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Impact of Bt Cotton in India

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The views expressed in this column are his own and not that of Cotton Association of India)

There has been a constant debate on the impact of genetically modified (GM) cotton. In India, thus far, GM cotton is available only in the form of Bt (Bacillus thuringiensis) cotton. The Bt cotton technology developers, seed companies and some researchers claim that Bt cotton doubled the yields, reduced insecticide usage by 50%, improved quality of cotton and thus farmers prospered. However, some activists allege that Bt cotton has aggravated the cotton crisis, especially in the dry tracts of Vidarbha. The allegations also point out that 'Bt-cotton is unsuitable for rainfed regions', 'insecticide usage has increased with Bt-cotton', 'input usage has increased with Bt-cotton', 'India's yields stagnated irrespective of the increase in Bt-cotton area' and bio-safety issues were not examined independently and stringently. Further some activists tried to associate goat and sheep deaths to feeding on Bt cotton.

EXPERT's Column

Dr K.R. Kranthi

A book 'Bt Cotton Q&A' written by Kranthi addressed some of these questions. The book published in 2012 by the ISCI (Indian Society for Cotton Improvement), Mumbai, can be downloaded from http://www.cicr.org.in/pdf/Bt_book_Kranthi.pdf

Excerpts from the book are summarised below, primarily to give the reader a perspective on the overall impact of Bt cotton in India. I am presenting some basic aspects of what Bt cotton is, before the impact can be properly understood.

Bacillus thuringiensis (Bt): Bt is a soil bacterium that produces many proteins which act as stomach poisons only to some worm species that eat crops, but are considered safer to cattle and human beings. The bacteria produce three types of proteins, crystal (cry), cytolytic (Cyt) toxins and vegetatively expressed insecticidal proteins (vip). For more than 50 years, in many parts of the world, Bt formulations were used as eco-friendly sprays on crops to control caterpillar worms. Thus far, until November 30, 2013, scientists discovered that about 67 different Bt species produced 402 proteins that are more specifically toxic to insects. These include 286 cry toxins, 11 cyt toxins and 105 vip toxins. Bt sprays are now used in many countries mostly on vegetables in integrated pest management (IPM) programmes.

Bt Cotton: Cotton plants producing Bt-cry proteins in all plant parts are called Bt cotton. First, a gene from the Bt cells is isolated and introduced into the cell of a cotton plant. The single cell of the cotton plant is then developed into a full plant through tissue culture. This Bt cotton plant produces the Bt protein in all its cells. Thus when target insects eat any plant part, they will die. A general biological rule is that 'one gene produces one protein'. A gene is a chemical micro thread of fixed length that codes for a specific protein. The genes of crystal (cry) proteins called cry1Ac and cry2Ab were introduced into cotton first by Monsanto, USA. Bt cotton was

The three cotton bollworms

American bollworm Pink bollworm Spotted bollworm

introduced into India as Bollgard (one gene cry1Ac) in 2002 and Bollgard-II (two genes cry1Ac+cry2Ab) in 2005.

A record number of 1128 Bt cotton hybrids: Hybrid cotton area in India reached 40% by the year 2001 in over 30 years since its inception in 1971. In 2013, more than 95% of India's cotton area was under hybrids. Interestingly, a total number of 40 hybrids were released by the public sector institutions in 40 years. With the advent of Bt cotton by the private sector, the scenario changed completely. In just five years between 2006 and 2011, about 800 new hybrids were released into the market. Bt cotton was first introduced In 2002 after the Genetic Engineering Approval Committee (GEAC) approved Bt cotton, Mahyco (Maharashtra Hybrid Seeds Company) released three hybrids MECH-12, MECH-162, and MECH-184 for commercial cultivation in central and south Indian cotton–growing zones. By 2005, there were 20 hybrids including some popular ones from Rasi and Nuziveedu seeds. In 2006, Nath Seeds and JK seeds released their new Bt cotton events with different version of the cry1Ac gene. Subsequently Metahelix India released the cry1C based Bt cotton. There was a steady increase in the number of Bt cotton hybrids available in the market. By 2012 there were 1128 Bt cotton hybrids.

Tissue cultured cotton plants

Genetically Modified Bt cotton Plants can be developed from a single cell through tissue culture after the Bt gene is introduced into the cell.

