

# FUTILE HARVEST

BY SUMAN SAHAI AND SHAKEELUR RAHMAN

## An evaluation of India's first commercial Bt cotton crop

*Gene Campaign is a grassroots organization created in 1993 to address issues of life patents and food security in rural India. In 2002, the Indian government made a controversial decision to allow the commercial planting of Bt cotton. The name is derived from the variety's modification with genes from bacillus thuringiensis, a microbe which produces a toxin lethal to some agricultural pests. What follows is an evaluation of this Bt cotton crop.*

### INTRODUCTION

Bt cotton is the first genetically modified crop to be commercially cultivated in India. After the first harvest, Gene Campaign conducted a small field study to collect data on Bt cotton and non-Bt cotton performance.

### METHODOLOGY

The survey was conducted in selected locations in Maharashtra and Andhra Pradesh, which are two of the six states granted permission to commercially cultivate Bt cotton. The survey included a total of 100 farming families randomly selected from those who had chosen to grow Bt cotton on a portion of their landholding. These farmers were also growing non-Bt cotton simultaneously. Of the total of 100 families surveyed, 25 were from Maharashtra and 75 from Andhra Pradesh. Scientists from the Agricultural University in Hyderabad accompanied the Gene Campaign researchers.

### BT AND NON-BT VARIETIES: A COMPARISON

The Bt cotton varieties compared were Bt 162 and Bt 184, belonging to transnational agribusiness combine Mahyco-Monsanto, and the non-Bt cotton varieties were the local hybrids Brahma and Banny.

The Bt cotton was found to have a shorter growing cycle (90-100 days) than the non-Bt cotton (100 to 120 days). However, the modified plants showed less vigorous growth, with fewer branches and smaller leaves. A major problem reported everywhere was the premature dropping of bolls in Bt cotton.

A comparison of bolls and fibre in non-Bt and Bt cotton [Table 1] showed that the number of bolls per plant was higher in the non-Bt cotton variety. Whereas the non-

TABLE 1: COMPARISON BETWEEN BOLLS AND FIBRE OF NON-BT AND BT COTTON.

Item	Non-Bt	Bt
Number of bolls/plant	95 (70 - 120)	50 (25 - 75)
Boll size	6 - 8 gm	3.5 - 5 gm
Fibre length	34.5 mm	30.5 mm
Cotton Quality (grade)	A & B	B & C

Source: Gene Campaign survey.

Bt variety averaged 95 bolls per plant, the Bt variety averaged only 50. Fibre length was also longer in the non-Bt varieties, which had better grade cotton. Non-Bt cotton was graded as A and B quality, whereas Bt cotton was graded as B and C.

Although both cotton types demonstrated a range of small to large bolls, more Bt cotton bolls were of a smaller size than the non-Bt cotton. Cotton traders admitted that because of the poor quality, demand for Bt cotton was low and they were mixing Bt cotton with non-Bt to dispose of their Bt cotton stocks.

One of the most significant findings of this study was the indication that this Bt cotton variety does not offer protection against pink bollworm (*Pectinophora gossypiella*). Pink bollworm attack was found to be severe after 60 to 70 days. There are two possible reasons for this. The first is that the period of Bt toxin expression does not coincide with the time of bollworm infestations. This would mean that, when the pest attacks, the cotton is not expressing the endotoxin gene, and

TABLE 2: COMPARISON OF PEST INFESTATION OF NON-BT AND BT COTTON.

Pest	Non-Bt Cotton	Bt Cotton
Leaf Sucker	Moderate	Moderate
Stem borer	Low	Low
Bollworm	Moderate	Moderate
Pink bollworm	Heavy	Heavy

Source: Gene Campaign survey.

therefore is unprotected against the pest. The other explanation is that the pink bollworm is not susceptible to the Bt endotoxin.

The latter theory receives support from the scientific literature. *Morin et al* (2003) report that field populations of pink bollworm harbor three genetic mutations that confer resistance to Bt toxin.<sup>1</sup> Normal pink bollworm caterpillars die when they eat bolls of genetically modified cotton plants that produce Bt toxin, but resistant caterpillars survive. This resistance is inherited as a recessive trait, so caterpillars with two mutant versions of the gene are resistant, but those with one or none are susceptible.

