Development and Adoption of Bt Cotton in India : Economic, Environmental and Health Issues

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Abstract

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. No extra efforts or equipment are needed to utilize this technology. But after the introduction of Bt cotton it brought into focus a variety of issues like economic, environmental and health and it has a controversy against to adopt it. Hence, the present study focused on the above issues.

Keywords : Bt Cotton, Environment, Health, Economic

Introduction

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[1].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. No extra efforts or equipment are needed to utilize this technology.

Bt cotton in India : Issues in Adoption

India is one among the 16 countries where commercial plantation of Bt cotton happens. It has the largest cotton production area in the world but yield levels are generally low because of low productivity and lack of availability of water, as only about one third of the total cotton area cultivated in irrigated and the remaining mostly produced under rain-fed conditions. Dry land agriculture in India covers 67 per cent of the net cultivated area and currently accounts for more than 60 per cent of food grains, 80 per cent of oil seeds, 90 per cent of green legumes and 70 per cent of cotton and even 50 per cent of paddy grown under rain-fed conditions[2]. Because of this, nearly 60 per cent of farmers prefer to leave agriculture if alternative was available due to the policy regime of agriculture[3]. An additional reason for low productivity was the limited supply of seeds and poor management practices. Due to declining production, the farmers have to spray more to control the pest problem, and as a result, the cost of production increased in addition to environmental and human health impacts. In India, out of Rs 2800 crores spent for pesticide consumption, about Rs 1600 crores (57%) were spent on cotton alone, and within this Rs 1100

[1] Kumbamu Ashok (2006), "Ecological Modernization and the " Gene Revolution": The Case Study of Bt Cotton in India", Capitalism Nature Socialism, 17 (4), December

[2] Rao Chandrasekhara N and Mahendra Dev S (2008), "Biotechnology in Indian Agriculture: Evidence from Panel Studies on Bt Cotton", paper presented at the Golden Jubilee Seminar of Institute of Economic Growth, Delhi on Future of Indian Agriculture: Technology and Institutions during 23-24 September.

[3] Rao., V.M., (2009) " Rain-fed Agriculture: in the Throes of a Crisis, The Indian Economic Journal, 57 (2), July – Sep, pp. 38-62

crores (68%) were spent only to control the bollworms.[4] In India about 166 species of insect pest were identified in the cotton field at different stages of its growth[5]. In China 31 insect species were found at Bt fields among that 23 were beneficial.[6] It has been mentioned that cotton cultivation was reduced by almost 75 per cent in the last few years of decade of 1990s due to pest attack and water scarcity[7].

Under Indian conditions, bollworm had a high critical capacity that is not well controlled in conventional cotton. On average, pest damage was about 60 per cent on the conventional trial plots in 2001. On the other hand, in United States and China, approximately, losses in conventional cotton due to insect pests accounted for only 12 per cent and 15 per cent respectively. Because, it was observed that higher pesticide application and lower pest pressure in United States and more favourable soil and climatic conditions in China. More than that, in China, pesticides have been subsidized but in India, in contrast, farmers were often indebted and credit constrained and do not have access to chemical pesticides at the right time (Qaim and Zilberman,2003)[8]. Under the situation described above came the Bt cotton into India in 2002.

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[4] Narayanamoorthy, A and Kalamkar S S (2006) " Is Bt Cotton Cultivation Economically Viable for Indian Farmers ? An Empirical Analysis, Economic and Political Weekly, 51 (26) June 30, pp. 2716-2724.

[5] Gandhi P Vasant and Nanboodiri (2006), "The Adoption and Economics of Bt Cotton in India : Preliminary Results from a Study", Paper presented at the IAAE 2006 Syiposia: The First Decade of Adoption of Biotech Crops –A World Wide View, at the Conference of the International Association of Agriculture Economics (IAAE), Gold Coast, Australia, August 12-18,2006

[6] Lalitha N and Iyengar Sudharshan (2002), " Bt Cotton in India : Controversy Visited", Indian Journal of Agricultural Economics, 57 (3), July – Sept, pp. 459-466

[7] Shah, E (2005), 'Local and Global Elite Join Hands: Development and Diffusion of Genetically Modified Bt Cotton Technology in Gujarat', Economic and Political Weekly,50(43), Oct 22, pp. 4629-4639.

