



DEBATES AROUND GM TECHNOLOGY: CHALLENGES AND OPPORTUNITIES OF GENETICALLY MODIFIED CROPS IN INDIA

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ABSTRACT

Agriculture is the backbone of Indian economy by contributing 18% to the GDP and almost 50% of the Indian population depends on agriculture. Green revolution and development of genetically modified crops have boosted the agriculture production in India. The modified crop offers more productivity by controlling crop failures due to pest attack and ensures food security. Application of Genetic Engineering extends to the development of crop which resolves the issue of malnutrition. But the new crop faced many hurdles in India due to resistance development in targeted pest, lack of need analysis, improper management, and implementation strategies, lack of transparency and conflict of interests in decision making. The entire agriculture system has to come up with an alternative method to retain sustainability in agriculture production. Integration of other modes of pest control along with the new technology is crucial. This paper looks into the experience of Bt. Cotton and other initiatives to reduce chemical consumption in cotton cultivation.

KEY WORDS: GM crops, Socio-economic, Agriculture, Biotechnology, Biofuel.

INTRODUCTION

The social context of a technology is very crucial in its diffusion and adoption. Any technology cannot stand isolated from its social premises as it is embedded in the social context. If the innovation happens in agriculture, the social context is very important as agriculture plays a social and economic role to satisfy the world population by providing food, feed, fiber, fuels, employment, and economic income. There are two major technological enhancement happened in agriculture. Green revolution in the 1970s had given a remarkable contribution to food security by introducing high yielding varieties and another revolution by developing GM (Genetically Modified) crops with the tools of Genetic Engineering (GE). In the 2000s, India entered into the path of the revolution with GM crops by commercializing Bt. Cotton. The main objective of biotechnology-based revolution is food security by reducing the use of chemical agents in controlling biotic stress.

These revolutions introduced a new system of farming. The highlight of the new farming system is the use of chemicals, fertilisers, and irrigation for excess production. Due to the structural shifts towards commercialization in agriculture, the new technology-based agriculture became a center of concerns and could not achieve the promised benefits. There are many possible ways to make use of science and technology wisely to overcome the crisis. Context-specific guidelines for the cultivation of GM crop, integration of other modes of pest control which are already in use, post cultivation monitoring, dissemination of proper information regarding the technology and its use are very important for the successful adoption of a technology. But these important measures are lacking in

the Indian context and the introduction of it has led to a polarized debate in India.

Emergence of GM crops as a sustainable solution

India attained self-sufficiency with increased production of wheat and rice in the 1980s through the green revolution. Dwarf varieties of rice and wheat developed and these were fertilizer responsive, high yielding and resistant to lodging and disease¹. But along with the great success, implications of chemical and water intensive crops have been visible since the 1990s through losing soil fertility, depletion of water sources and declining of agro-diversity. The share of agriculture and allied sectors in the GDP declined from 51.45% in 1950–51 to 13.68% in 2012–13 (GOI, 2015) and the share of agriculture in total workers declined from 75.9% in 1961 to 56.4% in 2004-05 (Dey, 2011). Even though the contribution from agriculture has gone down, the major population still depends on agriculture activities.

The new seed which was widely used during the green revolution yields higher than the traditionally or locally improved varieties but more prone to pest attack. A huge amount of pesticide was required to control insects. After the first reaping, the yield began to decrease. The practice of crop rotation gave way for continuous cultivation and use of fertilisers resulted in soil degradation. Pest became more resistant on the crop so that farmers increased the number of pesticide spray. The share of agriculture and allied sectors in the GDP declined from 51.45% in 1950–51 to 13.68% in 2012–13 (GOI, 2015) and the share of agriculture in total workers declined from 75.9% in 1961

¹The information retrieved from www.sciencelog.net/Agriculture > environment. Accessed on 7/4/2016.

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However, scientific and technological advancement promised to have another revolution with GM crops which has an inserted biological sequence of soil bacterium *Bacillus thuringiensis* (Bt) to control the major pest. Although GM traits encompass several categories (pest and disease resistance, abiotic stress tolerance, yield), herbicide tolerance and insect resistance dominate in the market. In India, Monsanto Mahyco Biotech Limited (MABL) developed Bt. Cotton which resists Pink Boll Worm and Genetic Engineering Approval Committee (GEAC) had given the green signal for commercial release in 2002. Bt. Cotton is the only GM crop which is commercially cultivated in India.

Though India holds the third position in cotton production, Indian cotton faced constraints in the global markets due to the contamination. An average of 7.3 sprays had to be applied per year (Scoones, 2005). Almost 160 species of insects and pests have identified. Among this American Bollworm and Lepidoptera pests are the main insects which cause severe damage to Cotton. So that cotton cultivation requires a great number of pesticide sprays and 55% of the pesticides sold in the country are used on cotton (Gandhi and Jain, 2016). Bt. Cotton emerged as a solution for the severe crisis in cotton cultivation and it embraced by the farmers in Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Punjab, and Rajasthan.

