traditional counterparts. On the other hand, due to reduced application of chemical pesticides, the populations of non-target

beneficial insects like ladybird beetles, green lacewings and other biological control agents as well as honey bees have been reported to be greater in *Bt*-fields thereby sustaining or enhancing biodiversity in the crop ecosystem

- ***Is Bt-cotton harmful to silkworm as was alleged for Bt-corn to monarch butterfly in the USA?***

The monarch butterfly and silkworm are both lepidopteran insects and it will not be a surprise if their young larvae die if they are made to ingest *Bt*-protein, as has been shown by certain laboratory experiments. However, the field realities are different. The habitats and food plants of the monarch butterfly (it feeds on milkweed) and silkworm (it feeds on mulberry) are different and there is very little chance for them to come in contact with adequate quantity of *Bt* protein from the pollen or other parts of *Bt*-corn or *Bt*-cotton in nature.

The so-called threat to monarch butterfly, perceived on the basis of reported mortality of caterpillars as a result of force-feeding them on the milkweed leaves artificially coated with *Bt*-corn pollen in the laboratory at Cornell University, USA, in 1999, was highly exaggerated in the media and became one of the most controversial issues with the activists in the USA demanding a moratorium on further planting of *Bt*-corn. The USDA, on its part, constituted several teams of scientists to investigate various aspects and reassess the potential risks to monarch butterfly by *Bt*-corn. Based on the results of their comprehensive studies which were reviewed by EPA (Environmental Protection Agency), it was concluded that *Bt*-corn is not a threat to monarch butterfly populations. A number of other independent studies also supported this view. Perhaps the results would be on the same lines with silkworm in India. The monarch episode highlighted the need for drawing realistic conclusions based on detailed scientific investigations rather than jumping to misleading conclusions and resorting to agitations based on preliminary laboratory studies.

- ***What about the possibility of pollen being transferred to weeds, resulting in 'Super Weeds'? One is also warned against 'Gene Pollution' or 'Gene Contamination.'***

Cotton has only one close weed relative in India. It is *Gossypium stocksii*. It is found in northern Gujarat where cotton is not cultivated. Besides, there is no record of bollworms feeding on this weed and also there is no other major lepidopteran common to both cotton and this weed. Further, the cotton pollen is heavy and cannot move beyond a few metres away from cotton fields. Therefore, the possibility of gene transfer and the development of 'Super Weed' is a remote possibility. Even in other countries and with other *Bt*-crops, there is no evidence that 'Super Weeds' have ever developed over the past decade.

In India, we have two types of cotton: the American cotton (*Gossypium hirsutum* and *G. barbadense*) and the 'Desi' (local) cotton (*Gossypium herbaceum* and *G. arboreum*). All the *Bt* cotton hybrids developed in India are *G. hirsutum*. The American cotton is tetraploid in genetic makeup whereas the 'Desi' cotton is diploid. There is no reproductive compatibility between the two. Even if cross pollination occurs between the tetraploid and diploid cotton plants, the zygotic embryo will not develop. The terms such as 'Gene Pollution' and 'Gene Contamination' are mere jargons in this case.

- ***What is the guarantee that Bt-technology will not pose any problems in the long future? How long can this technology last?***

A number of short-term and long-term potential consequences related to bio-safety and environmental safety, as perceived by the experts, are considered and investigated through scientific studies before any biotech product is approved by the regulatory authorities. Any genuine new concerns will also be handled thus. A technology is generally developed to overcome the difficult problems faced currently, for example cotton bollworms, while keeping the safety and benefits for future as well. It is not possible to foresee everything beyond a certain time frame.

We should follow the precautionary principle and minimize the risks as far as possible. No technology is absolutely free from risk. For fear of speculated risks, if we close the doors for new technologies, we cannot make progress and solve our problems.

Bt-technology has already lasted for a decade in several countries with no negative consequences whatsoever and is becoming more refined and popular. Furthermore, the use of this technology has led to significant reduction in chemical sprays with the concomitant benefits to the environment and farmer health as well as income. It is the responsibility of the scientists and regulators to sustain these benefits

Selected References:

Barwale et al., 1999;FAO, 2004; James, 2002; Kameswara Rao, 2005; Khadi et al., 2004;Losey et al., 1999; Manjunath, 2005 & 2005 (a); Mangala Rai & Prasanna, 2000; Mishra et al., 2006; Pisupati et al., 2002; Sears et al., 2001; http://www.ars.usda.gov/sites/monarch

VI. INSECT RESISTANCE MANAGEMENT

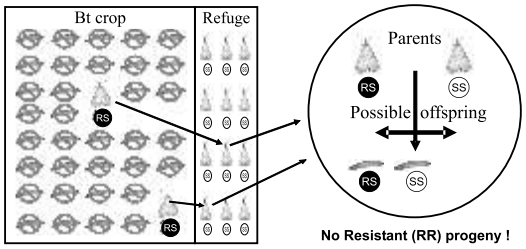
- ***Why should farmers plant non-Bt cotton along with Bt-cotton?***

Planting non-*Bt* cotton as border rows to *Bt*-cotton is currently recommended as a step towards delaying or preventing the development of resistance to *Bt* protein by bollworms. It is called 'Refuge.' This is practiced in other countries like the USA and Australia and has also been recommended by Govt of India. The 'refuge' crop could be 20% of the *Bt*-cotton area with the intervention of plant protection measures when required or 5% of the area without providing any chemical protection. However, studies are underway to determine whether alternative host crops of bollworms are common enough in Indian cotton-growing areas to fill this 'Refuge' function without the need for a structured non-*Bt* cotton 'Refuge'.

- ***How does refuge help in pest resistance management?***

The refuge strategy is designed to ensure the availability of the *Bt*-susceptible pest population so as to mate with the *Bt*-resistant population, should they arise. It is known that a great majority of larvae that feed on 'refuge' (i.e., non-*Bt*) crop, in the absence of adequate control measure, would complete their development and emerge as moths. Their number will be large and these remain as susceptible strain (SS). On the other hand, almost the entire population of newly hatched larvae that feed on *Bt*-plants would perish with only a very few developing into moths. These are the moths carrying the resistance gene (RS). Because of the overwhelming population of the SS moths in the vicinity, coming from the refuge (either from structured or natural) crops, and a very scant population of RS moths, the possibility of SS mating with RS is far greater than RS with RS. Resistance in this case being recessive, the pairing of SS and RS would result in a susceptible progeny. Thus, refuge helps in maintaining susceptible population. This is depicted in the figure. Theoretically, the refuge does not have to be cotton but could be any plant that supports *Bt*-susceptible bollworms.

Refuge Crop for Resistance Management



On Bt-Crop:

- Freshly hatched larvae while feeding on Bt plant ingest Bt protein and nearly all of them die within one or two days.
- A scant few may survive and develop into moths (RS).

On Refuge:

- Freshly hatched larvae feed on plant and a large number of them successfully complete their life cycle and develop into moths. All of them will be susceptible to Bt protein (SS).

The n o. o f r esistant m oths (RS) i s e xtremely l ow w hereas t hat o f s usceptible m oths v ery h igh. When a resistant moth (RS) looks for a mate, odds are greatly in favour of its finding a susceptible moth from the refuge. Pairing RS & SS results in susceptible progeny. Thus refuge helps in maintaining susceptible population.

- ***'Refuge' appears to be a burden, especially to our small farmers. Is it absolutely necessary?***

Insect resistance management (IRM) is very important to conserve the *Bt*-technology for long-term benefits and, therefore, refuge cannot be considered as a burden or waste. However, in India, *Helicoverpa armigera*, the most destructive bollworm, has a large number of alternative host crops (more than 80 plant species). Of these, crops like pigeonpea, chickpea, sunflower, corn, chili, tomato and okra (bhendi) are heavily infested and support very high populations of eggs and larvae of *H. armigera*. Some of these crops are cultivated in close proximity to each other and around the same time as cotton in several parts of central and southern India. In fact, studies have revealed that pigeonpea and chickpea are more preferred than cotton by *H. armigera*. These crops can act as natural refuge. Further, in India, the area presently occupied by *Bt*-cotton constitutes only around 42% of the total cotton area. Although it is expected to increase in the coming years, a large area of non-*Bt* cotton crop would still be available which can also serve as natural refuge. Under the circumstances, there appears to no need for structured refuge crop in

our country. In fact, in China, in view of the availability of alternative host plants, growing refuge is not mandatory. Perhaps this needs to be reviewed by the regulators in our country also, but until such time, the prevailing recommendation should be followed.

- ***Some farmers seem to use non-Bt cotton for gap filling as they are reluctant to buy the seeds again as these are costly. Is it advisable?***

It is known that *Bt* causes quick mortality of only the early instars, not the grown up larvae. Therefore, it is advisable not to use the non-*Bt* cotton for gap filling as the larvae may complete their early days on such plants and then move over to the adjacent *Bt*-plants and damage them. The cost of *Bt* seed is small as compared to the benefits.

- ***What are the other methods available to mitigate resistance development?***

Besides 'refuge', several other proactive insect resistance management (IRM) strategies have been developed and practiced. These include the 'Optimum Dose' strategy wherein the plant is empowered to express *Bt* protein at a much higher dosage (>25 times) than normally required for larval mortality. The objective is to bring about maximum mortality of pest larvae, giving minimum chance for the potential resistant larvae to survive. Another IRM strategy is 'Gene Stacking' or 'Gene Pyramiding.' In this approach, more than one gene, each having a different mode of action and binding to a different receptor in the insect gut, is incorporated into the same plant against the same pests. The idea is that even if the pest develops resistance to one gene, it would succumb to the other as the possibility of developing resistance to both the genes simultaneously is very remote. Monsanto has deployed 'gene stacking' in Bollgard® II (BG II) which has two *Bt* genes, namely *cry1Ac and cry2Ab2*, in the same cotton plant for control of bollworms.