[8] Qaim. Matin, and Zilberman, David (2003), " Yield Effects of Genetically Modified Crops in Developing Countries", Science, 299, Februray 7, pp-900-902.

Bt Cotton: Issues in Cultivation

Like any bio-technology, the introduction of Bt cotton also brought into focus a variety of issues. For the convenience of understanding these issues were brought under four categories :

i. Economic Issues
ii. Marketing of Bt cotton and Price
iii. Environmental Issues
iv. Health Issues

Economic Issues

The major economic issues concerning Bt cotton were a) Cost of cultivation b) Yield c) Price (Marketing) and d) Profit.

Bt cotton has been developed to provide resistance to certain cotton bollworms. Thus this resistance results in less use of pesticide in order to control insect pests of cotton. Bollworms are major pests in India and cotton growers have to buy huge amounts of pesticides to control cotton bollworms. From a macro perspective each additional hectare provides 82 per cent of aggregate income to Bt farmers. More female labour was required for cotton harvesting rather than the male labour required for spraying. All types of farm households, including those who were living below poverty line benefited more than conventional cotton (Qaim,2009)[9].

Secondly it has been reported that, Bt cotton increased 88 per cent in profitability, increased 31 per cent in yield gains and a significant 39 per cent of reduction of insecticide usage. And it contributed to alleviate of poverty for over 6 million small resource-poor farmers in 2010(Nair, Kadambini 2011).

Huesing and English (2004) [10] pointed out that Bt cotton increased. The net profit for Bt cotton farmers by 78 per cent over that of conventional farmers. In United States, the commercialisation of Bt cotton resulted in efficacy and lower chemical-related cost in particular to labour and increased yield. And it has decreased the use of nearly 862 metric tons of insecticides per year while increasing cotton yields by 83,916 metric tons. This was because the use of Bt

[9] Qaim, Matin (2009), " The Economics of Genetically Modified Crops", Annual Review of Resource Economics, 1, pp-665-694

[10] Huesing Joseph and Leigh English (2004) "The Impact of Bt Crops on the Developing World, AgBioForum, 7 (1&2), pp. 84-95.

cotton would reduce or save 2-5 applications of pesticides per year than the conventional variety and also it reduced the labour by 8-20 hours per hectare (Ismael et al 2001)[11]

Substantial gains have also arisen in the cotton sector through combination of higher yield and lower costs. In 2004, cotton farm income levels in the GM adopting countries increased by 1.62 US billion (Brooker and Barfoot,2005)[12]

Rao and Dev (2008)[13] pointed out that replacement of chemicals would reduce the employment opportunities for women in weeding. At the same time, Subramanian and Qaim (2009)[14] pointed out that female labourers earned more income than males because cotton requires more female labour for harvesting and due to reducing pesticide usage, the male labours were reemployed in non-agricultural activities. It also noted that census survey data confirm that per-acre labour cost for permanent workers is higher in Bt (Rs 436) than in conventional cotton (Rs 154). Bt farmers spent more money on picking because Bt cotton had higher yield than non-Bt cotton; about 50 per cent more return than non-Bt cotton (Mal, Puran et al 2010)[15].

Yatnalli (2012)[16] covered seven taluks of the Haveri district (Hirekerur, Ranebennur, Byadgi, Hanagal, Savanur and Shiggaon) in Karnataka in which, Bt cotton and non-Bt cotton cultivation is carried on an extensive scale. The data was collected from 315 cotton growers who were selected at random of

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[11] Ismael, Yousouf., Richard Bennett and Steven, Morse (2001), " Biotechnology in Africa : The Adoption and Economic Impacts of Bt Cotton in the Makhathini Flats of South Africa, paper presented at AfricaBio Conference: Biotechnology Conference for Sub-Saharan Africa during 26th and 27th September.