Challenges on GM crops in India

Cotton production escalated with the cultivation of Bt. Cotton in India. The area of Bt. Cotton cultivation expanded to 96% of 11.2 hectares of the cotton cultivated area (ISAAA, 2016). Farmers have extended the cultivation to both irrigated and semi-irrigated area. A large amount of cotton cultivation and production has increased production of cotton as well as cotton seed oil. the cotton oil production has increased from 0.46 million tons in 2002-2003 to 1.50 million tons in 2016-2017 (ISAAA, 2016). Cotton oil is widely used in Gujarat for cooking.

Along with the great success of Bt. Cotton, challenges, and criticisms on inadequacies of the technology in Indian context have been raised. While Bt. cotton was approved in 2002, the initial adoption was slow, only 5.6% of the cotton cultivated area was planted with Bt cotton in 2004-2005. There was an increase in the area of cultivation and yield after 2006 and from 2008 to 2012 yields began to decline, despite a progressive increase in the cultivation area². There is a drop in area planted by 0.8 million hectares, from 11.6 million hectares in 2015 to 10.8 million hectares in 2016 and cultivation of non-Bt. and hybrid cotton has gone up from 9.66 lh to 17.38 lh in 2016 (Damodaran, 2016). It was estimated that around 7.2 million farmers planted IR cotton in 2016, slightly less than 7.7 million in 2015 (ISAAA, 2016). In the study of Krishna and Qaim (2012) revealed that the majority of the farmers expressed concerns over the increasing secondary

pests' pressure in 2008 than in 2006. As technology very new to Indian scientists, the outcome of Bt. Cotton is very crucial for the other crops which are on the pipeline for the clearance. But still, Bt remains as a leading cotton seed variety which has been cultivated across India.

The resistance of pink bollworm was seen after one-year cultivation of Bt. Cotton (Sahai, 2003). The yield was already rising sharply in the pre-Bt cotton era due to non-Bt hybrid seed³. There were very few incidents of bollworm attack in Cotton were reported since 1982 (Kranti, 2015). Fertiliser and pesticide usage was the same in both Bt and non-Bt cotton cultivation. The first phase of Bt. Cotton was successful. It could reduce insecticide usage from 11,000 MT before Bt. Cotton to 4,600 MT in 2006. Now, Bt. Cotton farmers in Gujarat, Punjab, and Maharashtra are under the threat of secondary pest as well as the Pink Boll worm itself. Damage ranged between 11.0 to 67.0 % in Amreli on BGII. Farmers are forced to rely on heavy use of insecticides once again in cotton to control insects. The fate of Bt. Cotton is similar to hybrids in the green revolution. Now, the trend of insecticide usage is higher than pre-Bt. Cotton era and it reached 11,598 MT⁴. The damage was more than expected especially on the green bolls for second and subsequent pickings. High yielding varieties of crops like Bt. cotton need more water along with fertilizers⁵. The cultivation of it in drought-prone regions like Vidharbha and Warangal is an added risk. A study in Vidarbha region by the Council of Social Development (CSD) reports that 65% of the farmers stated that irrigation expenditure was more on Bt. cotton than on non-Bt cotton (Haque et al; 2014)

The main reason for increased pest attack is that farmers extend the crop up to April- May in irrigated lands. Pink Bollworm is a winter pest and extending the crop beyond the prescribed time creates suitable conditions for their survival. The farmers are advised by CICR scientists to cultivate Short duration single-pick varieties (150 days) provide high yields in high density to escape the pink bollworm attack (Kranti, 2015). But, the farmers try to get maximum remuneration from cotton cultivation as they invest huge amount on Bt. Cotton. Since Bt. Cotton seed price was four times higher than non-bt, cost of cultivation is higher in Bt. Cotton in 2003 (Sahai, 2003). After 2006 expenditure on insecticides increased by 2.3 fold from Rs.1240/ha in 2006 to Rs. 2799/- per hectare in 2013.

Indian biosafety regulations have strictly mentioned on the cultivation of refuge⁶ cotton plants along with Bt. Cotton to delay the resistance development. But farmers cultivated Bt. Cotton as an urgent need for crop loss. So they do not have any left out space for non-Bt. Cotton as refugees (Freeman, 2012). In India, the majority of the farmers are small-scale so they never cultivate refuge plant to delay/prevent to develop resistance (Purukayastha and Rath, 2010). Instead of cultivating refuge plants, farmers

³ The data retrieved from www.indiagminfo.org.

⁴ The data retrieved from www.indiagminfo.org.

⁵ The information retrieved from <http://www.thehindu.com/nes/national/study-questions-sustainability-of-bt-cotton-in-waters-tarved-vidharbha/article3563411.ece>. accessed on 10/03/2018.

² The information retrieved from <http://www.cotcorp.gov.in/statistics.aspx#area>. Accessed on 10/3/2018

cultivate Daal and Chillis and other crops as intercrops where space is left out for refugee plant (Freeman, 2012). Bt. Cotton cultivation is more suitable with a country like the US, where the farmers own hundreds of hectares of lands and there spacing for refugee is possible. Contextualization of technology is one of the major social factors which has to be considered by regulatory bodies while implementing the policies for commercial release of a technology.

