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An Analysis of the Environmental Impact of Bt-Cotton in India

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Abstract – **Pesticides and insecticides are the major problem for Indian agriculture. These are used to increase the productivity of land but it directly affects the environment and human health. Conventionally, cotton consumed more insecticides than any other crop equivalent to 46% of the total insecticide market for all crops in India. Bt-cotton technology has emerged as an advantageous alternative to traditional cotton varieties by inhibiting bollworm attack, thereby improving farm production and income. Basically this is an informative paper the objective of which is to analyse the impact of Bt-cotton on pesticides and insecticides through critical analysis of pesticides and insecticides and its market value. In conclusion, we offer recommendations and policy prescriptions for improving private and public research and development and commercialisation processes to further the potential contributions of biotech crops to maintain the environment through agriculture sustainability.**

Keywords – **Biotech Crops, Bt-Cotton, Environment, Insecticide, Pesticides.**

I. INTRODUCTION

A global warming, growing population and loss of biodiversity have a remarkable impact on our environment. Population of this planet will reach 9.5 billion by 2050. It means that in less than 50 years, world population is expected to increase by 3 billion. Feeding of these people will mean huge changes in the agriculture production, distribution, and stability of food products (James 2014). However, with increasing world population, a decelerating of the rate of crop improvement through conventional breeding and a decreasing area of land available for food production there is a necessity for new technologies to produce more food of improved nutritional value in a sustainable manner and an environmentally acceptable way (R.H. Phipps and J.R. Park, 2002). Modern biotechnology offer immense benefits in terms of increased productivity of land, better quality of food and resistance to biotic and a biotic factors. The biotech crops can minimize crop harm through disease and pest-resistant varieties, decrease use of chemicals and enhance stress tolerance in crops, thereby allowing economically productive farming on hitherto unproductive lands. Biotech crops are subject to debate that whether it is beneficial to sustainability of environment or not. In the developed world, there is a clear sign that the use of biotech crops has resulted in important benefits. These benefits are increased crop yields, decline in farm costs, increased farm profit and Improvement in health and the environment (James, 2013).In modern biotechnology, the desirable genes are transferred from one plant to another plant that is called genetic engineering. From the comprehensive global meta-analysis of 147 published biotech crop studies it have been confirmed that biotech crops have generated a number of benefits since 1995, it includes reduction in the use of chemical pesticide by 37%, increased crop yields by 22%, and increased farmer profits by 68% (Qaim, 2014).Cotton is a significant cash crop in India and in many parts of the sub-tropical world. Cotton and its value added products are major export earners for India's national income. It provides the significant raw material to Indian textile industry (Puran Mal, 2011). The Indian cotton industry provides employment to more than 45 million people, contributing 20% to the Gross National Product and 30% to the total agricultural exports. India annual exports of cotton yarn, thread, fabrics, and apparel earn to the tune of US$10-12 billion as foreign exchange. It accounts for more than 75% of the total fiber that is converted into yarn by spinning mills in India and 58% of the total textile fabric materials produced in the country (Subbiah & Jeyakumar, 2009). In 2002-2003, both the cotton cultivated area and production decreased because of high insect infestation in general and bollworms in particular. But after the adoption of Bt-cotton in 2002-03, area of cultivation and production increased and the use of pesticides and insecticides declined (Singh, 2009). Conventionally cotton consumed more insecticides and pesticides spray than other crops.Basically this is an informative paper, the objective of which is to analyse the impact of Bt-cotton on pesticides and insecticides through critical analysis of their usage.

1.1. *Literature Review of Bt-Cotton and Non Bt-Cotton*

The adoption of Bt cotton to the Indian market has reduced the dependency on agro-chemicals for crop protection, thereby rapidly changing the cotton scenario in India. Numerous studies have been done before and after the commercialisation of Bt cotton reporting that non Bt cotton is less profitable than Bt cotton. Naik (2001) reported that 78.8% profit increase due to better yields and 14.7% decrease in pesticide costs through the use of Bt cotton in India. Qaim and Zilberman (2003) and Barwale et al., (2004) found that Bt cotton generates 80-87% higher yield than non-Bt cotton, due to the availability of the Bt gene, which is able to controlling the bollworm species in different growing areas of cotton. Other studies show that farmers who have adopted Bt-cotton have substantial pesticide savings and higher effective yields in different developing countries (Bennett et al., 2004;Nazli et al., 2012; Qaim & de Janvry, 2005; Pray et al., 2005; Thirtle et al.,2003). Bt cotton has been shown to reduce pesticide use by67% and increased yields by an average of 21.3% in Burkina faso (Vitale et al., 2011). For the consumer perspectives, Bt cotton provides inexpensive foods with fewer pesticide use and pathogen loads (Huesing &