[12]Brooker, Graham and Peter Barfoot (2005), "GM Crops: The Global Economic and Environmental Impact- The First Nine Years 1996-2004", AgBioForum, 8(2&3), pp. 187-196.

[13] Rao Chandrasekhara N and Mahendra Dev S (2008), "Biotechnology in Indian Agriculture: Evidence from Panel Studies on Bt Cotton", paper presented at the Golden Jubilee Seminar of Institute of Economic Growth, Delhi on Future of Indian Agriculture: Technology and Institutions during 23-24 September.

[14] Qaim, M., Subramanian ,A (2009). "Village-Wide Effects of Agricultural Biotechnolgy : The Case of Bt Cotton in India, World Development, 37(1), pp. 256-267

[15] Puran, Mal., Krishna Kakumanu Reddy., Manjunatha, A and Siegfried Bauer (2010) " Economic Profitability and Adoption of Bt Cotton and non-Bt Cotton in North India" paper presented at International Research on Food Security, Natural Resource Management and Rural Development at ETH Zurich, Tropetag, September 14-16.

[16] Yatnalli,C.S.(2012) Analysis of Cost And Profitability of Bt & Non Bt Cotton - A Case Study of Haveri District (Karnataka) Asian Journal of Research in Social Science & Humanities, Volume 2, (1), January, pp. 80-95.

different sizes and the selected farmers are duly categorised under marginal, small and large farmers. The analysis showed that the share of Bt cotton has been increased from 14.72 per cent to 413.31 per cent in Haveri district. The results showed that as prices of cotton in regulated markets of Karnataka increased, the arrival decreased and vice-versa. It also revealed that the gain with Bt was only in the case of insecticide cost among the inputs. It is also concluded that the method of cultivation is financially feasible in all size group of farmers in study area.

A summary of results of seven cross country studies (Argentina, Australia, China, India, Mexico, South Africa and United States) by Qaim (2003.2005.2006 and 2009) Fitt (2003), Pray (2002), Traxler (2003) and Carpenter (2002) revealed the potential of Bt cotton over the convention cotton, in terms of insecticide reduction, increase in yield and increase in gross margin. The range of pesticide reduction varied from 33 per cent to 77 per cent and increase effective yield from 9 per cent to 37 per cent. However, Sahai (2003)[17], pointed out that economics of Bt cotton was not favourable to farmers. The seed cost was about four times more expensive than the good local hybrids. Certainly, 60 per cent of the farmers cultivating Bt cotton were not even able to recover their investment and incurred losses averaging Rs 79 per acre. The sample was randomly selected two districts by Kouser and Qaim (2012)[18]. The sample consisted of 352 cotton farmers (248 are Bt adopters and 104 are non-adopters). It was found that positive health and environmental externalities. They concluded that Bt cotton adoption results in significantly lower chemical pesticide use, higher yields, and higher gross margins, which was consistent with the results from other countries. In addition, lower pesticide use brings about significant health advantages in terms of reduced incidence of acute pesticide poisoning, and environmental advantages in terms of higher farmland biodiversity and lower soil and groundwater contamination. These positive externalities are valued at US$ 79 per acre, which adds another 39% to the

[17] Sahai, Suman (2003), “Genetically Modified Crops in India- Some Issues”, Gene Campaign, pp-6-7

[18] Kouser, Shahzad and Matin, Qaim (2012) “ Valuing financial, health, and environmental benefits of Bt cotton in Pakistan” Discussion Papers No. 105Department of Agricultural Economics and Rural Development, Georg-August-University of Goettingen, 37073 Goettingen, Germany, January

benefits in terms of higher gross margins. Adding up financial and external benefits results in total benefits of US$ 283 per acre, or US$ 1.7 billion for the entire Bt cotton area in Pakistan.