The effectiveness, contextualized implementation, and sustainability of the GM crop is a challenge in front of the government, farmers and society at a large. At the initial phases of the cultivation of insecticide-resistant GM crops gave maximum profits. When insects became resistant to biotic stress tolerant crops, farmers had to invest more in control measures. Even though there are many concerns over GM crops on biosafety, socio-economic impacts, biodiversity, monopoly of the company, sustainability, contamination and health implications, India can make use of the technology by extending to agriculture extension programs by providing training on safety measures, integration of other pest management mechanisms, extension of research to other crops which are more vulnerable. Many civil society organizations have taken up the initiative of agriculture extension work program which provides training to get maximum profit from less investment. Better Cotton Initiative is an example for such an initiative which ensures economic benefit as well as a better health condition.

Better Cotton Initiative and Other Possible Ways for GM Technology in India

Better Cotton Initiative (BCI) is a global initiative as a solution for the huge amount of chemical consumption in cotton cultivation. There were unusual outbreaks of pink bollworm in the largest cotton growing state of Maharashtra and the yield losses were estimated at 10%-30%⁶. So, BCI looks economic, environmental and social sustainable solution for pesticides in the context of crop failure due to pink boll worm in cotton. The BCI program aims to reduce input cost as they promote to integrate the existing methods of pest control such as integrated pest management and motivate farmers to adopt environment-friendly methods of pest control⁷. It also ensures better health and environment by reducing the chemical consumption. BCI is used in both Bt. and non-Bt cotton cultivation. Farmers have the freedom to choose seed varieties. BCI could achieve its aim by reducing 30 – 40% reduction in the use of chemicals (fertilizer and chemical pesticide) and 40% reduction in water consumption due to the adoption of improved water management practices⁸. BCI could record the net profit range of Rs.10112 – 44305 per ha in both Maharashtra and Gujarat.

Bt. Cotton cultivation requires proper monitoring system as well as extension works at the post-market release of the technology. The technology needs to be integrated

with the existing system and dissemination of technical knowledge is also very important. Dissemination of information on precautionary measures and detailed descriptions on its dosage is very crucial. But unfortunately, it is lacking in the Indian scenario. India can make use of GM technology for abiotic stress tolerance also rather than merely focusing on the biotic stress tolerant crop. Abiotic stress like drought, salinity in water and waterlogging are becoming a serious hindrance in agriculture production. The recombinant DNA technology is the best to introduce characters related to drought, floods, coastal storms, and other non-biotic stresses⁹. Drought is severely affecting grain production and quality, and the situation is becoming more serious with increasing global climate change (Bakhsh and Hussain, 2015).

According to Swaminathan (2017)¹⁰, GM technology can be used where needs cannot meet through other available techniques and methods. In India, many institutions are doing researches on drought and saline tolerant organic rice. Scientists from Kerala Agriculture University have developed organic rice which is saline prone, flood-prone and suitable for water scare environment. This rice variety is suitable in the coastal region of northern Kerala where heavy southwest monsoon results in flood and flushing of saline water (Chandramohan and Mohan, 2012; Vanaja, et.al., 2015). So the use of GM technology on food crops may be controversial as there is an alternative technique to address the issue. There are wide opportunities for bio-fuel production in the scenario of higher fuel price and GM technology may be a better alternative for oil production from vulnerable lands. India may become the third largest oil consumer by 2030. Bio-fuel production can potentially play a major role in this regard and can make use of the technology to develop nonedible oil crops as an alternative way for excess fossil fuel consumption.

CONCLUSION

The new technology-based agriculture became the center of criticisms and debates in India. Implications on biodiversity and gene contamination are widely debated; biosafety issues and challenges over small-scale farmers and farmers right over seed are still hurdles over GM technology. Contextualization of technology and proper implementation strategies are lacking. Dissemination of information on safety measures, guidelines for the usage of chemicals and the integration of existing mode pest controls needs to be followed after the market release of the technology. The need of the genetically modified technology is widely contested in Indian contexts where many alternative sustainable methods have been practiced. Fertiliser, insecticide and water usage has increased after the cultivation of Bt. Cotton and it intensified the risk at the drought-prone areas. India can make use of the vast

⁶ The information retrieved from https://bettercotton.org/wp-content/uploads/2018/05/Q1_2018-Report.pdf. Accessed on 29/10/2018

⁷ This information retrieved from <http://www.afpro.org/blog/2014/03/18/792/>. Accessed on 29/10/2018

⁸ Ibid.

⁹ The information retrieved from <http://www.mssrf.org/content/policy-relating-genetically-modified-crop-varieties-prof-m-s-swaminathan>. accessed on 13/3/2018

¹⁰ www.thehindu.com/opinion/interview/why-can-t-the-government-provide-a-higher-income-for-farmers/article

opportunities of the technology on fuel crops. Many types of research on fuel crop like *Jatropha* are going on. But it remains still at the laboratory level. Bio fuel crops are unlikely to face human safety concerns as it does not enter the food supply chain. But environmental concerns, sustainability, and coexistence with other crops have to be addressed.

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