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Risks and Potential Impact of Bt Cotton Cultivation in India

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GUEST COLUMN

Dr. Brijender Mohan Vithal
Cotton Expert

previous years was greatly reduced due to pest problems, production costs and environmental concerns. Bt cotton is a widely accepted tool for cotton producers and has proven to be efficient for the control of lepidopteron pests. So far, the management strategies used to prevent development of insect resistance to Bt cotton has been successful, though recently there are reports of Pink bollworm resistance development to Bt cotton.

Why Study the Impact of Bt Cotton Cultivation?

For more than 15 years, Bt cotton has been widely cultivated in almost all cotton growing states of India. Its cultivation has fulfilled all requirements and has gone through the different regulatory stages. During this period, both research institutions and biotech companies have generated scientific and technical information regarding Bt cotton cultivation in the country. In 2002, the official introduction of Bt cotton made it possible to reactivate this crop, which in

During October 2001, there was controversy over the publication of a paper by John Losey and colleagues at Cornell University in the journal 'Nature', in which laboratory studies suggested that Bt corn pollen harmed monarch butterfly larvae. This led to a situation, that as on date in the U.S., the U.S. Department of Agriculture (USDA) has been made responsible for conduct of field testing of all agricultural biotechnology crops. USDA evaluates whether a technology could pose any threat to plant or animal health. The U.S. Environmental Protection Agency (EPA) has regulatory authority for crops such as Bt cotton, which claims pesticide properties (i.e. pest-protected

plants). EPA regulates environmental exposure to these crops to ensure that there are no adverse effects to the environment, non-target insects and other organisms such as microbes, earthworms, nematodes, etc.

In the United States, the impact of Bt cottons to human health has been investigated and approved prior to their use by the U.S. Food and Drug Administration (FDA). FDA is making this review mandatory prior to use and is establishing guidelines for voluntary labeling. The Gene Technology Regulator, Australia, which coordinates assessments from the relevant health and environment authorities, also has robust regulatory requirements. Other countries and international groups are also expected to do similar reviews, prior to such approvals.

Efforts have thus been made to collect information, available in literature, on the impact of Bt cotton cultivation and has been presented below, for the benefit of our readers

Benefits of Bt Cotton

The introduction of Bt cotton has provided growers with a new tool for managing bollworms in cotton. Numerous benefits of this technology accrue to the grower, the global cotton industry and the society, on many levels such as, economic, environmental and social. These benefits include direct and indirect benefits. The important benefits of Bt cotton are given below in brief:

- The Bt cotton has in-built genetic resistance to bollworms and is very effective in controlling the yield losses caused by bollworms, to a considerable extent.
- Insects belonged to Lepidoptera (Bollworms) are sensitive to crystalline endo-toxic protein produced by Bt gene which in turn, protects cotton from bollworms.
- Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- It provides opportunities to grow cotton in areas of severe bollworm incidence.
- Better environment for parasites and predators which helps in controlling the

bollworms by feeding on larvae and eggs of bollworm.

- Bt cotton promotes eco-friendly cultivation of cotton and allows multiplication of beneficial insects i.e. parasites and predators of bollworms.
- Bt cotton also reduces environmental pollution and risk of health hazards associated with the use of insecticides, because insecticides are less used in Bt cotton.
- Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).
- Less health hazards as a result of rare use of insecticides (particularly those engaged in spraying of insecticides).

Limitations of Bt Cotton

Of course, though Bt cotton cultivation has many benefits, it also has certain limitations too, as given below:-

- High cost of Bt cotton seeds as compared to non Bt cotton seeds.
- Effectiveness upto 120 days, after that the toxin producing efficiency of the Bt gene reduces drastically.
- Ineffective against sucking pests like jassids, aphids, whitefly, etc.

Impact of Bt Cotton Cultivation On Soil Health:-

An assessment of the environmental fate of the introduced proteins has been conducted. Soil degradation of the protein (Cry 1 Ac) alone or in cotton tissue was studied under both, lab and field conditions. All available evidence shows that there has been no adverse or significant effect on soil health in terms of soil biology and ecology by growing Bt cotton. In general, the Cry proteins released in root and from plant residue of Bt cotton had no consistent, significant and long-term effect on the soil micro-flora.