Another study by Balakrishna (2012)[19] , carried out a study in Warangal and Guntur districts of the Andhra Pradesh during December 2007-January 2008. Multi-stage stratified random sampling method was used to select the 408 respondents from among the farm households. The study revealed that the productivity difference between Bt and Non Bt cotton farmers was largely attributable to Bt technology. The results of the estimated production functions reveal that seeds and fertilizer is the most important input to which output is highly responsive in both Bt and non-Bt cotton crop situations. On the other hand, it was observed that elasticity coefficient of output with respective to pesticides was higher in Non Bt cotton cultivation as compared to Bt cotton cultivation. The output elasticity of pesticide is higher in non Bt cotton cultivation than that of in Bt cotton cultivation. An increase in expenditure on pesticides resulted in increased output in non Bt cotton cultivation when compared to Bt cotton cultivation. Further, the plant protection chemicals and other inputs were used optimally by Bt cotton farmers as against excessive use by non Bt cotton farmers. Therefore, it is necessary to motivate the farmers for cultivation of Bt cotton with appropriate extension strategies and policy measures. The elasticity coefficient with respect to human labour is positive and significant in both Bt cotton and non-Bt cotton crop situations. The output elasticity of human labour is higher in Bt cotton cultivation when compared to non- Bt cotton crop situation. The results of the decomposition revealed that the net impact of Bt technology alone is estimated to have increased the output by 10.88 %. That is with some level of use of seeds, fertilizers, pesticides and human labour, the farmers have obtained 10.88 % more output per acre by using Bt cotton seeds when compared to those who have used non-Bt cotton seeds. Changes in the use of all other inputs put together have been increased output by about 15.65 %. The adoption of Bt technology enabled the farmers to save inputs significantly. And the value of extra output produced per acre with adoption of Bt technology is

[19] Balakrishna. A (2012) “Economics of Bt cotton in India” Journal of Development and Agricultural Economics, 4(5), 12 March, pp. 119-124

Rs.4,455/- per acre which is higher when compared to non- Bt cotton cultivation. It is a clear evident that by adopting Bt technology cotton farmers are benefited significantly. Therefore, Bt cotton needs to be expanded among all cotton growers to harvest the benefits in terms of higher yield and income.

Maharana et al (2011)[20] , made a comparative study of genetically modified Bt cotton and non Bt cotton with respect to the demographic and socio-economic conditions of farmers in two blocks from Warangal district in Andhra Pradesh. A total of 112 samples were selected containing a mixture of small & big cotton growers in the villages. Results showed that Bt cotton cultivation had a significant positive impact on average yields and on the economic performance of cotton growers rather than non-Bt cotton growers. In case of utilizing pesticides about three forth of the non Bt cotton farmers were going for high doses (78.15%) of pesticides as compared to Bt cotton farmers (42.5%). The comparative analysis of Bt & non Bt cotton growers with respect to modern management practices like ploughing by tractors, sprinklers irrigation, use of power sprayers etc. clearly revealed that the non Bt cotton growers were following more number of modern practices as compared to Bt cotton growers.

Developing countries grew close to 50% (49.8%) of global biotech crops in 2011 and for the first time are expected to exceed industrial countries hectare in 2012; this is contrary to the prediction of critics who, prior to the commercialization of the technology in 1996, prematurely declared that biotech crops were only for industrial countries and would never be accepted and adopted by developing countries. In 2011, the growth rate for biotech crops was twice as fast and twice as large in developing countries, at 11% or 8.2 million hectares, versus 5% or 3.8 million hectares in industrial countries. During the period 1996-2010 cumulative economic benefits were the same for developing and developed countries (US$39 billion). For 2010 alone, economic benefits for developing countries were higher at US$7.7 billion compared with US$6.3 billion for developed countries (James 2011)[21] .