English, 2004; Keetch et al 2005; Laibuni et al.,2012).Qaim et al., (2006); Gandhi and Namboodiri (2006); and Subramanian and Qaim, (2009) indicate that Bt cotton farmers get advantages from higher yields and decline pesticide expenditures in comparison with non-Bt cotton farmers. But other studied criticized on the basis of highest cost production of Bt cotton (Sahai & Rahman, 2003) and in this respect, private firms have fabricated the performance of Bt cotton in decreasing pesticide use and increasing yields (Venkateshwarlu, 2002). Research Foundation for Science, Technology, and Ecology, 2002 reported that new pests and diseases have been found in Bt cotton varieties, and Bt gene failed to provide protection from the bollworm. Shiva and Jafri (2004) observed that Bt cotton is inappropriate for developing countries, causing negative impacts on the small farmers. Further, Qayum and Sakkhari (2005) concluded that Bt cotton is not favourable forrain-fed areas and smallholder farmers, reporting nearly 30% less yield than non-Bt cotton. In spite of these concerns, it has been increasingly reported that the area under cultivation with Bt cotton is progressively increasing and farmers adopt this technology to increase yield and reduce pest damage. In view of this controversy, this study follows a systematic approach in order to offer useful information to policymakers.

II. Global Status of Biotech Crops

The area planted to GM crops increase from 1.7 million hectares in 1996 to 181.5 million hectares in 2014, with a rising proportion developed by developing countries. In 2014, twenty eight countries are cultivating the biotech crops in which 20 countries are developing and eight countries are developed. Twenty countries are growing 50,000 hectares or more and other eight countries are cultivating remaining area. Twenty developing countries and 8 industrial countries in order of area are: USA, Brazil, Argentina, India, Canada, China, Paraguay, South Africa, Pakistan, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Myanmar, Spain, Mexico, Colombia, Sudan, Chile, Honduras, Portugal, Cuba, Czech Republic, Costa Rica, Romania, Slovakia and Bangladesh (James, 2014).

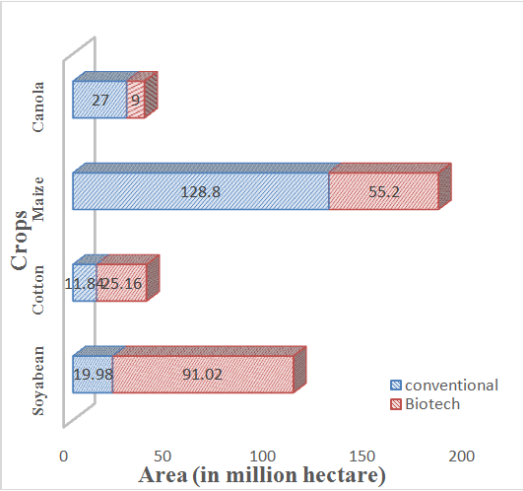

Fig. 1. Biotech Crops With Area Of Cultivation
Source: Clive James, 2014

Figure 1, compares the four principle biotech crops with conventional crops like soybean, maize, cotton and canola. In 2014, 82% (91.02 million hectares) of the 111 million hectares of the soybean planted globally were biotech. In 2014, global cotton area was 37 million hectare of which biotech cotton was planted to 25.1 million hectares, which is 68% of global cotton. 184 million hectares of global maize planted in 2014, of which was biotech maize 30% or 55.2 million. Finally, herbicide tolerant biotech canola was planted in 9 million hectares or 25% of the 36 million hectares of canola are grown globally in 2014. If the global areas of these four crops are combined, the total area is 368 million hectares, of which 181.5 million hectares or 49% were biotech. These adoption figures should be viewed as a sign of adoption, not as exact estimates of global adoption for the four crops. In this paper, we discuss the Bt cotton crop in the respect of India and analyse the impact of Bt-cotton on insecticides and pesticides on environment.