On Agronomic Performance:-

- Agronomic performance of all new cotton

varieties is typically assessed through field observations to determine morphology, yield, lint quality, plant growth characteristics, and susceptibility to diseases and insects. These factors were all unaffected by the insertion of genetic material, except for the targeted differences in the proteins produced and the commensurate yield increase.

On Cross-Pollination:-

- Cotton is normally considered a self-pollinating crop, but can be cross-pollinated by certain insects. However, the possibility of cross pollination of the introduced genes from Bt cotton to other *Gossypium* species or to other plants of the same family is extremely low to nil because the Bt gene has been inserted in upland cotton (2n=52) which cannot outcross with cultivated or wild diploid cotton species (2n=26).
- It can also not outcross with tetraploid wild species such as *G.tomentosum* which are found either in cultivated areas or extremely isolated species gardens maintained at different research institutes.
- The upland cotton in which Bt gene has been inserted does not have cross compatibility with outer genera of the family of Malvaceae.

On Health of Humans, Animals, Poultry and Butterflies:-

- The feeding of Bt cotton seed to animal has not been reported to have any adverse effect.
- Bt cotton seed and its cake do not have any adverse effect on digestion of animals. Moreover, no allergic or toxic effect of use of Bt cotton seed and meal has been reported.
- The oil extracted from Bt cotton seed has not been found to have any adverse effect on human health.
- No adverse effect of Bt cotton has been reported on Broiler chickens so far.
- Bt cottonseed (22% in the diet) while fed to growing lamb indicated some differences in blood indices between treatments, but all values were within the normal range of reported variations, however Bt cottonseed

(18% in the diet) had no effect on growing lambs.

- Bt cottonseed (1500 g/animal/day) fed to sheep showed no adverse effect.
- The field study on the effect of Bt pollen on butterflies showed that in case of cotton, adult butterflies and moths may visit a cotton field for nectar, but they do not eat pollen and moreover nectar contains no protein.

On Various Tissues and Organs of Animals:-

Gastro Intestinal Tract (GIT) is an important entry system for foreign molecules in animals. Here is a report of research study on rats. The mice were fed with normal feed along with 50% mixture of crushed Bt cotton seeds. The tissue samples were taken from stomach, intestines, blood, liver, kidney, heart and brain. Report indicated that the targeted gene was found in intestinal tissues that affect the inner lining of intestine and also that the acidic medium of stomach degrade the foreign Bt DNA fragments.

On Lactating Animals:-

Several researchers investigated the effects of Bt genes on nutrient utilization, blood composition and other performance of dairy lactating animal that feeds on cotton seeds. It was revealed that

- Nutrient uptake, digestion process, milk yield, composition, body physiology and blood composition were not varied in control and non-control tested animals.
- The milk saturation content and milk quality were similar in both control and treated experimental cows and no adverse morpho-physiological effects were found.
- The milk and blood of ruminates, tissues of pigs and other poultry are free from any Bt gene after feeding on Bt seeds, as it shows safer food for all animals.
- No toxic effect of Bt toxins on digestion process of animals was found.
- Higher concentration of hemoglobin and other serum compositions were noted in

lactating buffalo feeding on transgenic cotton seeds carrying Cry1Ac gene.

- Blood urea, N and creatinine concentrations were also found similar in cows both controlled and experimental lactating cows groups after feeding on Bt cotton seeds for 430 days.

Thus it has been concluded that nutrient uptake, digestion process, milk yield, composition, body physiology and blood composition were not varied in control and non-control tested animals. Bt protein have no adverse effect on qualitative and quantitative characters of lactating cows.

On Farmers' Health:-

While substantial research on the productivity effects of Bt cotton has been carried out recently, the economic evaluation of positive and negative externalities has received much less attention. Here, the focus is on farmers' health impact resulting from Bt-related changes in chemical pesticide use. Previous studies have documented that in developing countries, Bt cotton has reduced the problem of pesticide poisoning, but they have failed to account for unobserved heterogeneity between technology adopters and non-adopters. Given below are the outcomes of survey data from India to estimate unbiased effects and their developments over time:-.