BG II has been approved for commercial cultivation in Australia and USA in 2002. MAHYCO has completed the regulatory trials with BG II in India and it has been approved by GEAC in May 2006. Similarly,

the *Bt*-cotton developed by Nath Seeds has two genes, namely *cry1Ab* and *cry1Ac* with GFM event and that by J.K Seeds has only one gene, *cry1Ac,* but with an event (Event 1) different from Monsanto's. These were also approved in May 2006. Such diversity in genes or events also helps in resistant management. Various IRM strategies may be deployed so as to prevent or delay the development of pest resistance.

- ***Some studies have predicted that bollworms can develop resistance to Bt-cotton within 6 to 17 generations. Is it not alarming?***

Since its first commercialization in the USA in 1996, *Bt*-cotton has been cultivated on millions of hectares in 9 countries. During the last 11 years, although the bollworms might have passed through more than 100 generations (bollworms can complete a generation in 3-4 weeks under normal conditions), there has not been any scientific evidence indicating field resistance to *Bt*-cotton by any of the bollworm species in any country. This shows that it is not easy for the pest to develop resistance to *Bt* protein expressed *in planta.* It also suggests that the prevailing IRM strategies are working well.

Some of the predictions about the resistance have come from laboratory 'selection' experiments where the bollworms were continuously fed sub-lethal doses of *Bt* proteins in order to induce resistance. Such populations were used for investigating the mechanisms of resistance. Although the results did not match with the field realities these studies are helpful so that one can be always on the alert as pest resistance is one of the genuine and important concerns. One cannot expect any technology to last for ever. We should try to use scientific means to extend its durability as far as possible. One should also be on the look out for new insecticidal proteins, from *Bt* and other sources, and try to rotate these crops once in a few years. Fearing resistance, we cannot give up any useful technology on hand.

Selected References:

Barwale et aal., 2004; Chandrashekar & Gujar, 2004; Ghosh, 2001; Gujar, 2005; Jalali et al., 2004; James, 2002, 2004;Kranthi and Kranthi, 2004; Kranthi et al., 2006; Krattiger, 1997; Manjunath, 2004, 2005(a); Ravi et al., 2005; Tabashnik et al., 2003; Tuli et al., 2000;

VII. FIELD PERFORMANCE & ADOPTION OF *BT*-COTTON

- ***It is alleged that the Bt-cotton trials were conducted secretly, without the knowledge of ICAR and other public research institutions. Why were it so?***

The duly approved *Bt*-cotton trials were conducted by the applicants as per the guidelines and with the full knowledge of the government regulators and the data were also submitted to them. These were not expected to be publicized. Regarding involving other agencies, be it ICAR, IARI, Universities, State Dept of Agriculture or any other, it is the prerogative of the regulatory authorities. In fact, senior scientists from these and also several other organizations were/are included as experts in several regulatory committees such as IBSC, RCGM and GEAC and they were/are involved in one way or the other at some stage during the laboratory and field trials as well as during the approval process of *Bt*-cotton.

- ***How was the performance of Bt-cotton in the fields?***

Field trials conducted by public institutions like ICAR and by private seed companies like Mahyco, Rasi, Ankur, Nuziveedu and several others, before as well as after regulatory approvals, have clearly indicated that *Bt*-cotton hybrids provided satisfactory control of bollworms in all the locations and seasons, bringing profit to farmers. However, some of the NGOs who made parallel observations, claimed that *Bt*-cotton has failed to control bollworms and did not bring any benefits to farmers. Therefore, the final decision is best left to farmers as they will not adopt a technology if it is not beneficial to them. The fact remains that there is an ever-increasing demand for *Bt*-cotton seeds in India (see Chapter VIII).

- ***There were reports that Bt-cotton has failed in several states. What could have been the reasons?***

Bt-cotton has been developed for the specific purpose of controlling

bollworms. Therefore, it can be rightfully blamed if it has failed to provide protection against bollworms and the reason should be investigated. However, in some parts of Andhra Pradesh, Karnataka etc., cotton crops, both *Bt* and non-*Bt*, have sometimes suffered due to drought, para-wilt or some other biotic or abiotic stresses. Such failures have often been attributed to *Bt*-cotton which is not justified.

- ***There is a criticism that some of the Bt-hybrids have not performed well. Why?***

The various hybrids that have been developed by different seed companies as well as by the same company vary in their attributes, with or without *Bt*, and are generally meant for different agro-climatic regions. *Bt*-trait has no direct influence on the agronomic performance of a cultivar. It brings additional value to a cultivar by providing bollworm control. The yield potential of various hybrids, their suitability to different agro-climatic regions and *Bt*-trait are separate entities. If a right combination is made, they compliment each other. The unsatisfactory performances are often due to wrong choice of hybrids.

- ***How is farmers' response to Bt-cotton in India?***

Farmers' response has been overwhelming. The area under *Bt*-cotton in 2002, the first year of introduction, was about 29,000 ha (72,000 acres). It increased significantly from year to year to reach 3.8 m ha (9.4 m or 94 lakh acres) in 9 cotton growing states in 2006 – a remarkable growth rate in a short period of five years. Similarly, the number of farmers who adopted this technology also increased from a few thousand in 2002 to about 2.3 m (23 lakhs) in 2006 (see table). Such growths clearly reflect the farmers' confidence in this technology. Similar trends have been recorded in other countries also.

- ***What about the response from different states in India?***

Bt-cotton is presently cultivated in 9 states. The area has consistently increased from year to year in almost every state. The figures for 2005 and 2006 are given in the table to exemplify this.

AREA UNDER *BT*-COTTON IN INDIA, 2002-2006 (In 6 to 9 states)

Year	Area in Hectares	Area in Acres	No. of *Bt* farmers
2002	29,000	72,000	-
2003	86,000	2,13,000	75,000
2004	5,53,000	13,66,000	3,50,000
2005	12,67,000	31,31,000	10,00,000
2006*	38,00,000	94,00,000	23,00,000

*Source: DBT, 2006; *James, 2006*
(1 hectare = 2.471 acres. Figures rounded off in the table)

STATE-WISE ADOPTION OF *BT*-COTTON IN INDIA, 2005 & 2006

Zones	State	2005*	2006**
Central	Maharastra	6,23,000	18,40,000
	Gujarat	1,45,000	4,70,000
	Madhya Pradesh	1,43,000	3,10,000
South	Andhra Pradesh	2,27,000	8,30,000
	Karnataka	29,000	85,000
	Tamilnadu	19,000	45,000
North	Punjab Haryana Rajastan	81,000	2,20,000
	TOTAL, hectares	**12,67,000**	**38,00,000**

*Source: *DBT, 2006; **James, 2006*

- ***Which other countries have adopted Bt-cotton and what is the current status?***

As of 2006, genetically modified cotton was cultivated by 9 countries on 13.4 million hectares. Of this, 8.0 m ha had only *Bt* gene(s) (including 3.8 m ha in India), 4.0 m ha had *Bt* stacked with herbicide tolerance while another 1.4 m ha had only herbicide tolerance. The USA, India, China, Argentina, Australia, Mexico, South Africa, Colombia and Brazil were the countries that grew *Bt*-cotton. The area occupied by the genetically modified (GM) cotton in these countries from 2004 to 2006 is indicated in the table.

GLOBAL AREA UNDER GM-COTTON*, 2004 to 2006 (In million hectares)

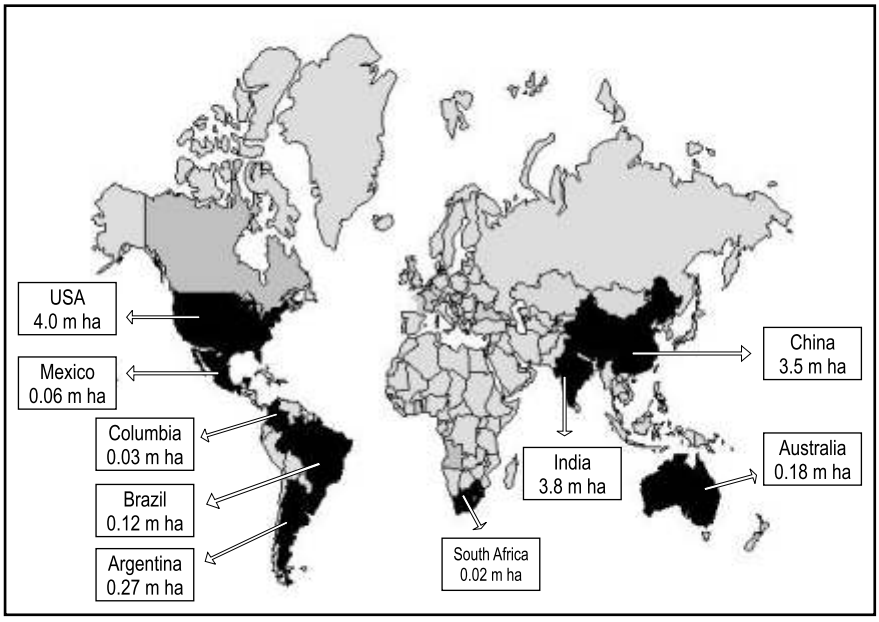
Country / year of introduction	2004	2005	2006
United States (1996)	4.2	4.6	5.3
India (2002)	0.5	1.3	3.8
China (1997)	3.7	3.3	3.5
Argentina (1998)	0.02	0.07	0.36
Australia (1996)	0.2	0.3	0.18
Brazil (2005)	-	-	0.12
Mexico (1996)	0.07	0.12	0.06
Columbia (2002)	<0.02	<0.1	0.03
South Africa 1998)	0.02	0.03	0.02
Total, million ha.	**9.0**	**9.8**	**13.4**

** Includes: Bt trait alone, Bt stacked with herbicide tolerance and herbicide tolerance alone.*
Source: James, 2002, 2006

The reduction in area in 2006 over 2005in Mexico was due to seed import constraints and in Australia due to reduction of total plantings of cotton owing to drought. In all other countries there was a significant increase in area with India recording an unprecedented 192% growth over the previous year. The country-wise break up of *Bt* cotton in 2006 is shown in the map.

