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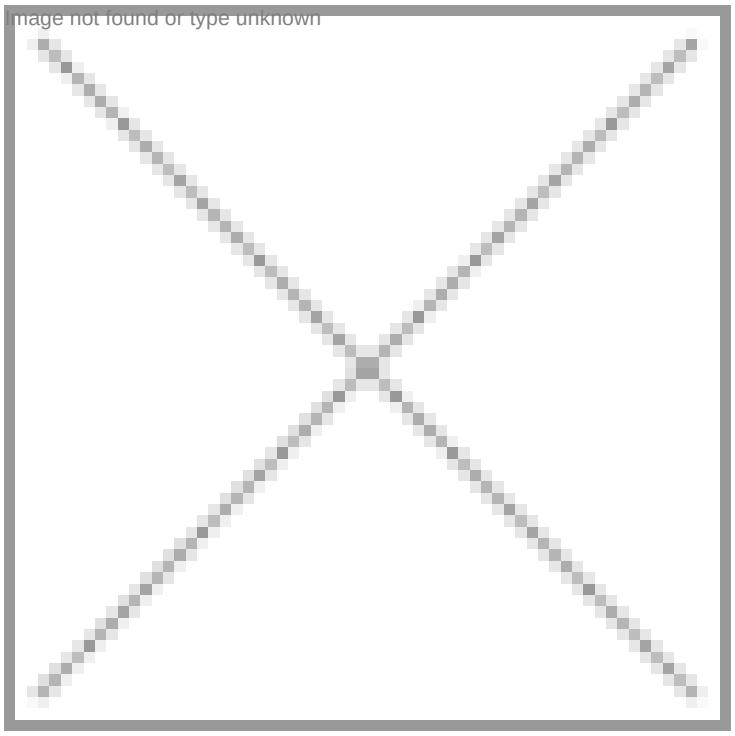

Safety aspects and benefits of Bt cotton

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Bt being a new technology, several technical aspects are not clear to many. This article makes an attempt to provide scientific information on Bt and Bt cotton.

Bt cotton, developed by Mahyco-Monsanto, is the first agribiotech product approved by the Genetic Engineering Approval Committee of Govt of India in March 2002 for commercial cultivation in India. This approval was preceded by comprehensive biosafety studies and more than 500 field trials were carried out for six-seven years as per the direction of the regulatory authorities to demonstrate its safety and benefits. Even so, those who are opposed to this technology have raised several issues regarding its safety, creating doubts and confusion in the minds of farmers and the general public alike. Also, being a new technology, several technical aspects are not clear to many stake holders.

What is Bt ?

Bt is the popular abbreviation for Bacillus thuringiensis, a bacterium commonly found in soil with ubiquitous distribution. Its insecticidal property was discovered in Japan way back in 1901. More than 90 varieties or sub-species of B. thuringiensis have been described so far. A unique feature of Bt is that each variety possesses a distinct gene encoding an insecticidal protein that can affect only a narrow range of insects belonging to a particular group. Thus, there are Bt proteins that can affect certain larvae of only Lepidoptera (moths and butterflies), Coleoptera (beetles), Hemiptera (bugs), Diptera (flies) and so on. A particular Bt protein active on one group of insects generally does not affect other insects or other organisms.

What are Bt crops?

Depending upon the type of pests to be controlled, the relevant Bt gene is isolated, studied, modified to be more like a plant gene and introduced into the desired plant by genetic engineering. Such a gene becomes stably integrated in the plant genome and becomes an inheritable trait. The technology is made available to the farmers in the seeds itself and therefore no special skills are required to adopt it. Such transgenic crops containing the Bt genes are called Bt crops.

How does Bt act?

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

- In the first place, the Bt protein has to be ingested by the susceptible insects as it has no contact effects. In the case of Bt cotton, 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.

All these conditions are available only in the susceptible insects and therefore they succumb when they feed on Bt plants. The mortality of bollworms that feed on Bt cotton is one such example.