- Bt cotton reduced pesticide applications by 50%, with the largest reductions up to 70% occurring in the most toxic types of chemicals.
- Results confirm that Bt has notably reduced the incidence of acute pesticide poisoning among cotton growers.
- These effects have become more pronounced with increasing technology adoption rates.
- Bt cotton now helps to avoid several million cases of pesticide poisoning in India every year, which also entails sizeable health cost savings.

Based on the low levels of environmental exposure to the introduced proteins and the data generated in the environmental safety assessments, it has been observed that there

are neither any anticipated adverse effects on the environment nor have any been reported since the introduction of Bt cotton in 1996 in any country (in 2002 in India) wherever it is cultivated. Indeed, the most significant impact on the environment from the use of Bt cotton technology is the reduction in pesticides consumption and escape from their allied effects.

On Non-Target Lepidoptera Larvae:-

Cotton pollen is in the size range of 90-100 microns as that of corn pollen, but is spiny in nature and is never transported by wind as that of corn. Cotton pollen leaves flowers only when harvested for food by bees, and these are unaffected by Bt proteins. Non-target Lepidoptera larva are neither exposed to Bt proteins nor to Bt toxins. Any larvae that forages on the cotton is, by definition, a target pest.

On Non-Target Organism:-

Reports are available on studies conducted of toxic effects on the non-target organism. Protein (Cry1Ac) levels considerably above the maximum predicted environmental exposure, demonstrated that Bt protein has no adverse impacts on these and related non-target organisms. Additional field observation studies of impacts of Bt cotton on non-target organisms have shown increase in populations due to the reduction in non-specific pesticide use.

On Other Non-Target Animals:-

Several researchers have studied the effect of Bt cotton on non-target herbivores. Results showed that a minute amount (10 mg/g) of Bt protein was detected in Bt fed *A. Gossypii*. So, only small amount of Bt protein was ingested during feeding on Bt-cotton. Many researchers proved that Bt cotton is safe for other living organisms too.

On Scoured and Bleached Cotton:-

Scoured and bleached cotton, as it is used for medical and personal hygienic products as well as for chemical products, does not contain DNA or protein from a transgenic plant.

BT Toxins in Animal Excretion:-

The lethal concentration of Cry1Ab toxin from animal feces come to our environment

both directly and indirectly that affect target and non-target organisms. Certain animals like pigs and cattle that feed on Bt crops to excrete toxic proteins in their wastes by effecting targeted and non-targeted organisms. Foreign DNA fragments of Bt cotton were also found in the muscles of many types of chickens.

Other Impacts of Bt Cotton Cultivation

Other impacts of Bt cultivation are as follows:-

- Parawilt: Some genotypes struggle with high boll retention, water imbalance, punctatum blood of hirsutum, undesirable heterosis, etc.
- High expectations, less results from rainfed and less fertile soils.
- Susceptibility to sucking pests.
- The development of resistance in target pest populations such as Pink bollworm.
- Furthermore, populations of secondary pests, such as cotton aphids, cotton spider mites, thrips, lygus bugs, cotton whitefly, cotton leaf hopper and beet armyworm, increased in Bt cotton fields after the target pest (bollworm) had been controlled, some of which then replaced bollworm as primary pests (whitefly in North India) and damaged cotton growth.
- The possibility of outbreaks of certain pests in Bt cotton was deemed much higher, due to lower stabilities of insect community, pest sub-community and pest-natural enemy sub-community, as well as increased pest dominance, in Bt cotton fields than in conventional cotton fields.

