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Bt cotton in India, pesticide use and environmental impact in India

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Abstract
Cotton is one of the principal commercial crops of the country. More than seventy countries in the world cultivate cotton. Cotton production is crucial as the whole spectrum of textile sector depends on it. Further, the export performance of textile sector is also depends on the quality of cotton produced. To put it straight cotton plays an important role in terms of generating direct and indirect employment as well as earning foreign exchange. Over the years, the production of cotton in India has been reduced due to the pest attack. The main pest is cotton bollworm. To control the pest incidence, the farmers have applied more than recommended levels of pesticides. This has escalated the cost of cultivation and many farmers fell in to the debt trap. This has led to suicides of cotton farmers in the states like Andhra Pradesh, Maharashtra, Karnataka and Orissa. In this context, it is advocated that Integrated Pest Management (IPM) is the best tool for minimizing the risk and problems in cotton cultivation. Further, inventions of cotton varieties that resist pest attach. One such technological breakthrough has been Bt cotton. The innovation in bio- technology in the form of Bt cotton controls the bollworms which has now occupied the centre stage.

Keywords: Cotton, Bt Cotton, Farmers

Introduction
In the year 2002, the first year of approval, three Bt-cotton hybrids, Mech 12, Mech 162 and Mech 184, were commercially planted on about 29,415 ha (72,685 acres) in six states - Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. In 2014, the adoption of Bt cotton in India increased by 600,000 hectares to a record 11.6 million hectares, equivalent to a high adoption rate of 95% of 12.25 million hectares total cotton area. In 2014, India planted the largest ever area of cotton – 105,000 ha more than the previous record cotton area of 12.1 million ha in 2011. Thus, in 2014, India achieved a near–optimal adoption rate of 95% at the national level, and this was distributed evenly among the ten cotton growing States. The number of Bt cotton farmers increased to 7.7 million in 2013-2014 from 7.3 million in 2012- 2013.

Bt cotton In India
Bt Cotton, is genetically engineered with Bt (Bacillus thuringiensis), a bio-toxin which comes from soil bacterium. Bt which was isolated from soil in 1911, has been available to farmers as an organic pesticide since 1930. The engineered Bt gene produces a protein that cuts into the guts of specific insects, rendering the cotton resistant to these insects. Biotechnology for control of bollworms is made available in the seed itself. Farmers have to just sow the Bt cotton seeds as they do with conventional seeds. The resulting plants have the in-built ability to produce Bt protein within their body and defend themselves from bollworms.

Adoption and Farmers Participation in Bt Cotton
The adoption of Bt cotton was increased from 50,000 hectares of Bt cotton in 2002, (when Bt cotton was first commercialized) to 11.6 million hectares in 2014 and the percentage of area under Bt cotton also increased from 1 per cent to 95 per cent in the same years. In the initial period only 0.05 million farmers cultivated Bt cotton and it has increased to 7.7 million in 2014. A cumulative 54 million small-holder cotton farmers planted Bt cotton in the thirteen-year period.

Table 1: Adoption of Bt Cotton in India

Year	Adoption of Bt cotton (Mha)	Total cotton area (Mha)	% Bt cotton area	Bt cotton farmers (Million)
2002-03	0.05	7.7	1	0.05
2003-04	0.1	7.6	1	0.08
2004-05	0.5	8.9	6	0.3
2005-06	1.3	8.9	15	1.0
2006-07	3.8	9.2	42	2.3
2007-08	6.2	9.4	66	3.8
2008-09	7.6	9.4	81	5.0
2009-10	8.4	10.3	81	5.6
2010-11	9.4	11.0	85	6.2
2011-12	10.6	12.2	88	7.0
2012-13	10.8	11.6	93	7.2
2013-14	11.6	12.25	95	7.7

Source: Choudhary & Kadambini, 2014

State-wise Cultivation of Bt Cotton in India

In the year 2002, the first year of approval, three *Bt*-cotton hybrids, Mech 12, Mech 162 and Mech 184, were commercially planted on about 29,415 ha (72,685 acres) in six states - Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. After that, it spread to all the other states.

Over the years, the area under Bt cotton cultivation has been on the increase (Table 2). In 2002, the area under cultivation was 50,000 hectares, and it has been reported that 9.4 million hectares were under Bt in 2010. The major states growing Bt cotton in 2014, listed in order of hectarage, were Maharashtra (3.9 million hectares) followed by Gujarat (2.5 million hectares), Andhra Pradesh and Telangana (2.3 million hectares, Northern Zone (1.4 million hectares), Madhya Pradesh (560 thousand hectares), and the balance of 835 thousand hectares in Karnataka, Tamil Nadu and other cotton growing States. It has been noted that in Madhya Pradesh, Tamil Nadu and others, the area under Bt cotton was decreased in 2014.

