An Overview of Genetically Modified Crops

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Abstract
This study presents the findings of research into the global socio-economic and environmental impact of biotech crops in the fourteen years since they were first commercially planted on a significant area. It focuses on the farm level economic effects, the production effects, the environmental impact resulting from changes in the use of insecticides and herbicides, and the contribution towards reducing greenhouse gas (GHG) emissions.
Keywords: Genetically Modified Crop, Socoi-Economic, Environmental

1.1 INTRODUCTION

The potential of transgenic crops to make major contributions to food security and agricultural sustainability worldwide is indisputable. World population increased fourfold during the last century, with current estimates placing it at 9.2 billion by 2050. We are now facing a situation where food demand is beginning to outstrip supply. This situation is compounded by the fact that we may be at the limit of the existing genetic resources available in our major crops (Gressel, 2008). Thus, new genetic resources must be found and only new technologies will enable cultivation of GM crops which help to increase the yield of crops. One such route is through the use of recombinant DNA technology to produce transgenic crop expressing desirable agronomic traits such as enhanced resistance to insect pests and herbicide tolerance. Those crops were first commercialized in the mid of 1990s. By 2007, approximately 12 million farmers in 23 countries (12 developing and 11 industrialized countries) grew biotech (GM) crops. In addition to this, 29 countries having granted regulatory approvals since 1996. In 2007, the global market value of GM crops was an estimated US$6.9 billion, representing 16% of the global crop protection market and 20% of the global seed market. The biotech crop market comprised US$3.2, US$2.6, US$0.9 and US$ 0.2 billion for maize, soybean, cotton and canola respectively. These four crops accounted 47%, 37%, 13% and 3% of global biotech crop market accordingly. Of the total biotech crop market, industrial countries accounts 76% (US$5.2 billion) and developing countries accounting 24% (US$1.6 billion).

In India, the chronology of Bt cotton started in the year 1995 when the Department of Biotechnology (DBT), Government of India, permitted import of 100 grams of transgenic Cocker-312 variety of cottonseed cultivated in the United States by Monsanto. This variety contained the Cry1 AC gene from the bacterium *Bacillus thuringiensis*. Since then several developments have taken place in the country and finally in March 2002, the Genetic Engineering Approval Committee (GEAC) under the Department of Biotechnology, Ministry of Environment, Government of India, accorded permission for the first GM crop -cotton- to a joint-venture of Mahyco– Monsanto for its three hybrids, viz., MECH-12, MECH- 162 and MECH-184 for commercial cultivation. Thus, Bt cotton appeared to be the first transgenic crop put into commercial cultivation in India. About 44,500 ha area was planted by 54,000 farmers with Bt-cotton during 2002, which has increased to 34.61 lakh ha, accounting for 37.90 per cent of the total area under cotton (James, 2008)

Agricultural production systems (how farmers use different and new technologies and husbandry practices) are dynamic and vary with time. This analysis seeks to address this issue, wherever possible, by comparing biotech production systems with the most likely conventional alternative, if biotechnology had not been available. This is of particular relevance to the case of GM herbicide tolerant (GM HT) soybeans, where prior to the introduction of GM HT technology, production systems were already switching away from conventional to no/low tillage production (in which the latter systems make greater use of, and are more reliant on, herbicide-based weed control systems - the role of GM HT technology in facilitating this fundamental change in production systems is assessed below In addition, the market dynamic impact of biotech crop adoption (on prices) has been incorporated into the analysis by use of current prices (for each year) for all crops

1.1.2 CURRENT CONDITION

Importance of Genetically modified crops

Farm income effects

GM technology has had a significant positive impact on farm income derived from a combination of enhanced productivity and efficiency gains (Table 1). In 2009, the direct global farm income benefit from biotech crops was $10.8 billion. This is equivalent to having added 5.8% to the value of global production of the four main crops of soybeans, maize, canola and cotton. Since 1996, farm incomes have increased by $64.7

billion. The largest gains in farm income have arisen in the soybean sector, largely from cost savings. The $2.1 billion additional income generated by GM herbicide tolerant (GM HT) soybeans in 2009 has been equivalent to adding 2.7% to the value of the crop in the biotech growing countries, or adding the equivalent of 2.3% to the $87 billion value of the global soybean crop in 2009. These economic benefits should, however be placed within the context of a significant increase in the level of soybean production in the main biotech adopting countries. Since 1996, the soybean area in the leading soybean producing countries of the US, Brazil and Argentina increased by 73%