BT-COTTON COUNTRIES & AREA IN 2006

*9 countries, 12.0 m ha**



** Includes 8.0 m ha with Bt (insect tolerance) alone and 4.0 m ha with Bt stacked with herbicide tolerance (1.4 m ha with herbicide tolerance alone is not included here)*

More countries and farmers are expected to adopt this technology in the coming years.

Selected References:

AcNielson-ORG Marg, 2004; APCoAB, 2006; Arunachalam & Bala Ravi, 2003; Bambawale et al., 2004; Barwale et al., 2004; Bennette et al., 2004; Choudhary, 2005; DBT, 2006; FAO, 2004; IMRB, 2005; James, 2002, 2004, 2005, 2006; Kameswara Rao, 2005; Khadi et al., 2004; Manjunath, 2005 (a); Naik, 2001; Rao, 2005; Sahai, 2003; Qaim & Zilberman, 2003; Qayum & Sakkhari, 2005

VIII. COSTS & BENEFITS OF *BT*-COTTON

- ***There is a complaint that farmers cannot use the saved Bt-cotton seeds for sowing and that every time they have to buy fresh seeds, thus adding to recurring cost. Why is it so?***

This is not peculiar to *Bt*-cotton alone, but is applicable to hybrids of any crop. Hybrids of many crops are preferred over varieties by farmers because they give much higher yields than varieties. It is a well-known fact that if the hybrid seeds saved from one generation are used to raise the next crop, the hybrid vigour will decline and the resulting harvest will gradually become poorer from generation to generation. The cost of such yield losses will be far greater than the cost of new seeds.

In India, *Bt* gene has been incorporated into cotton hybrids and, therefore, it is better that farmers buy fresh seeds that are specially produced under controlled conditions so that they can enjoy a better harvest and profit. In case the saved seeds are used, they do germinate and also express *Bt* protein, but yield will be poor because of the inherent weakness as explained above (also see Chapter IX).

- ***Why have the seed companies chosen to introduce the Bt gene only into hybrids? Why not into varieties so that farmers can save the recurring costs on seeds?***

In India, cotton hybrids, being high yielding, are increasingly preferred by farmers with about 70% (6.3 m ha) of the nearly 9.0 million hectares having been already occupied by them. A number of seed companies are coming out with newer and better hybrids almost every year and their area is bound to further increase. Historically, hybrids are more prone to pest infestation, including bollworms, than varieties and require more stringent pest control measures. Hence, hybrids are preferred for incorporating *Bt* genes. Additionally, the companies also have a vested interest. Since they spend huge sums of money on research for several years for developing new

technologies/products, they look forward to recovering their investment and making profit. Hybrid seeds offer a value capture mechanism through repeated sale of seeds. This keeps them in business. Perhaps, public institutions may think of introducing *Bt* genes into varieties as they generally do not look for return on investment.

- ***The cost of Bt-cotton seeds is 3 to 4 times more than that of the normal seeds. What is the justification?***

The cost of *Bt*-cotton seeds should not be compared with that of conventional seeds without considering the benefits associated with it. When farmers use the conventional seeds, they spend anywhere from Rs.3,500 to Rs.10,000 or more for an acre on spraying chemical insecticides from 5 to 20 times during a crop season in an effort to control bollworms. If this cost is added, the conventional seeds are far more costly than *Bt*-seeds. Even then, they are unable to get satisfactory control due to several reasons, one of them being that a pest like *Helicoverpa armigera* has developed resistance to most of the recommended insecticides. Hence they often become frustrated. In the case of *Bt*-cotton, bollworm control is in-built in the seeds and, therefore, there is no need for farmers to spend so much extra money on insecticides. The amount of money saved on insecticides coupled with yield benefits accruing out of bollworm control far outweigh the cost of *Bt*-cotton seeds. The genuine cotton farmers are aware of such benefits, nevertheless they would certainly welcome a reduction in the seed price.

- ***It is alleged that Bt-cotton is the monopoly of Mahyco-Monsanto and the company is exploiting the market. The A.P. government has challenged the price under MRTPC. Is it not possible to reduce the seed price?***

The companies which take the leadership role and risk huge investments in developing new technologies/products would be anxious to get back their investment. They may enjoy the benefits of the so-called monopoly only in the initial periods, that too when the sales are generally limited & the product is yet to be widely accepted.

Therefore, the price of a product, be it *Bt*-seeds or any other, will be initially high. As the volume of sales increases, the prices generally get reduced. For example, MMB (Mahyco-Monsanto Biotech Company) has voluntarily reduced its technology (or trait) fee from the initial Rs.1,250 to Rs.900 for a pack containing 450 gms of *Bt*-seeds (plus150 gms of non-*Bt* seeds of the same hybrid to be planted as refuge) meant for one acre. With further growth in sales and more competitors entering the market, the prices are likely to further come down. This is a market reality. It is important to ensure that in the name of competition, inferior or spurious products do not enter the market.

The Andhra Pradesh government has challenged the price of *Bt*-cotton seeds as exorbitant under MRTPC (Monopolies and Restrictive Trade Practices) and arbitrarily fixed Rs.750 as the maximum selling price of 450 gms of *Bt*-seeds. Several other states have also joined hands with A.P. On the other hand, MMB has counter-challenged this unilateral decision in the Supreme Court. Their contention is that the prices are market driven and farmers are getting attractive returns for their money. Perhaps it is wiser for the State Govts and the seed companies to discuss the various dimensions and implications of this issue and find an amicable solution as legal challenges are complicated, expensive and time consuming.

- ***Are there any proofs that Bt-cotton is more profitable to farmers?***

Both pre- and post-commercialization studies conducted by several public institutions and private seed companies (under the monitoring of RCGM) have indicated that *Bt*-cotton has increased farmers' income. For example, the multi-location field trials conducted by ICAR in 2001 with Mahyco's three *Bt*-cotton hybrids, as a part of the regulatory requirements, revealed that these hybrids yielded 60 to 92% more than the local and national checks and fetched a net profit between Rs.4,633 and Rs.10,205/ha which was about 67% higher.

Post-release, the nationwide surveys conducted by ACNielsen - ORG-MARG in 2003 and by the International Market Research

Bureau (IMRB) in 2004, revealed that on an average, yield increase owing to effective bollworm control ranged from 29 to 58% (4.25 to 7.4 quitalts/ha), pesticide reduction from 60 to 72% (savings of Rs. 2,800 to 3,200/ha) and increase in net profit to farmers from 60 to 78% (Rs.7,725 to 14,700/ha). In the surveys, more than 90% of the *Bt*-cotton users and 42% of the non-users expressed their intention to purchase *Bt*-cotton seeds in the next season. Another survey conducted by the Gokhle Institute of Politics and Economics, Pune, in 2003 in certain parts of Maharashtra has also indicated that *Bt*-cotton was profitable to farmers.

Another report indicated that the net economic benefits to Indian farmers from Bt-cotton was, on an average, $139/ha in 2002, $324/ha in 2003 and $260/ha in 2004, with a four-year aveage of $225/ha. Other studies also reported results in the same range, acknowledging that the benefits will vary from year to year and also from place to place due to varying levels of bollworm infestation, agronomic conditions and cultivation practices.

In a more recent (2006) study conducted in Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu by the Indian Institute of Management (IIM), Ahmedabad, the profit from *Bt*-cotton was found to be higher in all the states, both under irrigated and non-irrigated conditions. It reported an yield gain of 31%, reduction in the number of pesticide sprays by 39% and an 88% increase in profit (Rs.11,250 or US$250/ha) The farmers found advantage in pest incidence, pesticide cost, cotton quality, yield and profit. Almost all farmers indicated that they plan to plant *Bt*-cotton in the future. Similar results have been reported from several other countries also.

However, the results of alternative experiments and surveys carried out independently by Gene Campaign; Centre for Sustainable Agriculture; Research Foundation for Science, Technology and Ecology; Greenpeace and a few other NGOs in India who have always been opposed to this technology, found no such benefits. According to them, *Bt*-cotton suffered more bollworm damage, required more pesticide sprays, yielded less and produced poorer quality cotton than the non-*Bt* cotton.

The final judgment is best left to farmers. They have the option to choose *Bt*-cotton or non-*Bt* cotton whichever is beneficial to them. The fact remains that the number of *Bt*-farmers is increasing from year to year.

- ***Is this technology beneficial to small farmers also?***

Bt technology does not distinguish between small farmers and big farmers. It controls bollworms no matter who is growing the crop. In India, in 2006 about 2.3 m small cotton farmers were able to derive attractive economic benefits from *Bt*-cotton. Similarly thousands of small farmers in China, South Africa, Argentina and other developing countries have been amply benefited by this technology.

Selected References:

AcNielson-ORG Marg, 2004; APCoAB, 2006; Arunachalam & Bala Ravi, 2003; Bambawale et al., 2004; Barwale et al., 2004; Bennette et al., 2004; Brooks & Barffot, 2006; Choudhary, 2005; Gandhi & Namboodiri, 2006; IMRB, 2005; FAO, 2004; James, 2000, 2002, 2004, 2005, 2006; Kameswara Rao, 2005, 2006; Khadi et al., 2004; Manjunath, 2005 (b); Naik, 2001; Rao, 2005; Sahai, 2003; Qaim & Zilberman, 2003; Qayum & Sakkhari, 2005.