Development of Resistance in Pink Bollworm

The efficacy of Bt crops is short-lived if pests evolve resistance to the Cry proteins produced from Bt. Due to commercial growing of Bt crops, the risk of evolution of resistance by pests, increases. It was observed that bollworms developed resistance more quickly on transgenic Bt cotton than with topical Bt sprays, possibly because the Bt spray contains several insecticidal

crystal proteins and insect exposure to the toxin is over in a short time. In contrast, transgenic Bt cotton contains one insecticidal crystal protein (Cry1Ac) and the toxin is expressed throughout the growing season. This is what has happened in India for Pink bollworm, though there may be many other reasons too for Pink boll worm to attain a stage of a serious pest.

Toxicity of Bt

While Bt is rarely associated with disease in humans, in actual fact Bt-toxins are potential allergens for human beings. Field workers exposed to Bt spray experienced allergic skin sensitisation and induction of IgE and IgG antibodies to the spray. This demonstrates that Bt is able to penetrate the human body and elicit an immune response.

In light of these findings, a team of scientists have cautioned against releasing Cry-containing plants and plant products for human use. These same scientists have also demonstrated that recombinant Cry1Ac protoxin from *Bacillus thuringiensis* is a potent systemic and mucosal immunogenic, as potent as cholera toxin.

A review of all safety information indicates that Bt cotton does not pose any different risk to human or animal health than conventional cotton. Each of the proteins introduced into Bt cotton commercialised to date has been shown not to require a tolerance level, by the U.S. Environmental Protection Agency (EPA). This means these proteins are considered safe for human or animal consumption. Tolerance set by the EPA establishes allowable, safe limits of pesticides in food (i.e. cottonseed oil) and feed (i.e. cottonseed, cottonseed meal, cottonseed hulls). Additional approvals for the use in food and feed of products derived from Bt cotton have been obtained following scientific review in Japan, Australia, Argentina, South Africa, Mexico, Canada and China.

(The views expressed in this column are of the author and not that of Cotton Association of India)



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• **Madhya Pradesh :** Khargone • **Karnataka :** Hubli • **Punjab :** Bathinda • **Telangana:** Adilabad

UPCOMING LOCATIONS

• Yavatmal (Maharashtra) • Adoni (Andhra Pradesh), Mahbubnagar (Telangana)



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UPCOUNTRY SPOT RATES (Rs./Qtl)												
Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]							Spot Rate (Upcountry) 2017-18 Crop November 2018					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Strength /GPT	12th	13th	14th	15th	16th	17th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0-7.0	15	-	-	-	-	-	-
2	P/H/R	ICS-201	Fine	Below 22mm	5.0-7.0	15	-	-	-	-	-	-
3	GUJ	ICS-102	Fine	22mm	4.0-6.0	20	10545 (37500)	10545 (37500)	10545 (37500)	10601 (37700)	10601 (37700)	10601 (37700)
4	KAR	ICS-103	Fine	23mm	4.0-5.5	21	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)	10686 (38000)
5	M/M	ICS-104	Fine	24mm	4.0-5.0	23	-	-	-	-	-	-
6	P/H/R	ICS-202	Fine	26mm	3.5-4.9	26	-	-	-	-	-	-
7	M/M/A	ICS-105	Fine	26mm	3.0-3.4	25	10967 (39000)	10967 (39000)	10967 (39000)	11051 (39300)	11051 (39300)	11051 (39300)
8	M/M/A	ICS-105	Fine	26mm	3.5-4.9	25	-	-	-	-	-	-
9	P/H/R	ICS-105	Fine	27mm	3.5-4.9	26	-	-	-	-	-	-
10	M/M/A	ICS-105	Fine	27mm	3.0-3.4	26	11389 (40500)	11389 (40500)	11389 (40500)	11389 (40500)	11389 (40500)	11389 (40500)
11	M/M/A	ICS-105	Fine	27mm	3.5-4.9	26	11726 (41700)	11726 (41700)	11726 (41700)	11726 (41700)	11726 (41700)	11726 (41700)
12	P/H/R	ICS-105	Fine	28mm	3.5-4.9	27	-	-	-	-	-	-
13	M/M/A	ICS-105	Fine	28mm	3.5-4.9	27	-	-	-	-	-	-
14	GUJ	ICS-105	Fine	28mm	3.5-4.9	27	12513 (44500)	12513 (44500)	12513 (44500)	12513 (44500)	12513 (44500)	12513 (44500)
15	M/M/A/K	ICS-105	Fine	29mm	3.5-4.9	28	12570 (44700)	12570 (44700)	12570 (44700)	12570 (44700)	12570 (44700)	12570 (44700)
16	GUJ	ICS-105	Fine	29mm	3.5-4.9	28	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)
17	M/M/A/K	ICS-105	Fine	30mm	3.5-4.9	29	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)	12710 (45200)
18	M/M/A/K/T/O	ICS-105	Fine	31mm	3.5-4.9	30	13076 (46500)	13076 (46500)	13076 (46500)	13076 (46500)	13076 (46500)	13076 (46500)
19	A/K/T/O	ICS-106	Fine	32mm	3.5-4.9	31	-	-	-	-	-	-
20	M(P)/K/T	ICS-107	Fine	34mm	3.0-3.8	33	-	-	-	-	-	-