In another study, *Liu et al* (1999) show that, in the laboratory, the larval stage of the pink bollworm lasts for 21 days when it feeds on Bt cotton.<sup>2</sup> When feeding on non-Bt cotton, the larval stage lasts 15 days. Because mating occurs within a narrow period of time and moths are more likely to mate with co-mature individuals, the difference in maturation rates increases the chance of Bt-resistant individuals mating with each other. The offspring of such a union inherit two copies of the gene for Bt resistance, and are thus resistant to the modified cotton. This trait will persist and spread ever more rapidly in the bollworm population. Pink bollworm in India has probably been exposed to Bt toxin from the field trials that have been conducted these past years and from the use of Bt pesticide sprays.

Agricultural landholdings where both Bt and non-Bt cotton were cultivated have been divided into low-yielding, medium-yielding and high-yielding based on the type and quality of soil, topography, availability of water for irrigation and resource capacity of farmers.

TABLE 3: YIELD COMPARISON OF BT AND NON-BT COTTON IN QUINTALS PER ACRE.

Field Type	Non-Bt Cotton	Bt Cotton
Low Yielding	3.25 (2.5 - 4.0)	2.75 (2 - 3.5)
Stem borer	5.50 (5 - 6)	4.75 (4 - 5.5)
Medium Yielding	9.00 (7 - 11)	7.50 (6 - 9)

Source: Gene Campaign survey.

As seen in Table 3, average Bt and non-Bt yields per acre in low-yielding field type are, respectively, 2.75 quintals and 3.25 quintals [a quintal is a unit of mass equivalent to 100 kilograms]. In the case of medium-yielding field types, Bt and non-Bt cotton yields per acre are 4.75 quintals and 5.50 quintals. Similarly, in high-yielding field types, the per-acre yields are 7.5 quintals and 9.0 quintals. Thus, in all categories of landholdings, Bt cotton performed worse than its non-Bt counterpart.

Cotton traders confirmed that demand for Bt cotton was low, with prices ranging from 2000 to 2100 rupees (Rs.) per quart. Non-Bt cotton sold for Rs. 2200 to 2350 per quart.

TABLE 4: COMPARATIVE INVESTMENT IN BT AND NON-BT COTTON IN RS./ACRE.

Input	Non-Bt Cotton	Bt Cotton
Seed	400	1,600
Fertiliser	2,800 (1500 - 4000)	2,800 (1500 - 4000)
Pesticide	1,533 (600 - 2500)	1,316 (500 - 2200)
Total	4,733	5,716

Source: Gene Campaign survey.

## ECONOMICS OF BT COTTON CULTIVATION

The economics of cultivating Bt cotton are clearly not in favor of farmers. The seed is about four times more expensive than high-quality local hybrids. The difference in the price of seed is approximately Rs. 1200 per 450 gram bag, the amount needed to plant an acre. Against this outlay, savings on pesticide were meager, averaging Rs. 217 per acre.

As Table 4 shows, the investment per acre is much higher for Bt cotton than for non-Bt cotton varieties. The Bt cotton farmer had to invest, on average, 983 more rupees per acre than his non-Bt counterpart.

The per-acre yield of Bt cotton was lower than that of non-Bt cotton, of poorer quality, and fetched a lower price per quintal. Added to this was the higher investment in Bt cotton fields. The net result was significantly poorer results with Bt cotton, as are reflected in the data on comparative incomes [Table 5, on next page].

Net profit from Bt cotton was lower per acre compared to non-Bt cotton in all types of fields, from low- to high-yielding. In fact, 60% of the farmers cultivating Bt cotton were not even able to recover their investment, incurring average losses of Rs. 79 per acre. Not surprisingly, 98% of the farming families surveyed said they were not interested in growing Bt cotton again.

## NO TRAINING FOR FARMERS

As part of the study, we examined whether government agencies or Mahyco-Monsanto gave pre-cultivation training to farmers planting Bt cotton. It was found that neither state nor central government agencies had provided any training. While the seed company made available pamphlets showing that Bt cotton needed to be sprayed if the number of pests exceeded a certain level, the company's major efforts were directed towards broadcasting taped messages extolling their cotton's virtues.