IX. OPPOSITION TO *BT*-COTTON

- ***Why is there such a powerful campaign against Bt-cotton?***

Bt-cotton has faced opposition from a few NGOs and certain individuals right from 1998 when it was still undergoing the prescribed regulatory trials in India. Their tirade is continuing even now, five years after its approval and adoption on about 3.8 m ha by 2.3 m farmers. The issues raised by them were all encompassing scientific, social, economical, ethical, emotional and legal grounds. Most of the allegations made by them were/are based on perceptions without rationale, primarily aimed at sensationalism. No scientific data seem to satisfy them and it appears to be an unending debate.

- ***It is alleged that Bt-cotton contains the controversial 'Terminator Technology' and so the test crops were destroyed by the activists. What is the truth and status?***

The activists of the Karnataka Rajya Raitha Sangha (KRRS) launched a campaign against *Bt*-cotton and burnt a few RCGM-approved experimental plots in certain parts of Bellary and Raichur (Karnataka) in November 1998 alleging that they contained 'Terminator Technology' and that the terminator gene would escape and cause gene pollution and sterility in surrounding plants. They regularly issued scaring statements, held demonstrations, threatened the *Bt*-farmers and also ransacked the Monsanto laboratories in Bangalore during 1998-1999. A few other NGOs had also joined them in linking terminator technology with *Bt*-cotton. The truth is that *Bt*-cotton does not contain the so-called 'Terminator Gene.'

The colloquial name 'Terminator Technology' (TT) was coined by Rural Advancement Foundation International (RAFI), an NGO headquartered in Canada. This name became very popular with the media. The technology was originally designated as 'Technology Protection System'(TPS) and was jointly patented by USDA (United States Dept of Agriculture) and Delta & Pine Land (a leading cotton

seed company in the USA) in March 1998. The special feature of TT or TPS is that the seeds derived from the parent plants cannot be utilized for sowing as these would not germinate as such, but are otherwise fit for all other purposes. Such seeds need to be treated with a specific activator chemical compound to induce germination. The TPS was conceived with an idea to protect the proprietary traits from being pirated. This technology has not been commercialized in any crop as of 2006, nor has it been successfully advanced beyond some preliminary experiments. However, the pros and cons of TT became a subject of great controversy and hot debate in several countries. On its part, Monsanto has clarified and reiterated that its *Bt*-cotton does not contain the terminator gene.

Following the allegations by the NGOs and as per the direction of the regulatory authorities, the Dept of Genetics, University of Delhi (South Campus), Delhi, carried out molecular detection tests on Mahyco's *Bt*-cotton hybrids to ascertain the presence or absence of the 'Terminator Gene.' The PCR analysis of DNA isolated from individual seedlings derived from *Bt*-cotton hybrids revealed that these lines were positive only for *cry1Ac* gene and did not contain *cre* recombinant gene which is an integral component of TT. This conclusively demonstrated the absence of 'Terminator Gene' in *Bt*-cotton hybrids. Another 'common sense' test was carried out by a progressive farmer in Haveri and also by the University of Agricultural Sciences, Dharwad, Karnataka. They sowed the *Bt*-cotton seeds of the F1 generation and demonstrated that these germinated like normal seeds. It was unfortunate that the activists resorted to such extreme steps based on false assumptions without verifying the scientific facts.

- ***What happened to the public litigations against the Bt-cotton trials and approval?***

A Public Interest Litigation (PIL) was filed in the Supreme Court by the NGO, Research Foundation for Science, Technology and Ecology (RFSTE), New Delhi, against Govt of India (i.e. GEAC & MoEF), Monsanto and Mahyco, charging violation of the biosafety

procedures during the approval of *Bt*-cotton filed trials in India. The National Environment Appellate Authority who examined this petition, dismissed it as baseless in October 2003. Similarly, several other litigations filed against *Bt*-cotton by other NGOs also did not find favour in the court of law. Even so, it has not stopped them from filing petitions again and again.

- ***Another reason proffered is that Bt-cotton is a threat to the safety of humans and environment. Have these concerns been addressed?***

Safety concerns regarding *Bt*-cotton were addressed scientifically under the direction and supervision of the regulatory authorities in India as in the USA and several other countries before the crop was approved for commercial cultivation. The comprehensive studies carried out in India covered issues such as allegenicity, toxicity and effect on non-target organisms (goats, buffaloes, cows, rabbits, birds, fish, honey bees, ladybird beetles, earthworms and other soil organisms). The experiments were conducted by the concerned experts, mostly in various public-funded institutions, and the data were submitted to the regulators (also see Section V). It is only after satisfying that the *Bt*-proteins are safe and beneficial, regulatory approval was granted. Further, *Bt*-cotton has been cultivated on millions of hectares in several countries since 1996 (and in India since 2002) and scientific investigations have not shown any harmful effect. The detractors must realize that safety assessment related to environment and human/animal health has been given the top-most priority by the regulators as well as product developers and that they are as much concerned about these issues as they are!

- ***Another common allegation is that Bt-cotton deprives farmers' right to save seeds, thus rendering them dependent on the seed companies for supply of seeds.***

The seed-saving issue is not peculiar to *Bt*-cotton alone, but is applicable to all hybrids of any crop. Hybrids of many crops are preferred over varieties by farmers because they give much higher yields than varieties. It is a well-known fact that if the hybrid seeds

saved from one generation are used to raise the next crop, the hybrid vigour declines coupled with segregation of traits and the resulting harvest becomes poorer from generation to generation. The cost of such yield losses will be far greater than the cost of new hybrid seeds. Hence, it is more profitable for farmers to buy fresh hybrid seeds that are specially produced under controlled conditions of pollination and undergo quality control checks. They must always buy it from reliable resources. In fact, our farmers have been cultivating hybrids of several crops, including cotton, corn, vegetables etc., for many years and most of them are already aware of the basic differences between the seeds of traditional varieties and hybrids.

In India, *Bt* gene has been incorporated into cotton hybrids and, therefore, it is advisable for farmers to buy new seeds so that they can enjoy a better harvest and profit. In case they use the saved seeds, they will germinate but express *Bt* protein in a segregated pattern (i.e., a portion of the plant population will not contain the *Bt* gene). In addition, the yield will be poor because of the loss in hybrid vigour.

- ***What about the recent allegation by an NGO regarding mortality in sheep flocks after grazing on Bt-cotton fields at Warangal in Andhra Pradesh?***

During its 68th meeting held on May 2005, the GEAC deliberated at length on the representation received from the Centre for Sustainable Agriculture (CSA) regarding the alleged sheep mortality after feeding on the stubble of *Bt*-cotton crop in Warangal. After reviewing the case and the available data, it was the general opinion of GEAC that the report was highly exaggerated and was based more on hearsay than on scientific facts. They asserted that *Bt*-cotton, prior to its approval for commercial cultivation, has undergone animal feeding studies at the Industrial Toxicological Research Institute, Lucknow; National Dairy Research Institute, Karnal and at the G.B.Pant University, Izatnagar. No toxic effect was found in any animals even when they were fed with high doses of *Bt* protein through *Bt* cotton seed meal.

It should be realized that the *Bt* proteins produced in *Bt*-cotton are

insecticidal, that too specific to lepidopteran insects. The intestine of higher animals like sheep does not possess the necessary pH conditions to activate the *Bt* protein and also the specific receptors for protein-binding. These two are essential steps for the *Bt* protein to have toxic effect. Further, the amount of protein produced in *Bt* cotton plants is so small that it is adequate to kill only the first and second instar larvae of bollworms. The sheep mortality in Andhra Pradesh must have been due to factors other than *Bt* and these should have been thoroughly investigated before blaming *Bt*-cotton.

- ***Some have dismissed the Bt-cotton technology as not being suitable for the Indian conditions.***

It has already been demonstrated that *Bt*-cotton is effective against the Indian bollworms such as the False American Bollworm (*Helicoverpa armigera*), Pink Bollworm (*Pectinophora gossypiella*), Spotted Bollworm (*Earias vittella*) and Spiny Bollworm (*E. insulana*) under different agro-climatic conditions. The more recently (in 2006) approved second generation *Bt*-cotton technology stacked with two *Bt* genes, not only controls these cotton bollworms more effectively, but also the Tobacco Caterpillar (*Spodoptera litura*). The same *Bt*-cotton technology has also been successfully utilized in other countries like China, South Africa and Australia where the bollworm complex is almost the same as in India.

- ***It is also alleged that Bt-cotton is responsible for farmers' suicides.***

It is a very cruel allegation that has no empirical basis. On the contrary, *Bt*-cotton has come as a big relief to farmers who have been haunted by the bollworms for more than three decades. It has saved their crops and enabled them to reap a better harvest and profit. A national survey conducted by IMRB (International Market Research Bureau) in 2004 indicated that for every Rupee spent by the farmers, they received Rs.5.80 in value for reduced insecticide cost and increased yield over conventional cotton. In other words, it has fetched more income and improved their living standard. This is reflected by the fact that the

number of farmers who have adopted this technology which was only a few thousand in 2002, the first year, has steadily increased from year to year to reach about 2.3 m (23 Lakhs) in 2006 - more than a hundred-fold jump! Several independent committees set up by the state governments to investigate the cause for farmers' suicides have mostly cited several debt-related social and economic issues as being responsible for this tragedy, but definitely not *Bt*-cotton. Further, *Bt*-cotton cultivation has started in India only since 2002 whereas the farmers' suicide has been an issue since decades.

- ***The protestors have targeted multi-national companies for bringing a foreign technology into India and exploiting the farmers.***

Any technology introduced into India after being cleared by the union government as safe and beneficial - be it in agriculture, medicine or industry and no matter who has developed it - should be welcome. We are living in a globalized society today. While modern technologies from overseas have been readily absorbed in other sectors, for example healthcare, there is no reason why our farmers alone be denied of such benefits if these can contribute to their betterment. With regard to *Bt*-cotton, only the technology has been adopted as it was not available locally, but the *Bt*-trait has been incorporated in the local cotton hybrids developed by the Indian seed companies and made available to the farmers. Thus, the technology has been indigenized. The number of farmers who have adopted *Bt*-cotton in India has increased from year to year in the last five years and reached 2.3 m (23 lakhs) in 2006, clearly reflecting that they have accepted this technology and realized its benefits. Our farmers are wise and they know what is good for them. They cannot be exploited.