(Note: Figures in bracket indicate prices in Rs./Candy)

UPCOUNTRY SPOT RATES							(Rs./Qtl)					
Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]							Spot Rate (Upcountry) 2018-19 Crop November 2018					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Strength /GPT	12th	13th	14th	15th	16th	17th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0-7.0	15	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)
2	P/H/R	ICS-201	Fine	Below 22mm	5.0-7.0	15	12176 (43300)	12176 (43300)	12176 (43300)	12176 (43300)	12176 (43300)	12176 (43300)
3	GUJ	ICS-102	Fine	22mm	4.0-6.0	20	-	-	-	-	-	-
4	KAR	ICS-103	Fine	23mm	4.0-5.5	21	-	-	-	-	-	-
5	M/M	ICS-104	Fine	24mm	4.0-5.0	23	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)
6	P/H/R	ICS-202	Fine	26mm	3.5-4.9	26	-	-	-	-	-	-
7	M/M/A	ICS-105	Fine	26mm	3.0-3.4	25	-	-	-	-	-	-
8	M/M/A	ICS-105	Fine	26mm	3.5-4.9	25	-	-	-	-	-	-
9	P/H/R	ICS-105	Fine	27mm	3.5-4.9	26	12317 (43800)	12373 (44000)	12373 (44000)	12457 (44300)	12485 (44400)	12457 (44300)
10	M/M/A	ICS-105	Fine	27mm	3.0-3.4	26	-	-	-	-	-	-
11	M/M/A	ICS-105	Fine	27mm	3.5-4.9	26	-	-	-	-	-	-
12	P/H/R	ICS-105	Fine	28mm	3.5-4.9	27	12401 (44100)	12457 (44300)	12457 (44300)	12541 (44600)	12570 (44700)	12541 (44600)
13	M/M/A	ICS-105	Fine	28mm	3.5-4.9	27	-	-	-	-	-	-
14	GUJ	ICS-105	Fine	28mm	3.5-4.9	27	-	-	-	-	-	-
15	M/M/A/K	ICS-105	Fine	29mm	3.5-4.9	28	12851 (45700)	12851 (45700)	12851 (45700)	12851 (45700)	12851 (45700)	12851 (45700)
16	GUJ	ICS-105	Fine	29mm	3.5-4.9	28	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)
17	M/M/A/K	ICS-105	Fine	30mm	3.5-4.9	29	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)	12935 (46000)
18	M/M/A/K/T/O	ICS-105	Fine	31mm	3.5-4.9	30	13132 (46700)	13132 (46700)	13188 (46900)	13216 (47000)	13216 (47000)	13216 (47000)
19	A/K/T/O	ICS-106	Fine	32mm	3.5-4.9	31	13273 (47200)	13273 (47200)	13273 (47200)	13301 (47300)	13301 (47300)	13301 (47300)
20	M(P)/K/T	ICS-107	Fine	34mm	3.0-3.8	33	16253 (57800)	16253 (57800)	16253 (57800)	16281 (57900)	16281 (57900)	16281 (57900)

(Note: Figures in bracket indicate prices in Rs./Candy)