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[20] Lalitha, Maharana., P.P. Dash and Krishnakumar K.N. (2011) “A comparative assessment of BT and non-BT cotton cultivation on farmers livelihood in Andhra Pradesh”, Journal of Biosciences Research 2(2), pp. 99-111

The economic performance of Bt cotton in the Punjab province of Pakistan studied by Bakhsh Khuda (2011)[22] .Panel data for a period of two cropping seasons, 2008 and 2009 from three districts of the province were used in the analysis. The Punjab province is the largest producer of cotton crop in the country. This study is different from other studies conducted in Pakistan by collecting data on two cropping seasons. It accounts for year-to-year variability in yield and helps to understand the change in input use and output while controlling many factors, such as farm and farmer related characteristics. Results of the study have proved that Bt cotton brings huge benefits to farmers in the form of pesticide reduction, considerably higher yield and substantially higher monetary returns. Moreover, yield of both types of cotton has decreased from the cropping season 2008 to the cropping season 2009. But the decline in cotton yield is relatively higher on non-Bt plots, showing that Bt cotton performs well even when conditions are not suitable to cotton production. However, pesticide use against sucking pests has increased on Bt plots in the cropping season, 2009. It alarms that secondary pests can be a serious problem in future cotton production. Future research and development needs to focus on the issue of secondary pests of Bt cotton seed in the country. Econometric analysis show that Bt cotton contributes significantly in cotton yield, however, statistically insignificant pesticide hints that cotton growers were not able to apply pesticide efficiently due to lack of awareness, financial constraints and timely availability of pesticide products. Similarly, gross margin analysis confirms that Bt cotton seed substantially contributes in earnings of farmers growing cotton crop. The reason for higher returns is that the farmers growing Bt cotton are able to apply less pesticide use, resulting in low cost and healthy cotton crop. The wide spreading of technology demands for formalization of Bt cotton in the country, so farmers may be able to get true benefits of the technology, since it will create a incentive based environment for research and development in private and

[21] James. C (2011) " Global Status of Commercialised Biotech / GM Crops: 2010", International Service for the Acquisition of Agri-Biotech Application (ISAAA) Brief 42, Ithaca, New York

[22] Bakhsh., Khuda (2011), "Productivity of Bt Cotton And Its Impacts on Pesticide Use and Farm Returns: Evidence From Pakistani Punjab" Paper presented at the EAAE 2011 Congress Change and Uncertainty Challenges for Agriculture, Food and Natural Resources August 30 to September 2, ETH Zurich, Zurich, Switzerland

public sector organizations. Currently cotton growers are facing the problems of non-availability of quality Bt cotton seed in the market. unapproved Bt varieties with different names are available in the market creating mess for farmers during the selection of appropriate varieties.

Marketing of Bt cotton and Price

Yet another issue is the price of Bt cotton. Cotton is a commercial crop. Bhaduri[23] stated, "in general, the guiding mechanism underlying commercialisation may be market –incentive, and gains from trade in some situation. This is the normal process of commercialisation which may stand in sharp contact to an involuntary or forced process of commercialisation that is guided, say, by the compulsions of indebtedness of the peasant". It has been brought out, especially at the time of introduction, that the price offered to Bt cotton will be higher than that of non-Bt cotton. Further, it has been expected that the mill sector will prefer Bt cotton and procure it through contract farming and or through their agents.

Baffes[24] made an observation that cotton reforms are to be made to benefit the farmers by way of getting premium prices. Otherwise the seed companies and textile sector will get more benefits than the resource poor small farmers.

In this context, it is opt to point out the macro level scene in India. The policy of Central government on cotton export or import influences the price behaviour in the market. The lobby of textile mills used to oppose the cotton exports since they are worried about the shortage of inputs. However, the farmers used to question and protest against the ban of cotton exports because this reduces the getting a fair price for their produce.