1.1.3Socio-economic impacts on:
• Cropping systems: risks of crop losses, use of inputs, crop yields and rotations;
• Farm profitability: costs of production, revenue and gross margin profitability;
• Indirect (non pecuniary) impacts of the technology;
• Production effects;
Trade flows: developments of imports and exports and prices;
• Drivers for adoption such as farm type and structure;

1.1.4Environmental impacts on:
• Insecticide and herbicide use, including conversion to an environmental impact measure16;
• Greenhouse gas (GHG) emissions

1.1.5Global context of biotech crops

This section provides a broad overview of the global development of biotech crops over the fifteen year period 1996-2010. Although the first commercial biotech crops were planted in 1994 (tomatoes), 1996 was the first year in which a significant area of crops containing biotech traits were planted (1.66 million hectares). Since then there has been a dramatic increase in plantings and by 2010/11, the global planted area reached over 139 million hectares. This is equal to 71% of the total utilised agricultural area of the European Union or two and a quarter times the EU 27 area devoted to cereals. In terms of the share of the main crops in which biotech traits have been commercialised (soybeans, corn, cotton and canola), biotech traits accounted for 42% of the global plantings to these four crops in 2010.

1.1.6 Status of Genetically Modified Crops in the World during 2010

In terms of the share of total global plantings to these four crops, biotech traits accounted for the majority of soybean plantings (70%) in 2010. For the other three main crops, the biotech shares in 2010 were 26% for corn, 52% for cotton and 20% for canola(Fig 1)

1.1.7 Global biotech crop plantings by main trait and crop

The breakdown of the main biotech traits planted globally. Biotech herbicide tolerant soybeans dominate, accounting for 42% of the total, followed by insect resistant (largely Bt) corn, herbicide tolerant corn and insect resistant cotton with respective shares of 24%, 16% and 10%20. In total, herbicide tolerant crops account for 65%, and insect resistant crops account for 35% of global plantings (Fig 2).

1.1.8 Country wise Global GM Crop Plantings in world

In terms of country wise global GM crop planting prominent position is occupied by US fallowed by Brazil, Canada china and other countries

1.1.9 Gm crops in India - A Landmark

In India, the chronology of Bt cotton started in the year 1995 when the Department of Biotechnology (DBT) of the Government of India, permitted import of 100 grams of transgenic Cocker-312 variety of cottonseed cultivated in the United States by Monsanto.This variety contained the Cry1 AC gene from the bacterium *Bacillus thuringiensis*. Since then several developments have taken place in the country (Table 2) and finally in March 2002, the Genetic Engineering Approval Committee (GEAC) under the Department of Biotechnology, Ministry of Environment, Government of India, accorded permission for the first GM crop — cotton — to a joint-venture of Mahyco– Monsanto for its three hybrids, viz., MECH-12, MECH- 162 and MECH-184 for commercial cultivation and thereafter, plenty of Bt cotton hybrids from the private sector are being approved every year by GEAC (Jayaraman, 2004; Anon., 2006). Thus, Bt cotton appeared to be the first transgenic crop put into commercial cultivation in India. About 44,500 ha area was planted by 54,000 farmers with Bt-cotton in May– June 2002 (James, 2002), which has increased to 34.61 lakh ha, accounting for 37.90 per cent of the total area under cotton (James, 2006). During 2008-09, about 5 million small farmers were benefited from planting 7.6 M ha with Bt-cotton in the country, depicting a high adoption rate of 82 per cent . Benefits vary according to varying pest infestation levels in different years and locations

1.1.9 Impact of using GM IR cotton on farm level income in India

Over the year cost saving increased from 2002 to 2009 simultaneously farm income also and per centage farm level value of national production this because Bt cotton. Cost of cultivation come down over the year.

1.1.10 Marketing Perception for GM food Crops

GM foods are relatively preferred in China, Strong rejection of GM food in Europe Consumers are willing to pay a premium price for organic. Non-GM food products with least preference for GM food in our country, Consumers are more aware about GM foods and are not willing to pay better price for Non-GM food.

Legislation on GM food

- Legislation prohibits the import of GM foods and is in the declining trend
- Legislation that makes producers of GM crops liable for any contamination on Non-GM crops
- Many countries adopting GM labelling
- Better understanding of consumer attitudes and behaviour towards GM food is necessary to develop marketing strategies

Effect of labelling of GM food crops

- Labelling rules have contributed to a de facto segmentation of the international and national market
- EU import of US corn dropped by 70%
- After 1996, Spain and Portugal virtually ceased the importing feed grains with GM element

Successful marketing of GM foods

- Sunrise soy foods Ltd. of Vancouver, Canada has three differently labelled tofu products
- 1.GM soy
- 2.GM free soy
- 3.Organic soy
- There is a price difference among the three product charging the least for GM and the most for organic tofu

1.1.11**GM crop farms income benefits during 2009: developing versus developed countries**

The global acreage of biotech crops continued to grow strongly reaching 125 Mha with the number of countries planting biotech crops reaching the historical milestone of 25 countries, comprising 15 developing and 10 industrial countries. This strong growth has provided a very broad and stable foundation for the future global growth of biotech crops.