How are 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 newly hatched bollworm larvae feed on any part of the Bt cotton plant like leaves, squares, green bolls etc, they ingest Bt protein along with the plant tissues. As the bollworms are susceptible, 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 'pores' being formed in the insect intestine, causing destruction of the gut lining. The haemolymph (insect blood) carrying the 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). All the major cotton bollworms in India like the False American bollworm (Helicoverpa armigera), pink bollworm (Pectinophora gossypiella), spotted bollworm (Earias vittella) and spiny bollworm (Earias insulana) are susceptible in their early larval stages (first and second instars) to Bt proteins that are expressed within the Bt cotton plants. In other words, they possess all the specific conditions required for the activation and effectiveness of Bt protein and therefore they succumb. Thus, Bt cotton is helpful in controlling cotton bollworms.

How safe is Bt cotton to non-target organisms?

Comprehensive biosafety studies, as stipulated by the regulatory authorities, were carried out in India to ascertain the safety of Bt protein to animals and other non-target beneficial organisms. Feed-safety studies using the 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 GB Pant University of Agriculture and Technology, Pantnagar. The results revealed that the animals fed with unusually high dose of Bt protein via the 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 have approved Bt cotton as safe.

Does Bt cotton contain the 'terminator technology?'

It was alleged by the activists of a few NGOs that Bt contains the so-called 'terminator gene' and that this gene would escape and cause 'gene pollution' and sterility in the surrounding plants. Monsanto reiterated that their Bt cotton does not contain the so-called 'terminator gene' but the activists went ahead and burnt a few RCGM-approved Bt cotton trial fields as a mark of protest. Following such incidences, the Department of Genetics, University of Delhi (South Campus), Delhi, on the advise of the regulatory authorities, carried out molecular detection tests on Mahyco's Bt cotton hybrids and found that there was absolutely no trace of any 'terminator gene' in them. These hybrids tested positive only for the Bt gene. 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. If it had terminator gene, the seeds would not have germinated as such. These experiments conclusively demonstrated the absence of 'terminator gene' in Bt cotton.

Can bollworms develop resistance to Bt cotton?

Pest resistance is a concern with any control measure and not peculiar to Bt cotton alone. In view of this, insect resistance management (IRM) strategies have been developed and are in place so as to prevent or delay the possible development of bollworm resistance to Bt cotton. These include the following:

Insect Resistance Management (IRM) strategies

Refuge crop: Planting non-Bt cotton as border rows to Bt cotton is currently recommended as one of the key elements of IRM. It is called 'refuge.' This is practiced in other countries like the US and Australia and has also been recommended by the GEAC in India. The 'refuge' crop could be 20 percent of the Bt cotton area with the intervention of plant protection measures when required or five percent of the area without providing any chemical protection.

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 expected that a great majority of bollworm 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. These remain as susceptible strain (SS) and their number is generally large. 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 susceptible (SS) moths in the vicinity, coming from the refuge crop, and a very scant population of the resistant (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, the refuge helps in maintaining susceptible population which would succumb to Bt-protein when they feed on Bt cotton. Theoretically the refuge does not have to be cotton but could be any plant that supports Bt-susceptible bollworms. Studies have revealed that in India, a pest like Helicoverpa armigera has a large number of alternative host crops like pigeonpea, chickpea, tomato, sunflower, capsicum etc. These would further help in IRM and have the potential to replace structured 'Bt cotton' refuge.

Other IRM strategies

Besides 'refuge', several other IRM strategies have also 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 it developing resistance to both the genes simultaneously is very remote.

In the last five years of its large scale cultivation in India and for eleven continuous years in several other countries on millions of hectares, there is no indication that any of the bollworm species has developed field resistance to Bt cotton anywhere in the world. This shows that it is not easy for the pests to develop resistance to Bt protein expressed in planta and also that the present IRM strategies are working well. Nevertheless, resistance is a genuine concern and we should continue to be watchful.

Bt cotton is safe

Bt cotton is a thoroughly researched biotech product that has undergone all the tests pertaining to bio-safety and agronomic performances as prescribed by the concerned regulatory authorities in each country including India. Its safety to non-target organisms including animals and humans as also to environment has been demonstrated through comprehensive scientific studies.

During all these years of its continuous cultivation on million of hectares, there is no proven scientific evidence that Bt cotton has caused any negative impact related bio-safety, cross pollination or pest resistance anywhere in the world.

The major benefits from Bt cotton include effective control of bollworms leading to significant yield increase, drastic reduction in chemical sprays and substantial increase in net profit to farmers. Efforts should be made to sustain these social, economic and environmental benefits.