

Important Role of Bt Cotton in Pest Management

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SUMMARY

Cotton is called 'White Gold', is an important commercial crop in India. The major impact in cotton production is its higher susceptibility to pests, especially in bollworms. In India, cotton is infested by both Lepidopteran caterpillars and Hemipteran sap-sucking bugs. Bt cotton requires certain control measures for sucking pests in India. Bt cotton contains endotoxin protein inducing gene from soil bacterium *Bacillus thuringiensis* so it refers to transgenic cotton. Bt cotton minimizes the bollworm infestation and reduce the pesticide usage.

INTRODUCTION

Cotton is an important cash crop of India. It plays major role in Indian economy, because it provides livelihood to more than 60 million people by way of support in agriculture, processing and use of cotton in textiles. In global level one of the major fibre crops is cotton. Cotton is cultivated in tropical and subtropical regions. In India, farmers increased the cotton productivity by planting Bt cotton on 11.2 million ha representing 96% of cotton area. In the world level developed countries growing transgenic crops successfully as maize, brinjal, corn and soybean but in Indian condition only Bt cotton is successfully cultivated. Strains of the bacterium *Bacillus thuringiensis* produce over 200 different Bt toxins, each harmful to different insects. Most notably, Bt toxins are insecticidal to the larvae of moths and butterflies, beetles, cotton bollworms and flies but are harmless to other forms of life. The gene coding for Bt toxin has been inserted into cotton as a transgene, causing it to produce this natural insecticide in its tissues. In many regions, the main pests in commercial cotton are lepidopteran larvae, which are killed by the Bt protein in the genetically modified cotton they eat. This eliminates the need to use large amounts of broad-spectrum insecticides to kill lepidopteran pests (some of which have developed pyrethroid resistance). This spares natural insect predators in the farm ecology and further contributes to noninsecticide pest management.

Bacillus thuringiensis :

- The *Bacillus thuringiensis* is a gram positive, aerobic, endosporic soil bacterium.
- Bt was first discovered in 1901 by Ishiwata from diseased Japanese silkworm. He named it *Bacillus sotto*.
- *Bacillus thuringiensis*, is isolated from diseased Mediterranean flour moth (*Ephestia kuehniella zeller*) obtained from Thuringiensis province in Germany.
- It produces crystal (crystalline paraporal body) that is proteinaceous during sporulation and possess insecticidal properties.

What is transgenic plant? :

- A transgenic plant contains a gene or genes which have been artificially inserted instead of plant acquiring them through pollination. The inserted gene sequence (transgene) may come from other unrelated plants or from a completely different species.
- The first transgenic plant was produced in mid-1980s, but first was grown in 1994 and large scale cultivation was taken up in 1996 in USA.
- In India first genetically modified (GM) crop is Bt cotton. India was initially approved on March 26th, 2002, for commercial cultivation in six states belonging to southern and central cotton cultivation zones of the country.

What do you mean by Bt Technology? :

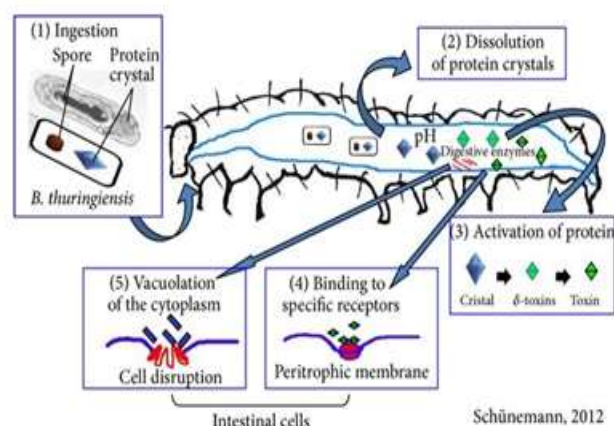
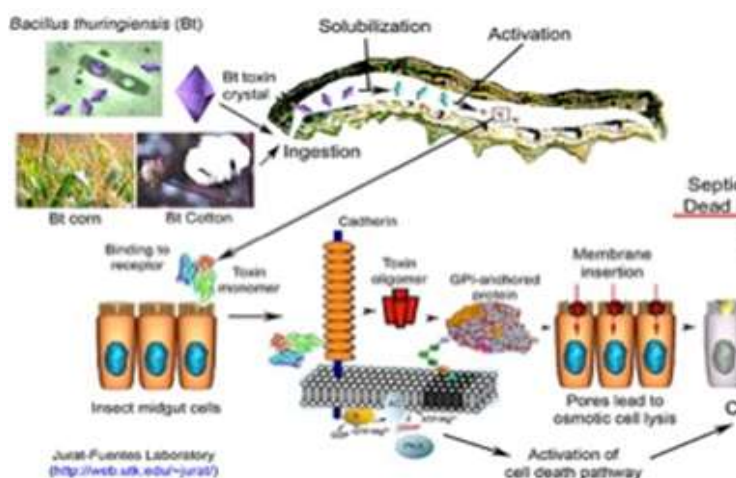
- The application of the technology to improve the biological function of an organism by adding genes from another organism *Bacillus thuringiensis* (Bt).
- Bt is a gram positive, motile, spore forming bacterium that produces crystal proteins (Cry proteins) which are toxic to many species of insects.
- *Bacillus thuringiensis* (Bt) is a bacterium that produces insecticidal proteins during its sporulation.

Bt cotton :

- Bt cotton contains endotoxin protein inducing gene from soil bacterium *Bacillus thuringiensis* so it refers to transgenic cotton. The insertion of the genes from *B. thuringiensis* to plant.
- Plant cells to produce crystal proteins.
- When the susceptible insects eat these Cry proteins, their own digestive enzymes activate the toxic form of proteins.
- The main reason for the introduction of Bt cotton was to reduce the insect pests (*Helicoverpa armigera*, commonly referred to as American Bollworm) infestation.