No technical assistance was provided to the farmers during cultivation by any governmental agency or by Mahyco-Monsanto. In the absence of any extension help, farmers had no one to assist them when they faced problems and pest attacks during cultivation.

TABLE 5: COMPARATIVE INCOME FROM BT AND NON-BT COTTON

	Non-Bt Cotton			Bt Cotton		
	Farmers (%)	Income/acre (Rs.)	Net Profit/acre (Rs.)	Farmers (%)	Income/acre (Rs.)	Net Profit/acre (Rs.)
Low-Yielding	35	7394	2661	60	5637	-79
Medium-Yielding	58	12512	7779	35	9737	4021
High-Yielding	7	20475	15742	5	15375	9659

Source: Gene Campaign survey.

## NO REGULATORY STRUCTURES

One of the most shocking revelations of this investigation was the fact that neither state level nor district level Committees were set up in either Maharashtra or Andhra Pradesh where Bt cotton was being commercially grown. This is a breach of law and a direct violation of India's Environment Protection Act, which in 1989 prescribed rules for the manufacture, use, import, export and storage of hazardous microorganisms and genetically engineered organisms and cells.

Enquiries made during the survey also revealed that no one had collected field data on insect attacks or crop performance in Maharashtra or Andhra Pradesh. In these areas, at least, no baseline data was gathered to evaluate the impact of Bt cotton on the environment, on beneficial insects, on other cotton crops and on the ecosystem. This amounts to gross negligence.

## WHY THE MAHYCO-MONSANTO COTTON FAILED

A number of factors probably contributed to the failure of Mahyco-Monsanto's Bt cotton. The first is the poor quality of the variety itself. It is well known that Mahyco-Monsanto's cotton varieties, MECH 162 and MECH 184, which were transformed to Bt 162 and Bt 184, are poor to modest performers, giving modest yields. A better performing cotton would yield a better Bt cotton. The Genetic Engineering Approval Committee (GEAC), the office responsible for permitting the planting of Bt cotton, must answer why it approved this variety of Bt cotton when better quality Bt cotton hybrids belonging to Indian companies are in the pipeline.

With the substantially higher cost of seeds, the economics of the Bt crop are not favorable for the farmer. The modest savings in pesticide do not make up for expenses incurred on seed. Moreover, Bt cotton must be grown within a refuge of non-Bt plants, necessary for resistance management. The recommended refuge size is 20% of the area cultivated by the GEAC. Using 20% of the land on managing resistance makes the Bt cotton even less viable, especially for small farmers.

A further problem appears to be the vulnerability of Bt

cotton to pink bollworm, a significant cotton pest in India. If, as the study demonstrates, this is indeed true, then the Bt strategy for cotton is likely to fail: because the Bt endotoxin protects only against the green bollworm and not against the pink, farmers will have to continue spraying pesticides.

The GEAC has to be held just as accountable for the failure of Bt cotton as companies providing the seed. Why did they keep the field trial data secret when there were so many demands to examine it? The GEAC must explain how approval for commercial planting was granted where no state and district level committees were established. The GEAC must also assign responsibility for the failed cotton crop, and make Mahyco-Monsanto compensate those farmers who suffered losses. This is required under Indian law. Section 39.2 of the Protection of Plant Variety and Farmers Rights Act of 2001 clearly states that:

*Where any propagating material of a variety registered under this Act has been sold to a farmer or a group of farmers or any organization of farmers, the breeder of such variety shall disclose to the farmer or the group of farmers or the organization of farmers, as the case may be, the expected performance under given conditions, and if such propagating material fails to provide such performance under such given conditions, the farmer or the group of farmers or the organization of farmers, as the case may be, may claim compensation....* □□□

**Dr. Suman Sahai**, a geneticist, is the founder and president of Gene Campaign. **Shakeelur Rahman** is a project coordinator at Gene Campaign.

## References:

- 1 Morin, Shai et al. 2003, Three cadherin alleles associated with resistance to *Bacillus thuringiensis* in pink bollworm, Proceedings of the National Academy of Sciences, 100 :5004-5009.
- 2 Liu, Yong-Biao, Bruce E. Tabashnik, Timothy J. Dennehy, Amanda L. Patin, and Alan C. Bartlett, 1999, Development time and resistance to Bt crops, Nature, 400:519.