III. Indian Scenario

After the commercialization of Bt cotton in India, the cyclic infestation of bollworm has been suppressed. India adopted its first commercial biotech crop in 2002 which is termed as bt cotton. Remarkably, the increased the area from 50,000 hectares of Bt cotton in 2002 to 11.6 million hectares in 2014 represents an extraordinary 230-fold increase in thirteen years (Chaudhary B. and Gaur, K. 2015). Over the succeeding eight years, 2007-2014, India continued the growth of cotton mainly due to the introduction and fast adoption of dual gene Bt cotton technology coupled with supply of better quality seeds by private sector and determined efforts by around 8 million cotton farmers in the country. In 2014, India accomplished a historic milestone by producing more cotton than China and became the number one cotton producing country in the World. First time in the history of agriculture, India deposed China to get the crown of the white gold (USDA, 2014; Reuters, 2014).

IV. BT-Cotton and Environment

The environmental impacts have been associated with the growth of food production. They may be grouped into followings: loss of crop, erosion, loss of soil fertility, depletion of nutrient reserves, salinization and alkalinisation, pollution of soil, loss of fertile field lands to urban development, pest resurgence and genetic resistance to pesticides,destruction of natural control mechanisms and chemical contamination (Hosam, 2010). The need is to achieve sustainable agriculture that can get higher yield and increase income without affecting the environment. If the advantages of pesticides include improved economic potential in terms of increased production of food and fibre, then their disadvantage have resulted in serious health implications to human health and environment. (Wasim Aktar, 2009).The negative consequences on human health, wild life, biodiversity andwater quality associated with the release of huge quantities of toxic

products into the environment increasingly has become a matter of anxiety (Harper and Zilberman, 1989; Agne et al., 1995). Biotech crops that acquire Cry genes from Bacillus thuringiens is (Bt) were commercialized in many countries and extensively adopted by small farmers over the last 19 years. Many studies showed that Bt crops provide resistance to some lepidopteran and coleopteran insect pest species, have helped decrease chemical pesticide use and increase productivity of yield (Qaim and de Janvry, 2005; Huang et al., 2005; Wossink and Denaux, 2006;Morse et al., 2006; Krishna and Qaim, 2007; Subramanian and Qaim, 2009; Carpenter, 2010). Conventionally, cotton consumed more insecticides than any other crop in India and it was a significant amount of the total pesticide market for all crops (Chaudhary B. and Gaur, K., 2010). The largest Bt cotton areas are found in India, where the technology is mainly used to control the spotted bollworm (Eariasvittella), the American bollworm (Helicoverpaarmigera) and to a lesser extent, pink bollworm (Pectinophoragossypiella), and related species (Qaim, 2009). In India, the cotton sector is heavily dominated by smallholder farmers with land areas of less than five hectare, who benefit from Bt technology adoption in terms of higher incomes and health hazards associated with pesticide use (Huang et al., 2002; Hossain et al., 2004; Qaim et al., 2009; Kouser and Qaim, 2011). Bt cotton contributes to a broader rural development and poverty reduction (Subramanian and Qaim, 2010; Ali and Abdulai, 2010). Basically Bt cotton helps to maintain the environment sustainability and also maintain the health of farmers through reduction of pesticide and insecticides spray.

V. Impact On Insecticides And Pesticides

After the adoption of Bt cotton in 2002, there was continued decline in the use of insecticides and pesticides, these are threat to the sustainability of environment and human health. In last thirteen years, Indian farmer enjoyed the increasing the production of bt-cotton, in addition bt cotton has made an important contribution in declining the cost of production by drastically reducing applications of insecticide sprays to control key cotton pests such as American bollworm, pink bollworm, spotted bollworm and Spodoptera. Through Bt cotton farmers are able to decrease the insecticide sprays in a season from more than two dozen sprays to 2-3 sprays. Conventionally, cotton consumed more insecticides than any other crop equivalent to 46% of the total insecticide market for all crops in India (Kranthi, 2012). Year by year, the market share for cotton insecticides as a percentage of total insecticides continued to decline steeply from 46% in 2001, to 26% in 2006 and to 20% in 2011. There has been a very steep decline in insecticide usages particularly on Helicoverpaarmigera from 71% in 2001 to 3% in 2011. "Between" 2001 to 2011, at the macro-level the percentage of cotton insecticides to the total pesticides market in India registered a steep decline of 33% to 11% at a time when total pesticides market in the country increased meaningfully during the same period (CIBRC, 2012).