Mode of action of Bt :

- Bt cotton was created through the addition of genes encoding toxin crystals in the Cry group of endotoxin.
- When insects attack and eat the cotton plant the Cry toxins or crystal protein are dissolved due to the high pH level of the insect's stomach.
- The dissolved and activated Cry molecules bond to cadherin-like proteins on cells comprising the brush border molecules. The epithelium of the brush border membranes separates the body cavity from the gut while allowing access to nutrients.
- The Cry toxin molecules attach themselves to specific locations on the cadherin-like proteins present on the epithelial cells of the midgut and ion channels are formed which allow the flow of potassium. Regulation of potassium concentration is essential and, if left unchecked, causes death of cells.
- Due to the formation of Cry ion channels sufficient regulation of potassium ions is lost, resulting in the death of epithelial cells. The death of such cells creates gaps in the brush border membrane.
- Larvae affected by Bt become inactive, stop feeding, and may regurgitate or have watery excrement. The head capsule may appear to be overly large for the body size. The larva becomes flaccid and dies, usually within days or a week.



List of Transgenic Cotton (Bt Cotton) Trade name	Bt protein	Crop	Company	Insect pest
Bollgard	Cry1Ac	Cotton	Monsanto	Tobacco budworm, cotton bollworm, pink bollworm
Bollgard II	Cry1Ac+ Cry2Ab	Cotton	Monsanto	Tobacco budworm, cotton bollworm, pink bollworm
Widestrike	Cry1Ac+ Cry1Fa	Cotton	Dow	Tobacco budworm, cotton bollworm, pink bollworm

Savings of Insecticides Due to Bt Cotton :

- Traditionally, cotton consumed more insecticides than any other crop in India and was a significant proportion of the total pesticide (insecticides, fungicides and herbicides) market for all crops. For example, of the total pesticide market in India in 1998 valued at US\$770 million, 30% was for cotton insecticides only, which were equal to 42% of the total insecticide market for all crops in India.

- Subsequent to the introduction of Bt cotton, cotton consumed only 18% of the total pesticide market, in 2006, valued at US\$900 million as compared to a much higher 30% in 1998.
- Similarly, the market share for cotton insecticides as a percentage of total insecticides declined from 42% in 1998 to 28% in 2006. This saving in insecticides between 1998 and 2006 coincided with the introduction of Bt cotton which occupied 3.8 million hectares equivalent to 42% of the hectares of the cotton crop in 2006.
- More specifically, the sharpest decline in insecticides occurred in the bollworm market in cotton, which declined from US\$147 million in 1998 to US\$65 million in 2006- a 56% decrease, equivalent to a saving of US\$82 million in the use of insecticides to control cotton bollworm in 2006.
- Thus, insecticide use for control of bollworm dropped by half at the same time when approximately half the cotton area (3.8 million hectares) was benefiting from controlling bollworm with Bt cotton.

Advantages of Bt Cotton :

- The Bt cotton has inbuilt genetic resistance to bollworms and is very effective in Controlling the yield losses caused by bollworms to a considerable extent (Bacheler and Mott, 1996). The resistance is governed by a single dominant gene.
- Use of Bt cotton reduces use of pesticides resulting in reducing the cost of cultivation.
- It results in improvement of yield levels and also improves the margin of profit to the farmers (Naranjo, 2005).
- It provides opportunities to grow cotton in areas of severe bollworm incidence.
- It promotes ecofriendly cultivation of cotton and allows multiplication of beneficial insects *i.e.*, parasites and predators of bollworms (Fitt *et al.*, 1994, Luttrell *et al.*, 2015).
- It also reduces environmental pollution and the risk of health hazards associated with the use of insecticides because in Bt cotton insecticides are rarely used. An average reduction of 3.6 sprays per crop season has been reported in Bt varieties as compared to non-Bt.

Disadvantages of Bt Cotton :

- We don't know the consequences of inserting the BT gene into the cotton gene pool. Since it affects all larval insects, there are chances that beneficial caterpillars in the area will be killed too.
- Famous cotton-based firms like Monsanto might put special crop seeds out of the reach of developing countries, which may require them to protect already-polluted groundwater, environment, etc.
- It is ecologically a hectic task to cultivate such a crop, due to its need of pesticides for 8-10 times in a single season (to get a decent yield). This requires a tractor, and subsequently its fuel as well as the farmer's time and money (Rajput *et al.*, 2016).
- It poisons the groundwater and is a health hazard to humans and other organisms.

CONCLUSION

Plenty of insects inhabit the cotton crop, including the target and non-target insects. Transgenic Bt cotton has resistance against major target insect pests. *H. armigera*, *Earias* spp & *P. gossypiella* and significantly reduce the insecticide applications. This reduction in pesticide use has a positive impact on natural enemies and increased the stability of beneficial rare species. Bt cotton varieties with Cry1Ac toxin are ineffective against armyworm, *Spodoptera* spp. Bt cotton has no resistance against sucking insect pests. jassid, whitefly, thrips, aphid & mealybug and insecticides are used to control these pests. To increase the stability of Bt based products as an important tool of IPM in cotton, it is crucial that such varieties should be transformed with *Bt* toxin genes, which also have other resistance traits against non-target insect pests to reduce the number of insecticide applications. There is also needed to re-determine the economic threshold levels for sucking pests and bollworms in Bt cotton due to increased beneficial abundance and the change of pest status. The biotechnological efforts, in developing the transgenic Bt cotton varieties, should also focus on the sustainable temporal and intra-plant expression of Cry1Ac toxin in all plant parts.

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