Table 2: State-wise Adoption of Bt Cotton in India from 2002-2014 (000'ha)

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Maharashtra	25	30	200	607	1840	2800	3130	3396	3710	3960	3995	3860	3950
Andhra Pradesh	8	10	75	280	830	1090	1320	1049	1650	1820	1935	2011	1175
Gujarat	10	36	122	150	470	908	1360	1682	1780	1930	2015	2130	2525
Madhya Pradesh	2	13	80	146	310	500	620	621	610	640	605	620	560
Northern Region	-	-	-	60	215	682	840	1243	1162	1340	1390	1365	1425
Karnataka	3	4	18	30	85	145	240	273	370	570	520	580	610
Tamil Nadu	2	7	5	27	45	70	90	109	110	220	220	194	110
Other	-	-	-	-	5	5	5	8	8	120	120	146	115
Total	50	100	500	1300	3800	6200	7605	8381	9400	10600	10800	10995	11570

Source: Choudhary & Kadambini, 2014 and Various Issues

Cotton and Pesticide

Much of the world's cotton yield increase during 1970's and 1980's was due to expansion of pesticide use, particularly insecticides. It pointed out that, without insecticides a significant share of yields, would be lost (Elbehri and MacDonald, 2003) [4]. A lack of standards for agricultural inputs (such as pesticides and fertilizer) could resulted in huge quality differences in products sold on local markets. At the same time, farmer's observation was not always a reliable measure of the infestation level. Additional factors that determine the level of pesticide use, for example pest resistance or beneficial organism populations, can only be assessed from the results of scientific testing. Such testing is time consuming and requires expertise and hence collaboration with natural scientists. Finally, an important component of the (farm-level) benefits and costs of the technology can originate from health and environmental effects. But even if respondents notice these effects, they generally have severe difficulties in attributing them to a certain practice or a change in behaviour, especially, if impact occurs or becomes obvious only in the long run.

Pesticide Consumption and Bt Cotton in India

Traditionally, cotton consumed more insecticides than any other crop in India. Bt cotton has made a substantial contribution to stop the cost of production by drastically reducing applications of insecticide sprays to control key cotton pests such as American bollworm, pink bollworm, spotted bollworm. Over the years, the market share for cotton insecticides as a percentage of total insecticides declined steeply from 46 per cent in 2001 to 26 per cent in 2006 and to 20 per cent in 2011.

Year	Total insecticides to control bollworms (Metric tons)	AGR
2002-03	4470	-
2003-04	6599	47.63
2004-05	6454	-2.20
2005-06	2923	-54.71
2006-07	1874	-35.89
2007-08	1201	-35.91
2008-09	652	-45.71
2009-10	500	-23.31
2010-11	249	-50.20
2011-12	222	-10.84

Source: Choudhary & Kadambini, 2014

The quantity of insecticides used to control bollworm reduced by 96 per cent from 5748 metric tons of active ingredients in 2001 to as low as 222 metric tons in 2011. Thus, insecticide use for the control of bollworm dropped significantly at the same time 95 per cent (see table1) of total cotton area in 2014 was benefiting from controlling bollworm with Bt cotton.

Environmental Impact

The beginning of use of pesticides in crop cultivation in general and cotton in particular has created such an amount of greater acceptance as it has created a revolution in control of pests and thereby increases in yield. Over a period, however, the pesticides have become synonymous with environmental hazards. In this context the GM crops, especially Bt cotton have been given a red-carpet welcome. At the same time, this also raised a new type of environmental issues. A few such issues, mostly clearing beneficial effects are presented here for a wider discussion and understanding. From the view point of Brookers and Barfoot (2005)[1] the most common way in which changes in pesticide use with GM crops has can be presented in terms of the volume (quantity) of pesticide applied. Although comparison of total pesticide volume used in GM and non-GM crop production systems can be a useful indicator of environmental impacts, it is an imperfect measure because it does not account for differences in the specific pest control programmes used in GM and non-GM cropping systems. For example, different specific products used in GM versus conventional crop systems, differences in the rate of pesticides used for efficacy, and differences in the environmental characteristics (mobility, persistence) are masked in general comparisons of total pesticide volumes used. The same authors made two observations, one in 2005 and another in 2010[2]. According to them, GM technology has contributed to increase the environmental benefit through reducing pesticide use. It has reduced 172 million kg less pesticide and 14 per cent reduction in the environmental footprint associated with pesticide use and it has also made a significant contribution to reducing the green house gas emission upto 10 billion kg, it has equal to removing five million cars from the roads for a year. Their another study revealed that, it could reduce the three quarter of the environmental gains in developing countries from GM IR cotton. The adoption of bio-tech crops would reduce the 352 million kg less pesticide used by the Bt growers. Since 1996, the bio-tech crops reduced up to 16.3 per cent of environmental impact associated with insecticide and herbicide use on the global area planted.