Our scientists are also trying to develop indigenous technologies, but even most of these are based on foreign know-how. Several public and private organizations in India have been trying to develop their own *Bt*-cotton and other transgenics for the last several years and it is hoped that they will come out with some good products. This would offer more choice to our farmers to choose whatever is more beneficial to them.

- ***Have the criticisms of Bt-cotton served any purpose?***

Healthy criticism is always helpful in identifying gaps and refining a technology. Some of the issues raised by certain scientists and NGOs such as those related to the methods adopted for field trials, implementation of regulatory policies, transparency of scientific data, importance of cultivars with superior agronomic genotypes etc have made positive contributions towards fine-tuning certain aspects. The technology developers and regulators have learnt their lessons - it is not just enough to have a good technology, but it is equally important to create adequate awareness and knowledge in the stakeholders about the new products and also address the perceptions created by misinformation. The regulators, on their part, must have realized that if the official approval of new products, especially those with proven merits elsewhere, is unduly delayed, some miscreants will introduce them in a clandestine way as exemplified by the illegal *Bt*-cotton. The message to the scientists and scientific bodies is that they should speak up and write unambiguously as otherwise it will be misinterpreted by the opponents and highlighted in the media leading to their own embarrassment.

Bt-cotton is a thoroughly researched product of biotechnology. Unfortunately, most of the people who are involved in organising protests etc, are non-scientists, pseudo-farmers or professional agitators. Their destructive activities will only hurt our farmers who need modern technologies and proper guidance for their progress.

- ***What should be done to clear the misunderstanding regarding Agricultural Biotechnology?***

Public/ farmer awareness and education on the safety and benefits of biotechnology should be given top priority. The biotech industry and scientific community should make united efforts in this endeavour, especially to mitigate the unsubstantiated anti-biotech stories being hoisted aggressively by the anti-biotech lobbies to create doubts and fear and mislead the public. Media can play a very helpful role in highlighting the positive contributions of biotechnology. They need to verify the scientific truth before reporting sensational stories.

Government should take strict action against vandalism and illegal seed producers.

Selected References:

APCoAB, 2006; Kameswara Rao, 2006(a); Manjunath, 2004, 2005(a); James, 2002, 2006; Sahai, 2003; Scoones, 2006; Shantharam, 2005; Shantharam & Prakash, 2006; Shiva et al., 1999. www.gmwatch.org., April 2006; www.envfor.nil.in/divisions/csurv/geac-68

X. LEGAL AND ILLEGAL *BT*-COTTON

- ***How many Bt-cotton hybrids have been officially approved in India?***

Starting with Mahyco's 3 *Bt*-cotton hybrids (MECH 12 *Bt*, MECH 162 *Bt* and MECH 184 *Bt*) in March 2002, another 20 hybrids from four companies were duly approved by GEAC and commercially planted by 2005. In 2006, yet another 39 hybrids were approved which will be ready for planting in the 2006-07 cotton season. Thus, altogether 62 hybrids have been approved in India between 2002 and 2006. Of these, 55 (48 with a single gene and 7 with two genes) belonged to Mahyco-Monsanto and its sub-licensees, 4 to J. K. Seeds with a single gene and 3 to Nath Seeds with two genes. Altogether 15 companies were involved (see table next page).

- ***Are there any new organizations trying to bring out transgenic cotton in India?***

The following organizations are trying to bring out transgenic cotton with insecticide genes sourced from *Bt* or plant, using a different event or as sub-licensee of other seed companies (see Table). Their experiments are at various stages of regulatory approvals. Besides, some of the above mentioned seed companies are continuing their efforts to introduce *Bt*-genes into newer hybrids.

Transgenic cotton under development and field trials in 2005-06

Organization	Transgene
Bioseed Research India Pvt Ltd, Hyderabad*	*cry1Ac, cry2Ab2*
Green Gold Seeds Ltd, Aurangabad	GFM *cry1Aa*
Kaveri Seeds Co. P. Ltd., Secundarabad*	*cry1Ac*
Metahelix Life Sciences Pvt Ltd., Bangalore	*cry1Ac*
Nandi Seeds Pvt. Ltd., Mehaboobnagar*	*cry1Ac*
Namdhari Seeds Pvt. Ltd., Bangalore*	*cry1Ac*
Proagro Seeds Co. Ltd., Hyderabad*	*cry1Ac*
Syngenta India Ltd., Pune	Vip-3A (non-*Bt*)
University of Agricultural Sciences, Dharwad	*cry1Ac*
Vibha Agrotech Ltd., Hyderabad*	*cry1Ac*
Zuari Seeds Ltd., Bangalore	GFM *cry1Aa*

** Sub-licensees of MMB* *Source:DBT via Mishra et al., 2006*

BT-COTTON HYBRIDS APPROVED BY GEAC BETWEEN 2002-2006

Seed companies	Genes / Event	*Bt*-cotton hybrids approved between 2002 and 2006	No. of hybrids
A) Mahyco-Monsanto Biotech Co. Ltd. (MMB) and its sub-licensees			
MAHYCO (Maharashtra Hybrid Seed Company), Jalna, Maharashtra	*Cry1Ac* Event MON 531 (Bollgard©)	Mech 12, Mech 162, Mech 184, MRC 6025, MRC 6029, MRC 6301, MRC 6304, MRC 6322, MRC 6918	9
	Cry1Ac & cry2Ab2 Event MON 15985 (Bollgard© II)	*MRC 7201*, MRC 7301*, MRC 7326* MRC 7347*, MRC 7351**	*5**
Rasi Seeds Ltd, Coimbatore, Tamil Nadu	Bollgard©	RCH 2, RCH 20, RCH 111, RCH 118, RCH 134, RCH 138, RCH 144, RCH 308, RCH 314, RCH 317, RCH 368, RCH 371, RCH 377, RCHB 708	14
Ankur Seeds P. Ltd, Nagpur, Maharashtra	Bollgard©	Ankur 09, Ankur 651, Ankur 2534	3
Nuziveedu Seeds, Hyderabad, Andhra Pradesh	Bollgard©	NCS 138, NCS 145 (Bunny), NCS 207 (Mallika), NCS 913,	4
Ganga Kaveri Seeds Ltd, Hyderabad Andhra Pradesh	Bollgard©	GK 204 GK 205, GK 207, GK 209	4
Ajeet Seeds, Aurangabad Maharashtra	Bollgard©	ACH 33 1, ACH 155-1	2
	Bollgard© II	*ACH 11-2**	*1**
Tulasi Seeds, Guntur Andhra Pradesh	Bollgard©	Tulasi 4, Tulasi 117	2
Vikram Seeds Ltd, Ahmedabad Gujarat	Bollgard©	VICH 5, VICH 9,	2
Vikki Agrotech, Hyderabad Andhra Pradesh	Bollgard©	VCH 111	1
Emergent Genetics India P. Ltd. Hyderabad Andhra Pradesh	Bollgard©	Brahma	1
Pravardhan Seeds Pvt. Ltd, Hyderabad Andhra Pradesh	Bollgard©	PRCH 102,	1

Table contd...

Seed companies	Genes / Event	*Bt*-cotton hybrids approved between 2002 and 2006	No. of hybrids
A) Mahyco-Monsanto Biotech Co. Ltd. (MMB) and its sub-licensees			
Prabhat Agri Biotech Ltd. Hyderabad Andhra Pradesh	Bollgard©	PCH 2171, PCH 2270	2
Krishidhan Seeds Pvt. Ltd. Jalna Maharashtra	Bollgard©	KDCHH 9810, KDCHH 9632, KDCHH 9821,	3
	Bollgard© II	*KDCHH 441**	*1**
B) Other Seed Companies			
J. K. Agri Genetics Ltd. Hyderabad Andhra Pradesh	*Cry1Ac* Event I	JK Varun, JK Durga, JKCH 99, JKCH 1947	4
Nath Seeds, Aurangabad Maharashtra	*cry1Ab* and *cry1Ac* Event GFM	*NCEH-2R**, NCEH-3R**, NCEH- 6R***	*3***
15 Companies	**3 Genes: cry1Ac cry2Ab2 cry1Ab** **4 Events: Mon 531 Mon 15985 Event 1 Event GFM**	**Single gene - 52:** **Mahyco (Bollgard) = 48** **JK Seeds = 4** **Two genes - 10:** **Mahyco (Bollgard II) = 7** **Nath Seeds = 3**	**62**

*** Stacked with two genes*

Source: Modified from GEAC, 2006;DBT via Mishra et al., 2006.

- ***What is the purpose of having so many Bt cotton hybrids?***

Every organization tries to develop new and improved hybrids to suit different agro-climatic regions. Also, the hybrids developed by different companies possess different genetic backgrounds and their agronomic performances vary. It offers a wide choice to farmers. *Bt*-gene has been introduced into some of these hybrids. For example, of

the 62 *Bt* hybrids approved in India so far, 36 hybrids from 15 companies have been recommended for cultivation in Central Zone (Gujarat, Madhya Pradesh, Maharashtra), 14 from 6 companies for North Zone (Haryana, Punjab, Rajasthan) and 31 from 13 companies for South Zone (Andhra Pradesh, Karnataka, Tamil Nadu) with a few hybrids being recommended for more than one zone. *Bt*, being a trait, can be incorporated into any desired cultivar to confer resistance to bollworms. Several new hybrids developed by various companies are undergoing regulatory trials and awaiting approval. It is an ongoing process.