Bacillus thuringiensis

The black colored crystal protein can be seen in the cell. Insects eat this and die.

Bt cotton captured the market: Within six years after its approval in 2002, by 2008, Bt cotton occupied 80% of India's cotton area. The area increased significantly to 120 lakh hectares by 2011, with about 30 to 35 lakh hectares of new additions. The new areas were mainly, about 15 lakh hectares in Gujarat and 10 lakh hectares each in Andhra Pradesh and Maharashtra.

The main reason for the immense popularity was the bollworm menace. By the year 2000, the American bollworm emerged as a major terror to cotton producers. Insecticide usage was rampant. Insecticide cocktails were tank-mixed and 20-30 applications were not uncommon. Despite the excessive usage, the bollworm continued to survive and cause damage to cotton. The normal damage to yields ranged from 15% to 50% and the bollworm could cause a complete crop failure in outbreak years. The bollworm menace caused a decline in cotton area from 87 lakh hectares in 2001 to 78 lakh hectares in 2002. The introduction of Bt cotton in 2002 which gave spectacular protection against the three bollworms, including the American bollworm, resulted in a resurgence of cotton.

Strong impact on cotton farming: Despite anything that may have been said or written against Bt cotton, it is clear that farmers endorsed the technology and there is a huge continued demand. There has been shortage in specific brands and instances of farmers standing in long queues to obtain specific hybrid brands are common. Studies conducted by the Central Institute for Cotton Research, CICR Nagpur showed that Bt cotton effectively controlled bollworms, especially the American bollworm, Helicoverpa armigera, thus preventing yield losses from an estimated damage of 30.0% to 60.0% each year in India thus far for a decade from 2002. The usage of insecticide reduced and quality of the harvested cotton improved significantly.

Reduction in insecticides: Before 2001, more than 1.0 kg insecticide active ingredient was used per hectare on cotton. After 2005, it declined to 0.6 kg per hectare due to the impact of Bt. Similarly insecticides worth Rs 1084/ha were used during 2001-2004 on an average annually, which declined to an annual average of Rs 771/ha during 2005-2011. Cotton consumed 13,176 M tonnes which was 46% of the total insecticides used in India in 2001. Introduction of Bt cotton in 2002 resulted in

a significant decline to 4623 M tonnes, which was less than 21% by 2006. For bollworm control, the reduction in insecticide usage was spectacular. Over 10 years from 1995 to 2004, the average insecticide use for bollworm control was 6767 M tonnes per year, which reduced to an average of 1089 M tonnes per year after 2005. However the average usage of insecticide for sucking pest control was 3335 M tonnes during 1995 to 2004, which increased to an average of 4600 M tonnes during 2005 to 2011, because of the increase in area of hybrid cotton from 40% in 2001 to 94% in 2011.

No more fear of bollworm attacks: The widespread cultivation of Bt cotton over the past ten years also reduced the intensity of bollworms significantly on cotton and also on other host crops. Clearly, there have been no outbreaks of the American bollworm after 2001 either on cotton or other subsequent crops such as chickpea and pigeonpea. Bt cotton also helped farmers to overcome the fear of impending bollworm infestations and the associated stress of using deadly cocktails of insecticide mixtures.

Healthy bolls and better fibre quality: Bt cotton protects bolls from damage caused by bollworms and thus the proportion of bollworm affected 'bad-kapas' in Indian cotton became almost negligible. Generally, any damage to the green bolls aggravates further damage by secondary pathogens or other insects, thus leading to bad boll opening and poor fibre quality. Moreover, the general quality of cotton becomes bad because of the mixing with affected poor quality bolls. Prior to 2004, Indian cotton was less respected in the global markets because of such poor quality. Studies conducted by CICR and CIRCOT (Central Institute for Cotton Technology, Mumbai) showed that the quality of seed-cotton and fibre from Bt-cotton fields was found to be significantly superior than non-Bt cotton. Bt cotton did not have any adverse effects on fibre quality. However, the textile industry pointed out that

micronaire (fineness) value declined in the later pickings. Incidentally, the trash content in Indian cotton also reduced because of good boll opening and better picking. The introduction of Bt cotton also brought about a major changes in the proportion of long staple cotton in the country. About 80% of Indian cotton is now of the long staple category. Prior to 2002, long staple cotton production was only 38% of the total cotton.