Table-1 Value of the Total Pesticide Market in India in 2001 and 2010 Relative to the Value of the Cotton Insecticide Market

ITEM/YEAR	2001	2006	2010
Total pesticide market (in million US$)	US$713 million	US$748 million	US$1,707 million
Cotton insecticides as % of total pesticide market	33%	17%	11%
Total insecticide market (in million US$)	US$504 million	US$404 million	US$952 million
Cotton insecticides as % of total insecticide market	46%	26%	21%
Value in US$ millions of cotton bollworm market & (savings due to Bt cotton) in 2004 over 2010	US$160 million (in 2004)	-	US$25 million (Savings of US$135 million, or 85%, compared with 2004)

Source: Kranthi, 2012; CIBRC, 2012; Chemical Industry, 2012; Compiled by ISAAA, 2014

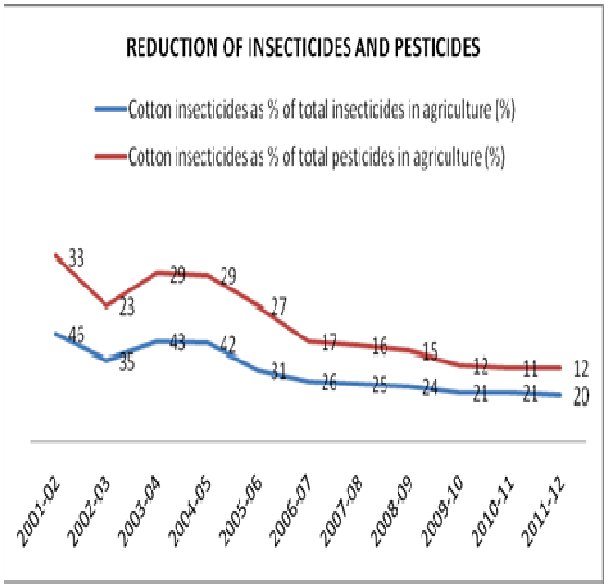

Fig. 2. Percentage Reduction of Insecticides on Cotton Relative to Total Insecticides/Pesticides Used in Agriculture in India, 2001-2011

Source: Kranthi, 2012; CIBRC, 2012; Compiled by ISAAA, 2014

This saving in insecticides on cotton between 2004 and 2014 coincided with the large scale adoption of Bt cotton from half million hectares in 2002 to 11.6 million hectares in 2014-15, equivalent to 95% of the total cotton crop in 2014-15. Table 1 and figure 2 shows that the total pesticide market in India in 2001 valued at US$713

million in which 33% was for cotton insecticides only, which were equal to 46% of the total insecticide market for all crops in India (Kranthi, 2012). Subsequent to the introduction of Bt cotton, in 2006 cotton consumed only 18% of the total pesticide market, valued at US$900 million as compared to a much higher 30% in 1998. Similarly, the market share for cotton insecticides as a percentage of total insecticides declined from 46% in 2001, to 26% in 2006 and to 20% in 2011. The percentage of cotton insecticides to the total insecticides used in agriculture in India decreased to 20% in 2011 from 46% in 2001, after the introduction of Bt cotton in India in 2002. At the macro-level, the percentage of cotton insecticides to the total pesticides market in India registered a sharp decline from 33% in 2001 to 11% in 2011 at the time when total pesticides market in the country more than doubled from US$713 million in 2001 to more than US$1,707 million in 2011.

VI. Conclusion

The development of Biotech crops has focused predominantly on enhancing conventional pest control approaches. Scientific valuations show that these biotech crops generally deliver significant economic and some environmental benefits over their conventional crop alternatives. Prospects to promote biotech crops that deliver multi-faceted advantage for the environment and to the poor are basis for a sustainable food system and should not be ignored because they represent global public goods. In India, after the adoption of Bt-cotton, cotton production increased from 13.6 million bales in 2002-03 to 39 million bales in 2013-14, area increased from 50 hectare to 11.6 million hectares and percentage of cotton insecticides to the total insecticides used in agriculture in India decreased from 20% in 2011 from 46% in 2001, which was a record for the cotton crop in India. Benefits of Bt-cotton in term of market value as well as quantity of insecticides and pesticides showthe scope of other biotech crops in India. In this paper, we develop an idea that can guide the development of biotech crops in line with the theory and practice of modern sustainable agriculture. We offer recommendations and policy prescriptions for improving private and public research and development, and commercialization processes to further the potential contributions of biotech crops to maintain the environment through agricultural sustainability.

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