- ***There are strong reports that illegal Bt-cotton is rampant in our country. Is it true?***

Yes, it is true. Realizing the market potential of *Bt*-cotton in India, certain agencies are exploiting the situation through development and sales of unapproved *Bt*-cotton. In fact, illegal *Bt*-cotton crops were first detected in certain parts of Gujarat in 2000/2001 even prior to the regulatory approval of Mahyco's *Bt*-cotton in March 2002. Navbharat Seeds Pvt. Ltd., Ahmedabad, was identified as the offender. The company was marketing the seeds of its hybrid, Navbharat 151, claiming that it was naturally bollworm-resistant. On suspicion, GEAC got such seeds tested by the Central Institute of Cotton Research, Nagpur. PCR and ELISA tests revealed the presence of *cry1Ac* gene in all the samples. Besides, the samples also contained seeds of F1 and F2 generations. Since this product had not gone through the mandatory biosafety screening and approval, it is a serious violation of regulatory procedure. Later, such illegal or spurious seeds were also found in Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and elsewhere where they continue to occupy several thousand hectares. According to a recent estimation, the illegal *Bt*-cotton occupied at least 30% of the total *Bt*-cotton grown in our country. It is really shocking.

- ***What are the impacts of illegal Bt-cotton?***

Illegal *Bt*-cotton negatively impacts in several ways:

- Sale of illegal seeds is a blatant violation of bio-safety norms and business ethics.
- Spurious producers are not accountable for purity, performance and safety.

- They may spoil the credibility of the product and technology.
- They can afford to sell their products at a much lower price as their investment on research and product development is meager.
- It will affect the confidence and enthusiasm of the law-abiding technology developers.
- Tax revenue is lost at the government levels.
- Farmers will be misled and confused.

It is a serious challenge and urgent action is needed to curb this malpractice.

- ***What action has been taken and what could be done to combat illegal seeds?***

The Agriculture Ministry had ordered destruction of the illegal *Bt*-cotton and some stock was also burned as warning, but the farmers and state government demanded compensation. This of course was not forthcoming. A case was also registered against the managing director of Navbharat Seeds Pvt Ltd. Several state governments have also conducted a few raids and threatened to take penal action against those involved in such activities. Subsequently, the issue was pushed aside as it was taking a political turn.

To curb this malpractice, the government should strictly implement the Environment Protection Act (EPA) and take punitive action against the guilty. The state authorities have a greater role to play in solving this problem by identifying illegal seed production plots, ginning mills and retailer warehouses. They should strengthen the hands of the State Biotech Coordination Committee (SBCC) and the District Level Committees (DLCs). Introducing a system for mandatory registration of cotton seed production plots similar to the mandatory registration system already in place for public hybrids will also help. Moreover, farmers and dealers should also cooperate with the governments in discouraging illegal seeds.

- ***Is there any likelihood of any other biotech crops being commercialized in India?***

Several public and private institutions in India have introduced *Bt*

genes into brinjal (egg plant), cabbage, cauliflower, corn, okra, pigeonpea and rice to control various lepidopteran pests. Work is also in progress on various other beneficial traits to overcome biotic (pests, diseases, weeds) and abiotic (drought, salinity, cold etc) stresses as well as to enhance the quality of food (improved nutrition, enhanced shelf-life, edible vaccines etc). Altogether about 17 crops are undergoing such experiments in various public and private laboratories in India. Globally, about 63 countries are working on about 57 crop species for various beneficial traits.

Selected References:

GEAC, 2006; James, 2005, 2006; Jayaraman, 2001, 2004; Kameswara Rao, 2005; Mangala Rai & Prasanna, 2000; Manjunath, 2005(a); Manju Sharma et al., 2003; Mishra et al., 2006; Prakash, 2001; Scoones, 2006.

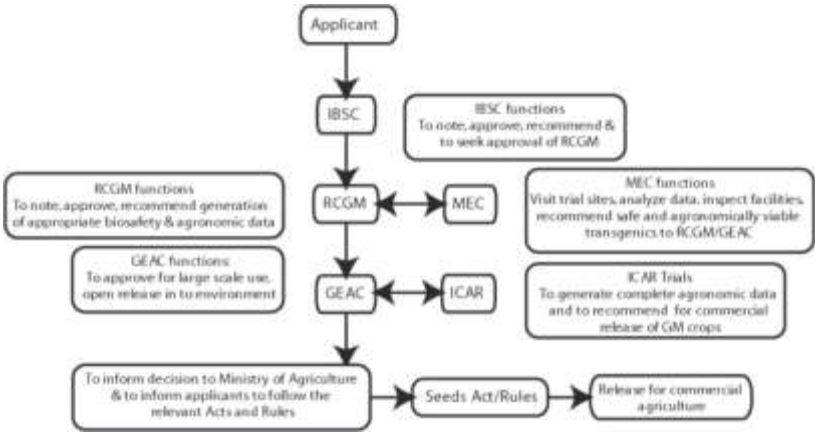
XI. REGULATION OF BIOTECH CROPS

- ***What steps have been taken by Government of India to ensure that biotech crops are safe?***

The Government of India has adopted a policy of precautionary principles, on case by case basis, for careful evaluation of the risks and benefits of biotech crops and other GM products, at various stages of their development, before they are approved for commercialization. Such rules were framed and guidelines notified in 1989 under the Environment Protection Act 1986 (EPA). The guidelines were amended in 1990, 1994 and 1998 to keep pace with the progress made in the GMO research.

- ***Who are responsible to implement these policies?***

Two nodal agencies, Ministry of Environment and Forests (MoEF) and Dept of Biotechnology (DBT) under the Ministry of Science and Technology (MoST) are responsible for implementation of the biotech policies. They have constituted four major committees to handle various issues: Recombinant DNA Advisory Committee (RDAC), Institutional Bio-Safety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM) and Genetic Engineering Approval Committee (GEAC).



These committees are further assisted by State Biotechnology Coordination Committee(SBCC), District Level Committee(DLC) and Monitoring and Evaluation Committee (MEC). All these committees have specific responsibilities (see figure).

- ***There are criticisms that these committees do not have competent experts and the regulation in India is weak. How far is it true?***

The major committees are comprised of eminent experts drawn from various fields from various organizations across the country. They view the safety of a product from various perspectives and at various levels. The safety assessments are made through experiments based on scientific principles under their expert guidance. It is unfair to say that the committees are not represented by experts. The biosafety regulations in India are as stringent as anywhere else in the world. However, there is scope of implementing these more strictly. If any one has any specific suggestions for improvement, these can be communicated to the regulatory authorities for their consideration. We should always strive for excellence.

- ***If there are proper regulations, how then that the illegal Bt-cotton seeds are so common in the market?***

The laws are clear, but to be effective their enforcement should also be very stringent. Any infringement of the prescribed regulations is a punishable act. The government did try to take some action against the offenders, but did not punish them adequately to serve as a warning to others. The presence of illegal seeds is not a healthy trend and calls for strict and urgent action.

- ***There are criticisms that our regulatory system is too cumbersome, slow and costly. Are there any efforts made to simplify these?***

The Indian agri-biotech policies and protocols have evolved and become more stream-lined with *Bt*-cotton which was the first product that was scrutenized for biosafety. Monsanto, being the pioneer, has

paid the price. It has been the focus of all the debates, opposition and disputes. Monsanto-Mahyco had to patiently pass through all the hurdles before it got the approval of *Bt*-cotton after struggling for 6-7 years. It had also cost huge sums of money. Undoubtedly, this has smoothened the way for future applicants. Today, the protocols are more clear, the applicants know before hand what exactly are to be done and the approvals are relatively faster. This is reflected by the fact that about 42 new *Bt*-cotton hybrids were approved in 2006 alone as compared to 3 hybrids in 2002, 1 in 2004 and 16 in 2005. The approval process has also been simplified from 'hybrid-based' approval to 'event-based' approval. If an honest effort is made, everything improves with time.

Selected References:

Ghosh, 2001; Ghosh & Ramanaiah, 2000; Manjunath, 2005 (a); MoEF, 2005; Scoones, 2003, 2006. http://www.envfor.nic.in/divisions/esurv/geac/notification/html

XII. EPILOGUE

India made its long-awaited entry into agricultural biotechnology in March 2002 with the regulatory approval of three *Bt*-cotton hybrids developed by Mayco-Monsanto for control of bollworms. This approval was preceded by a large number of laboratory studies and about 500 field trials carried out from 1996 to 2001 to demonstrate the safety and benefits of *Bt*-cotton as per regulatory requirements. This technology came as a big relief to cotton farmers who have been haunted by bollworms for more than three decades. Realizing the potential of *Bt*-cotton, reputed seed companies like Rasi, Ankur, Nuziveedu and several others, numbering more than 20, have already become sub-licensees of MMB (Mahyco-Monsanto Biotech Company) for this technology while two other companies, J.K.Seeds and Nath Seeds, have come out with newer versions of *Bt*-cotton. Efforts by several other organizations, both public and private, are also in progress. The public institutions intend to introduce *Bt*-gene(s) into several public cotton varieties/hybrids that have been developed by them for different agro-climatic regions.

By 2006, altogether 62 *Bt*-hybrids from 15 companies have been officially approved by GEAC for commercial cultivation. These included 52 hybrids with single *Bt*-gene (48 from MMB and its sub-licensees and 4 from J.K.Seeds) and 10 hybrids with two genes stacked (7 from MMB and its sub-licensees and 3 from Nath Seeds). Altogether, three genes (*cry1Ac*, *cry2Ab2*, *cry1Ab*) and four events (MON 531, MON 15985, Event I and GFM event) have been involved. Such diversity in genes and genotypes offers wide choice to our farmers and also helps in preventing or delaying resistance development in bollworms. All the *Bt* hybrids commercialized so far are *Gossypium hirsutum*. The *Bt* technology could extend to *G. arboreum* and the premium long-staple cotton, *G. barbadense*.