Advantage of early harvest: Bt cotton conferred other advantages such as more balanced plant growth, earliness and determinate habit, because of the effective protection of early fruiting parts and higher retention of first formed bolls due to low damage to fruiting point and bolls. Protection of the first flush resulted in 2 to 3 week early maturity of the crop in many hybrids in many parts of the country. Due to early retention of bolls in Bt cotton hybrids, the boll bursting commenced nearly 15-20 days in advance and required lesser number of pickings to complete the harvest. There have been several added benefits to this. In North India, farmers were able to take up wheat cultivation immediately after early harvest of cotton. The number of picking reduced and the yield per each of the few pickings, increased. Farmers were able to get remunerative returns because of higher prices generally prevalent early in the market during the initial cotton arrivals.

Increase in export reduced imports: The quality of Indian cotton which was hitherto considered as inferior, is now acceptable internationally as export quality, with improvement in quality after the introduction of Bt cotton. India became a leading global exporter of raw cotton with exports averaging at 53 lakh bales over nine years from 2003-2011 compared to an average of 1.18 lakh bales during the years 1997 to 2002 prior to the introduction of Bt cotton. Indian cotton exports reached an all time high of 128 lakh bales in 2011. Imports declined from an average of 16.50 lakh bales over 6 years between 1997 to 2002, to an average of 6.9 lakh bales over 9 years from 2003 to 2011. In 2001, 25.3 lakh bales were imported which plummeted to lakh bales in 2.4 in 2010.

Criticism: There are issues related to Bt cotton in India, which must be addressed. Activists have been highlighting these. Primarily the main issue relates to hybrids and Bt technology per-se. A survey of global impact of Bt cotton shows that the potential of Bt technology was not harnessed in India to its fullest potential, mainly because Bt was available only as hybrids and not as varieties. India is the only country in the world to use Bt hybrids in such an extensive manner. It wouldn't have been a matter of concern if the extensive cultivation of hybrids in 95% area of the country would have catapulted India to the top rank in the world. Unfortunately that is not the case. Despite such a brilliant technology as Bt in the much touted high yielding hybrids and the best of all available technologies, India ranks 32nd in productivity out of the 80 cotton growing countries. This ranking leaves India behind at least 20 countries which do not have Bt cotton and behind 31 countries which cultivate only varieties and not hybrids. Hybrids are inherently designed to perform best under high input conditions. Many of the hybrids available in the India are of long duration and are not ideally suited for rain-fed tracts, which suffer from severe soil moisture deficit during the boll formation stage. Many hybrids are susceptible to many insect pests and diseases and need chemical inputs for effective protection, thus diminishing the advantage that Bt cotton gives by reduction of chemicals for bollworm control. The high cost of hybrid seed production also contributed to spurious seed in the market and concomitant poor quality of the fibre. The problems of yield stagnation and resurgence of insecticide usage over the past 6-7 years is primarily because of the insistence on hybrids for Bt and also because of the long list of hybrids which were approved for cultivation in rain-fed regions without ascertaining their suitability for rainfed soils that constitute 60% of Indian cotton area. However, it must also be stated that the yields in Vidarbha have also increased after Bt cotton was introduced, but the input costs increased as well. On a comparative note with other rain-fed regions of the world such as Brazil, the productivity of Vidarbha is five-fold less.

Field experiments conducted at CICR showed that goats were healthy even after feeding in Bt cotton fields continuously for three months. Such studies must be conducted by veterinary institutions under the aegis of the GEAC to reconfirm safety.

Other criticisms relate to the decrease in varieties available to farmers, which would have enabled them to use farm saved seeds. It is true that the strong Bt hybrid market has had a negative impact on the availability of varieties. CICR has taken up active initiatives to conserve and maintain seeds of the varieties that were released in India. The institute is also promoting varieties that can be cultivated by farmers for high yields with low inputs especially in rain-fed tracts where hybrids are not very suitable. The seed and chemical input costs have sky-rocketed over the past 3 to 4 years and rain-fed farmers face the heat of high production costs that do not commensurate with the market prices. There is thus an imminent need to develop technologies that can obtain hig h yields with low input costs in a sustainable manner. This can happen with varieties and certainly not with hybrids which cannot be sustainable for the entire cotton growing tracts of India.