Environmental Issues

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

[23] Bhaduri, Amit (1985), " Class Relations and Commercilisation in Indian Agriculture : A Study in the Post- Independent Agrarian Reforms of Uttar Pradesh" in Raj,K.N et al (Ed) Essays in the Commercilisation of Indian Agriculture, OUP, New Delhi, p.307

[24] Baffes, John (2005), " Cotton : Market Setting, Trade Policies and Issues" in Ataman Aksoy and John C. Beghin (Ed), Global Agricultural Trade and Developing Countries, World Bank, Washington, pp. 259-273

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)[25] 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[26]. 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

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[25] Brookes, Graham and Peter Barfoot (2005), "GM Crops: The Global Economic and Environmental Impact- The First Nine Years 1996-2004", AgBioForum, 8(2&3), pp. 187-196

[26] Brooker, Graham and Peter Barfoot (2010), " Global Impact of Biotech Crops : Environmental Effects,1996-2008", AgBioForum, 13(1), pp.76-94

hazardous chemicals, such as organophosphates, carbamates and synthetic pyrethroids (Qaim and Zilberman,2003)[27]

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)[28].

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)[29]

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

[27] Qaim. Matin, and Zilberman, David (2003), " Yield Effects of Genetically Modified Crops in Developing Countries", Science, 299, Februray 7, pp-900-902

[28] Wu Kong Ming (2007), Environmental Impact and Risk Management Strategies of Bt Cotton Commercilisation in China, Journal of Agricultual Biotechnology, 15(1), pp.1-4

[29] Sahai, Suman (2003), Genetically Modified Crops in India- Some Issues", Gene Campaign,pp-11-12

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 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.

Health Issues

A major argument against introduction of GM crops has been raised on the health front- human, animal (livestock) and plants. For example Vandana Shiva[30] pointed out that the issue of health and animal welfare are intrinsically

[30] Shiva, Vandana (1998), Bio piracy : The Plunder of Nature and Knowledge, South End Press, Boston, p.33

related to the ecological impact of the new technologies on the capacity of self-regulation and healing. The issue of intrinsic worth is intimately related to the issue of self-organisation, which is also, in turn, related to healing.

Many scientists and social science researchers premise their argument that on evidence on effects of transgenic foods caused allergic reactions has been currently available, instead transgenic foods have been judged as safe to eat (Pehu and Ragasa,2008)[31]. Apart from these, this technology contributes to increase the value addition like higher amino acids in Soybean, Vitamin A rich rice often called Golden Rice, protein rich potato etc to increase the quality of the produce (Rao and Mahendra,2008)[32]

GM crops, particularly Bt crops, are also associated with health benefits. As a result of less insecticide uses, the farmer's health was not affected. Because compared to developed countries, the farmers spray pesticides manually as they were less educated and don't have knowledge about the negative side of the effects (Qaim, 2009)[33]. In China, the farmers do not use any protective methods during spraying. The farmers used hand-pumps or had a small engine in the backpack sprayers. Hence, it is important for improving farmer's health in the reduction of pesticide use (Huang et, 2002)[34]. In South Africa, since introduction of Bt cotton in 1997, it noted that, Bt cotton reduced the cotton poisoning due to reduction of pesticides particularly hazardous insecticides such as Rogor and Endosulfon (Elbehri and MacDonald, 2003)[35]

Due to pesticide poisoning, nearly three million people were poisoned and 200,000 died every year. The largest number of deaths particularly in developing countries, was noted in Sri Lanka,(around 1500 individuals a year died from pesticide poisoning during the period 1986-1996). It included

[31] Pehu, Eija and Ragasa, Catherine (2008), " Agricultural Biotechonolgy : Transgenic in Agriculture and their Implications for Developing Countries", World Development Report.

[32] Rao Chandrasekhara N and Mahendra Dev S (2008), "Biotechnology in Indian Agriculture: Evidence from Panel Studies on Bt Cotton", paper presented at the Golden Jubilee Seminar of Institute of Economic Growth, Delhi on Future of Indian Agriculture: Technology and Institutions during 23-24 September.