The response to *Bt*-cotton by Indian farmers and its performance have been very encouraging. The area occupied by *Bt*-cotton in 2002, the

first year, was only about 29,000 hectares in six states which significantly increased from year to year to reach 3.8 million hectares (9.4 m acres) in nine states in 2006. Similarly, the number of *Bt*-farmers also increased from a few thousand in the first year to about 2.3 million in 2006, clearly indicating their confidence in this technology.

The major benefits from *Bt*-cotton included higher yields owing to effective control of bollworms, drastic reduction in the application of chemical pesticides and greater profit to farmers. Coincidental with its steep increased adoption from 2002, the average yield of cotton in India, which had one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02 to 450 kg per hectare in 2005-06, with most of the increase in yield of up to 50%, or more, attributed to *Bt*-cotton. At national level, this is a major factor in higher cotton production increasing from 15.8 million bales in 2001-02 to 24.4 million bales in 2005-06, which is a record cotton crop for India (source: minutes of the third meeting of the Cotton Advisory Board for 2005-06; James, 2006). This is what a good technology can do to improve our productivity and economy.

India has a robust, multi-tier regulatory system comparable to any other country in the world. The major regulatory committees like RCGM (Review Committee on Genetic Modification) and GEAC (Genetic Engineering Approval Committee), constituted by Govt of India, are composed of a number of eminent experts drawn from various reputed institutions across the country. They use their collective wisdom in scrutinizing the scientific data from various perspectives before approving any product as safe. In fact, safety is accorded the highest priority in biotechnology. In the last five years of its commercial cultivation in India and for eleven continuous years on thousands of hectares in several other countries, *Bt*-cotton has not caused any negative impact related to safety of human/ animal/environment nor has there been any crop contamination or pest resistance anywhere in the world. It has an impeccable global safety record as are the other *Bt*-crops. The detractors of biotechnology do not seem to take cognizance of these facts.

A few NGOs and certain individuals have opposed *Bt*-cotton as unsafe and pronounced it as a failure even before it completed the biosafety and agronomic trials as stipulated by the regulators and continue to do the same even years after its proven safety and benefits. They must realize that the regulators as well as product developers are as responsible and concerned about the safety of humans and environment as they are! Healthy criticism is welcome, but blind opposition and creating suspicion and fear through unsubstantiated allegations have no place in science. Fear is the worst enemy of progress.

The current global scenario of agricultural biotechnology is quite encouraging. The year 2006 marked the completion of a decade of large scale commercial cultivation of transgenic crops, including *Bt*-cotton, in multiple countries. It has been a tough journey punctuated with speculated risks, calculated opposition and mischievous controversies, as with some of the new technologies in the past, but finally leading to greater support, acceptance and success of the products following their proven merits, safety and benefits. This is reflected by the fact that in 2006, biotech crops were grown on 102.0 million hectares (or 252 million acres) in 22 countries (11 developing, 11 industrial), including India, on six continents, by 10.3 million farmers, marking a 60-fold increase in the area since their first commercialization on 1.7 m ha in 6 countries in 1996. Such a fast rate of adoption of a new technology is unprecedented in agriculture.

According to ISAAA (James, 2006), the outlook for the next decade of commercialization, 2006 to 2015, points to continued growth in the global hectarage of biotech crops, up to 200 million hectares, with at least 20 million farmers growing biotech crops in up to 40 countries or more by 2015. Most of this growth is expected to take place in the developing countries of Asia, led by China and India.

The Indian Government is very supportive of biotechnology. Research on more exciting transgenic traits such as nutritional enhancement and tolerance to abiotic stresses like drought and salinity as well as biotic stresses like pests and diseases are making rapid progress in several public and private organizations.

These products would add value to sustainable agriculture and contribute towards meeting the food demand of the burgeoning population. With its vast resources, India has the potential to emerge as a supreme power in agriculture if modern technologies are appropriately reviewed and adopted. Farmers are the greatest beneficiaries of agricultural biotechnology. This augurs well for the future.

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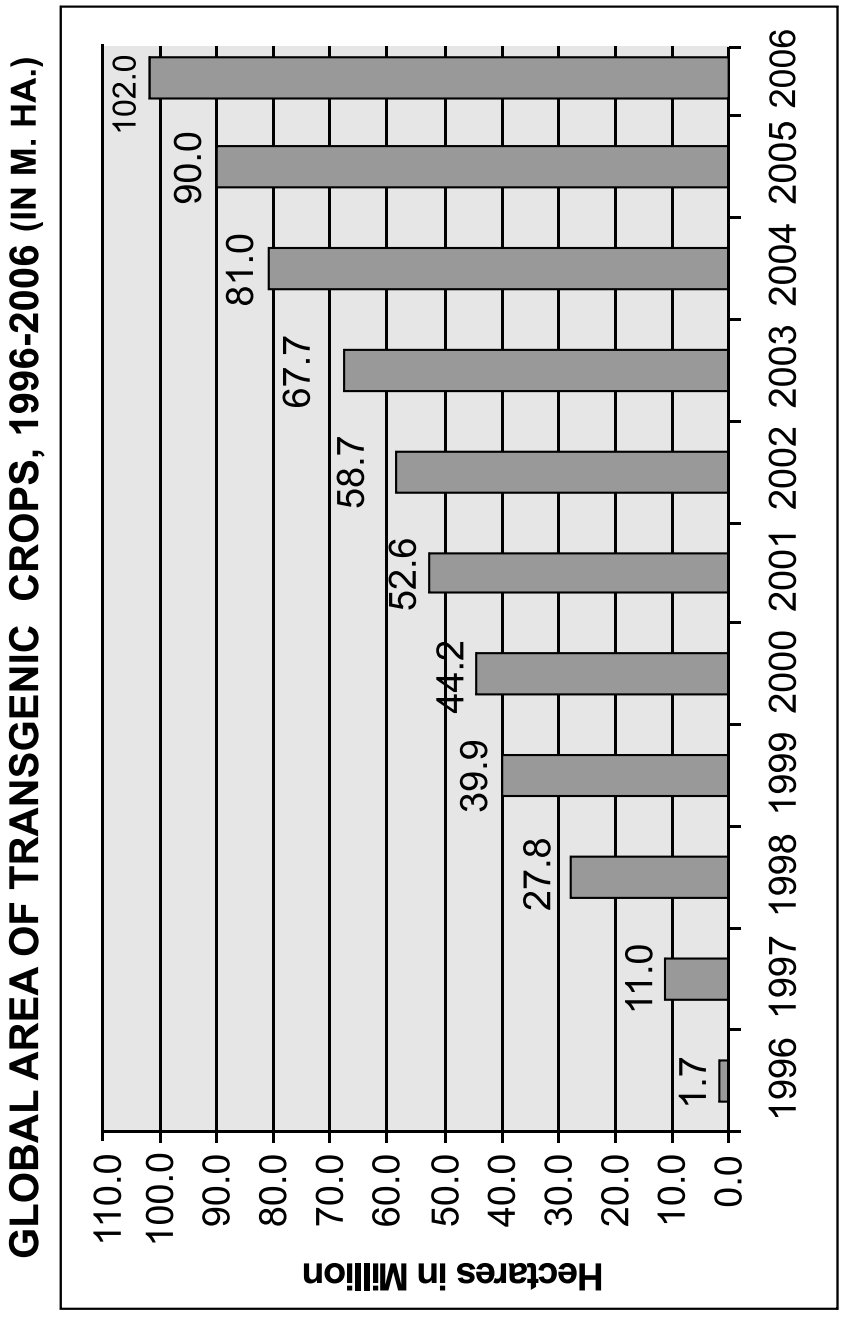
- All India Crop Biotechnology Association (AICBA), New Delhi - *www.aicba.com*
- Association of Biotech Lead Enterprise (ABLE), Bangalore - *www.ableindia.org*.
- BioSpectrum, Bangalore - *www.biospectrumindia.com*
- Biotech Consortium India Limited (BCIL), New Delhi - *www.biotec.co.in*
- Dept. Of Biotechnology (DBT), New Delhi - *www.dbtindia.nic.in*
- Foundation for Biotechnology Education and Awareness (FBAE), Bangalore - *www.fbaeblog.org*
- International Society for the Acquisition of Agri-Biotech Applications (ISAAA), New Delhi - *www.isaaa.org*
- South Asia Biosafety Program (SABP), Vadodara, Gujarat - *www.agbios.com*



Data from: James, 2006

60-fold increase in 11 years

GLOBAL AREA AND % ADOPTION OF MAIN TRANSGENIC CROPS WITH PLANT PROTECTION TRAITS, 2006

(HT = HERBICIDE TOLERANT, IR = INSECT RESISTANT WITH *BT*)

Crops	HT	IR *(Bt)*	HT + IR	Total Transgenic area (m ha)	Global area of the crop (m ha)	Biotech area as % of global area
Soybean	58.6	–	–	**58.6**	91	64%
Corn	5.0	11.1	9.0	**25.1**	148	17%
Cotton	1.4	8.0	4.0	**13.4**	35	38%
Canola	4.8	–	–	**4.8**	27	18%
Others	< 0.1	< 0.1	–	**0.1**	–	–
Total million ha	**69.8**	**19.1**	**13.1**	**102.0**	**301**	**34%**
Trait %	68.5%	18.7%	12.8%	100.0%		

Data from: James, 2006

MRC 7326, BG II (Bambino)

Bambino

Bt-cotton field laden with bolls

Photos: Mahyco

Q & A ON *BT*-COTTON IN INDIA

Answers to more than 70 questions on all aspects

by T M Manjunath

Bt-cotton, being the first and until now the only agri-biotech product approved by the Genetic Engineering Approval Committee of Govt of India in March 2002, has attracted enormous interest, curiosity and controversy right from 1996 when its regulatory studies were initiated in India. Comprehensive biosafety and agronomic studies have clearly demonstrated *Bt*-cotton to be safe and beneficial, and an increasing number of farmers have quickly adopted this technology, as evident from the exponential increase in its area to 3.8 million hectares (9.4 m acres) in 5 years. At the same time, those who are opposed to this technology have made serious allegations that *Bt*-cotton is a threat to human/animal/environmental safety and not at all beneficial. Such claims and counter-claims have created a lot of doubts and confusion in the minds of some farmers and the general public alike. It is also possible that, being a new technology, several technical aspects that are not clear have got enmeshed in such arguments.