Bt plots were reduced by almost 70 per cent both in terms of commercial products and active ingredients. Most of these reductions occurred in highly hazardous chemicals, such as organophosphates, carbamates and synthetic pyrethroids (Qaim and Zilberman, 2003)[3]

In another framework Bt cotton has approximately reduced the occurrence of 95 per cent and 85 per cent for pink bollworm and cotton bollworm, respectively. With the commercialisation of Bt cotton, the infestation of both pink and cotton bollworm tends to decrease gradually. The decrease in application of pesticides in Bt cotton caused an increase in species and population density of natural enemies and enhanced the effects of natural control against some insect pests. For example, the increase of natural enemies such as ladybugs, chrysopa and spiders effectively controlled the development of populations in cotton aphids during the boo-setting stage (Wu Kong Ming, 2007)[4.]

Herbicide tolerance as a trait should not be allowed in India or in developing countries for important economic and health reasons. In these countries weeding is a source of many benefits to the rural community. A weed is only point that is growing at the wrong place at that time. It is not useless plant. Weeding provides wage labor to agricultural labor, which are usually the landless farmers. In addition, weeding was mainly done by women, it provides income to landless labourers as well as the rural people consume all the plants that were collected as weeds as fodder for the livestock that is maintained by the family as an additional source of income, Sahai, (2003)[5]

In India, results of Bt adoption were different. Introduction of insect resistance had a significant impact on yields, with increases of 40–80% as farmers in India did not have good pest control available to them. Reduction in pesticide use for bollworm control was also substantial but less than in China. Like Chinese farmers, Indian farmers increased their net incomes despite higher seed prices. Indian seed and biotech firms had more ways to appropriate benefit from the technology embodied in the seed than did Chinese companies. Indian farmers typically use hybrid seed and, until 2006, the Indian government only permitted one company to supply a Bt gene. However, farmers in India captured two-thirds of the social surplus generated by Bt cotton adoption even in the early years before price controls were mandated. Perhaps this chapter's most important contribution is new evidence presented on recent changes in benefits from Bt cotton adoption. In China, CCAP economists have found that pesticide use for bollworm in Bt cotton has continued to decline up to 2007 when their last study was conducted. This is consistent with findings by entomologists that the bollworm population in all crops has declined because of Bt cotton. This suggests positive externalities for other crops such as maize and vegetables that had been sprayed extensively for bollworm but now have less damage and require fewer sprays. As yet, no outbreaks of Bt-resistant bollworms have been reported in China. CCAP economists have also found that in some villages a minor pest, mirids, has become an increasing problem since Bt cotton was introduced, seemingly due to the decline in broad spectrum pesticides 108. previously used to control bollworms. The benefits from reducing pesticide sprays for bollworm outweigh costs of increased spraying for mirids. Chinese farmers rather than biotech or seed companies continue to be Bt cotton's main beneficiary as seed prices remain low because IPR enforcement is still weak and most seed used is varietal, not hybrid. Indian farmers now obtain a greater share of benefits from Bt cotton. State government policies increased farmer benefit at the expense of the seed and biotechnology industry. In both India and China, Bt cotton has spread to all areas where bollworm is a major pest, in India about 90% of the cotton area and in China about 70–80%. The area under Bt cotton

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is likely to remain the same until new superior traits are introduced. Thus, the development and commercialization of new GM crops is the most likely avenue for increased benefit from crop biotechnology in the near future. Ramachandra (2002)[6], mentioned that Bt toxin does not effect on the pests like Thrips, Jassids and Aphids. Prasad (2008)[7] in his report pointed out that, the bio-safety studies on grazing on Bt cotton crop by sheep were lacking and that no serious studies have been done to ensure the safety of Bt cotton in animals. Further, sheep death might be due to high content of nitrares/ nitrites. and not that of Bt toxin (Prasad, 2008) [6]

Conclusion

From the study, it was found that since 2002, the adoption of Bt cotton in India and other states has been increasing. In cotton, the major problem was cotton bollworm, in order to control the pest; the farmers were spraying more amounts of pesticides. Prior to introduction of Bt cotton in the economy, a steep decline in percentages of pesticides applied in cotton particularly on cotton bollworm and now it was effectively controlled by the Bt cotton

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