[33] Qaim, Matin (2009), " The Economics of Genetically Modified Crops", Annual Review of Resource Economics, 1, pp-665-694

[34] Huang, Jikun., Ruifa, Hu., Cuihui, Fan., Pray, Carl. F, and Scott, Rozelle (2002), " Bt Cotton Benefits,Costs and Impacts in China, AgBioForum, 5(4), pp-153-166

[35] Elbehri, Aziz and MacDonald, Steve (2003), " Transgenic Cotton and Crop Productivity : A General Equilibrium Analysis for West and Central Africa", Paper presented at 6th International Conference on Global Economics Analysis, The Hague, Netherlands, 12-14, June

occupational poisoning and self ingestion. In Less Developed Countries (LDCs), the farmers had inadequate protective gear, there is no regulations that requires the use of protective gear during the use of pesticides, no storage facility, inadequate education and finally it had limited access for medical treatment (Wilson and Tisdell, 2001)[36].

Controversy over Bt Cotton

Iyengar and Lalitha (2002)[37], raised certain questions about Bt cotton:

a. Is there scope for saving the seeds or exchanging seeds with fellow farmers?
b. Are the transgenic varieties similar to the terminator genes?
c. Will the transgenic seeds lead to mono-cropping?
d. Will the pests develop resistance to Bt toxin?
e. What would be the impact on humans, environment and bio-diversity of the soil?

They also pointed out that, the countries like US had taken more than ten years for conducting field trials for commercialisation. But Indian government had taken bold step for introduction of transgenic crops. The field trial data were unreliable because, the trials were conducted in off-season, when the pest attack was low. Hence, scientists and the state have to give satisfactory answers to the above questions, then only it will help to popularise Bt cotton in India.

The impact of biotechnology solutions was subject to a considerable degree of uncertainty due to natural fluctuations in the biotic and abiotic environment (climate, pest pressure and availability of water) so that a data set with information from only one or a few years was insufficient for general impact conclusions (Diemuth E. Pemsl 2005)[38].

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[36] Wilson, Clevo and Tisdell, Clem (2001), " Why farmers Continue to Use Pesticides Despite Environmental, Health and Sustainability Costs", Ecological Economics, 39, pp.449-462

[37] Iyengar Sudarshan and Lalitha N (2002), " Bt Cotton in India : Controversy Visited", Indian Journal of Agricultural Economics, 57 (3), July – Sept, pp. 459-466.

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Sahai, (2003)[39], was against the introduction of Bt cotton. According to him, Bt cotton was not controling the pink bollworm. The toxin in Bt cotton was proving ineffective against pink bollworm and does not kill it. He pointed out that, incidence of pink bollworm was on a rise and the pest attack was getting stronger every year. Bt cotton farmers would have to continue to spray to control pink bollworm. The pink bollworm attack was found to be severe after 60-70 days. Pink bollworm was not disposed to the Bt endotoxin. Another important point was, the recommendation of GEAC to cultivate 20 per cent of refuge cotton was not viable to farmers, particularly for small farmers as the refuge area was nonviable.

Conclusion

Bt cotton was introduced in 2002 onwards. During the initial period there was an issues and controversy against to adopt Bt cotton. From the review it was found that Bt-cotton was helped to minimize chemical sprays and contributing to cleaner environment and conservation of biological and biodiversity. Bt-cotton offers protection from bollworms right from the early days of the crop, leading to a healthy crop, better boll retention, greater harvest and more profit. Above all, it was found that Bt-cotton offers protection only against bollworms, not sucking pests and other nonlepidopteran pests. Though the announcements and advertisements by the State and companies clearly claim that only the bollworms are controlled in Bt cotton, the popular (farmers) perception was twofold and diagnostically opposite:

i. Number of pest attacks are possible in Bt cotton
ii. Even Bt cotton requires lot of pesticide sprays

Therefore, separate control measures have to be taken against such pests as and when required. It is always necessary to understand clearly the scope of a particular technology for its proper utilization.

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