An attempt is made in this publication to explain the *Bt*-technology and clarify various doubts/perceptions by presenting the facts based on scientific data so that the readers can make an informed decision. For the sake of convenience, the information on diverse aspects of *Bt*-cotton has been presented in a simple manner in the form of answers to more than 70 questions, divided into several sections such as cotton bollworms, *Bacillus thuringiensis* (Bt), development of *Bt*-cotton, efficacy, safety, insect resistance management, field performance and adoption, costs and benefits, opposition to *Bt*-cotton, legal and illegal seeds, and regulation. It is hoped that this publication will be useful to various scientists, teachers, students, policy makers, seed companies, journalists, NGOs, extension workers and, above all, progressive farmers.

Dr T M Manjunath, an agricultural entomologist with over four decades of R & D experience, has worked extensively and published more than hundred papers on the bioecology and control of a number of crop pests, including cotton bollworms, and made significant contributions to biological control, integrated pest management and agricultural biotechnology. He has first-hand knowledge on *Bt*-cotton and its stake holders and continues to take keen interest in biotech awareness and education.

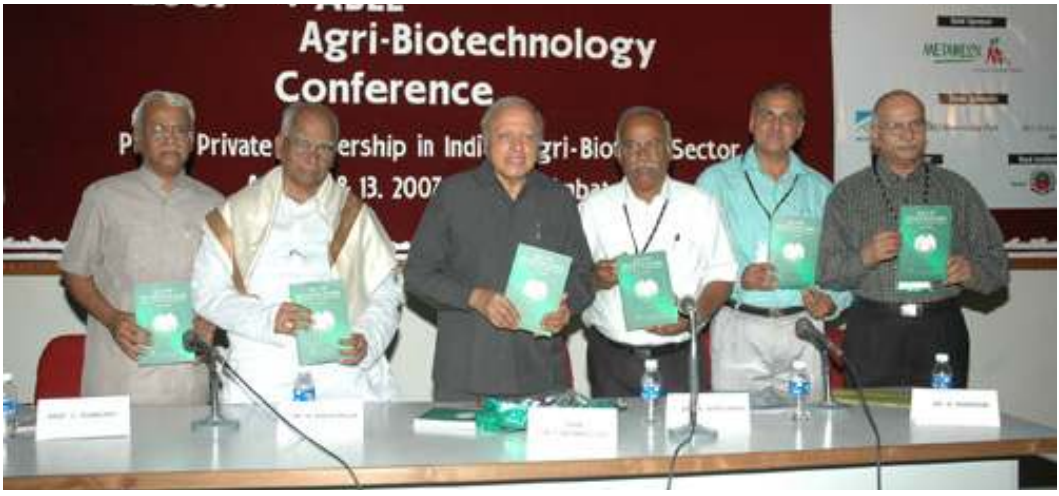
ALL INDIA CROP BIOTECHNOLOGY ASSOCIATION

Book Release
and
Press Reports

Book Released

The book on "Q&A on *Bt*-cotton in India: Answers to more than 70 questions on all aspects" by Dr. T. M. Manjunath and published by the All India Crop Biotechnology Association (AICBA), New Delhi, was formally released by the renowned agricultural scientist, Prof. M. S. Swaminathan, during the inaugural session of an Agri-Biotechnology Conference jointly organized by the Association of Biotechnology Led Enterprises and Tamil Nadu Agricultural University at Coimbatore on April 12, 2007.

T. M. Manjunath introducing his book on Bt-cotton



The book on Bt-cotton in India was released by Prof. M. S. Swaminathan on 12-04-2007.

From Left: Prof. C. Ramasamy, Vice Chancellor, TNAU; Dr. N. Mahalingam, Chairman, Sakti Group of Companies; Prof. M. S. Swaminathan, Chairman, MSSRF; Mr. M. Ramasamy, Managing Director, Rasi Seeds & President, AICBA; Dr. K. K. Narayanan, President, ABLE; Dr. T. M. Manjunath, former Director, Monsanto Research Centre & author of the book.

PRESS REPORTS

THE HINDU

News Update Service
Sunday, April 15, 2007, 13.55 hrs
http://www.hindu.com/thehindu/holnus/015200704151321.htm
Agri. & commodities

'BT cotton not caused any negative impact on safety'

Coimbatore, April 15 (PTI): BT cotton has neither caused any negative impact related to safety of human or animal or environment nor has there been any crop contamination or pest resistance any where in the world for the last 11 years, an expert in the field and a key member of Mahyco-Monsanto team has claimed.

In fact, safety had been accorded the highest priority in biotechnology and in the last five years of its commercial cultivation in the country and for 11 years in on thousands of hectares in several other countries, it has an impeccable global safety record as are the other BT-crops, T M Manjunath in his just released book +Q and A on BT-Cotton India: Answers to more than 70 questions on all aspects,+ maintained.

The detractors of biotechnology did not seem to take cognizance of the facts that a number of experts drawn from various reputed institutions of India, used their collective wisdom in scrutinising the scientific data from various perspectives before approving any product as safe, Manjunath, a former Director of Central Institute for Cotton Research, Nagpur, (to be corrected as: Monsanto Research Centre, Bangalore) and a key member of the Mahyco-Monsanto team which was responsible for the introduction of bt cotton in India, said.

Despite the continued opposition by "a small section", Indian farmers, who have been haunted by bollworms for more than three decades, had accepted this technology, he claimed.

This was reflected by the fact that area under bt-cotton, which was about 29,000 hectares in 2002, the first year of approval, has steadily increased from year to year to reach about 3.8 milion hectare grown by more than 2.3 million farmers in nine states by 2006, Manjunath said.

Presently, with the approval of more than 60 bt cotton hybrids developed by various Indian seed companies and also newer and improved versions of Bt-cotton, there would be an increasing demand for these transgenic seeds, Manjunath claimed.

Making an attempt to clear a lot of doubts and enable people to develop more confidence in crop biotechnology, Manjunath in his book said that coincidental with its steep increased adoption, the average yield of cotton in India increased from 308 kg per hectare in 2001-02 to 450 kg per hectare in 2005-06 with most of the increase in yield of up to 50 per cent or more, attributed to BT cotton.

The book, which desribed as very cruel the allegation that BT cotton was responsible for farmers' suicides, said it had no empirical basis. On the contrary, Bt cotton has come as a big relief to farmers and has saved their crops and enabled them to reap a better harvest and profit, Manjunath said.

In fact, an International Market Research Bureau survery in 2004 indicated that for every rupee spent by the farmers, they received Rs.5.80 in value for reduced insecticide cost and increased yield over conventional cotton, he said.

Further, BT cotton cultivation has started in India only since 2002, whereas the farmers' suicide had been an issue since decades, Manjunath claimed.

"Healthy criticism is welcome, but blind opposition and creating suspicion and fear through unsubstantiated allegation have no place in science." With vast resources, India has the potential to emerge as a supreme power in agriculture if modern technologies were appropriately reviewed and adopted and the farmers would be the greatest beneficiaries of agricultural biotechnology, Manjunath said.

This expert's book helps you cotton to BT

Express News Service

April 24

The author through his book explains that BT-technology aims at clarifying doubts by presenting facts based on scientific data

TM MANJUNATH, a Bangalore-based researcher and writer saw the release of his book titled 'Q & A on BT Cotton in India: Answers to more than 70 questions on all aspects' in New Delhi recently.

The author, who is an eminent agricultural entomologist, through his book explains that BT-technology aims at clarifying doubts by presenting facts based on scientific data.

A person who served as the director of Monsanto Research Centre in the city says, "I was in Monsanto when BT- Cotton was introduced. So I have been closely associated with BT-Cotton from its initial stage to regulatory approval and commercialisation."

'Q & A on BT-Cotton in India: Answers to more than 70 questions on all aspects' is a result of his experience with the subject. The book is replete with information on diverse aspects of BT-Cotton, presented in the form of answers to questions in several sections like cotton ballworms, Bacillus thuringiensis, development of BT-Cotton, efficacy, safety,

T M Manjunath

insect resistance management, field performance and adoption, costs and benefits, opposition to BT-Cotton, legal and illegal seeds and regulation, he tells.

Manjunath has a doctoral degree from the University of Agricultural Sciences, Bangalore for his study on agricultural entomology. He has worked as a researcher for more than four decades. He has lent his services to Commonwealth Institute of Biological Control from 1962 to 1976 and later moved to the University of Agricultural Sciences and worked there till 1982. Subsequently, he served as vice president of Bio Control Research Laboratories (BCRL) of Pest Control (India) Limited from 1981 till 1997. His final appointment was as director of Monsanto Research Centre where he served from 1998 till his superannuation in June 2004.

That apart, he has presented over a hundred research papers and delivered just as many lectures on BT-Cotton, both in the country and abroad. For his studies on BT, he has been closely interacting with farmers, scientists, students and teachers for the last few years.

The author, who earlier co-authored a book on rice, 'Pattada Besaya Samasyagalu Haagu Parihara (Cultivation of Rice, problems and solutions), in the late 70s, says, he is planning many more books on BT, most of which will be in Kannada so that it will be useful for farmers and for Kannada-speaking people.