1.1.12 Negative impact of Genetically modified crop

Case study: Bt maize in Spain

Several reports and studies have documented the negative social and economic effects of GM cultivation for conventional and organic farmers in Spain. There has been a massive decline (between 5% and 75%) of organic maize production in the main GM maize cultivation areas in Spain.29 At least two traditional regional maize varieties have ceased to exist because they were contaminated and therefore no longer planted.30 Negative social effects of GM crop cultivation have also been documented: farmers whose fields were contaminated have not dared to make an official complaint due to pressure from seed companies or for the sake of social peace with neighbours.31 Overall, farmers who try to stay GM-free have to bear considerable costs. In response to a European Commission questionnaire on socioeconomic effects of GM crops, Spanish environmental, farmer and consumer groups documented numerous examples of farmers' unsuccessful attempts to escape contamination.Contamination remains widespread. Spain, like many other EU Member States, has no mandatory co-existence measures. Data gathered by the EU's *Joint Research Centre* shows that despite this, benefits for GM farmers are only moderate and restricted to one specific region. The study has been criticised for basing profit calculations on insecticide savings, when it has been shown that before Bt maize arrived, only 5% of the maize area in Spain used insecticides to control the corn borer, the pest insect targeted by Bt maize.

Moratorium on Bt Brinjal in India

The MoEF stated that the GEAC is a statutory body authorized to grant approval for environmental release of genetically modified organisms, yet the MoEF seized the opportunity presented to him by the GEAC, for a final decision. Notwithstanding his assurance that the moratorium applies only to *Bt* brinjal, and to no other genetically engineered (GE) crops under development, the moratorium has created a regulatory uncertainty. No research and development of GE crops is possible without the shadow cast by the moratorium. Already there are second thoughts on some transgenic vegetable projects that are in advanced stages of development. No investor, Indian or foreign, feels secure in pursuing even the existing projects, let alone starting new ones. With bleak prospects of

- employment caused by the slump, education and training in GE crop technology will also
- suffer. Of the 28 States and seven Union Territories in the Indian Union, only nine have actually opposed the release of *Bt* brinjal 'at this point of time' and four conveyed no decision and the stand of the rest of the States is unknown. Yet, the MoEF claimed that all States who
- responded to his letter have expressed apprehension and the media erroneously reported that
- All the States have rejected *Bt* brinjal. Ignoring the vast scientific evidence, the MoEF gave credence to activist claims that a) *Bt* brinjal may contain unknown toxins, b) India is the country of origin of brinjal

and brinjal is a largely self pollinated crop and hence gene flow from *Bt* brinjal would lead to the loss of currently available diversity of brinjal in India, and c) as there is a lot of uncertainty and doubt about the safety of *Bt* brinjal, the 'Precautionary Principle' makes the moratorium imperative.

CONCLUSION

It may now be time to rely on our innovative abilities to produce more food globally in a changing climate and to maintain sustainability while preserving the surrounding environment. Agriculture is an inherently unnatural situation and once this is fully understood by the broader community, we may be able to advance towards a rational debate on the role of biotechnology in food production. The global agricultural biotechnology industry faces a conundrum although it had significant success in marketing

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Table1: GM Crops Under Regulatory Evaluation in India
(Total: 17 crops, 8 traits as of 2012)

Traits	Crops
Insect resistance	Brinjal , corn cotton, okra, rice, sorghum, and tomato etc..
Virus resistance	Cotton, groundnut, papaya, potato, tomato and watermelon
Herbicide tolerance	Corn and cotton
Herbicide tolerance&	Corn, cotton and rice
Insect resistance stacked	
Drought tolerance	Chickpea, groundnut, mustard and sorghum
Yield enhancement	Rice
Delayed ripening	Tomato
Male sterile, female inbred lines	Mustard and rice

Table 2:Rapid adoption from 2002 To 2012 (in Million)

Year	Total cotton area in hectares	Bt-cotton area in hectares	% of cotton area occupied by Bt-cotton
2002	8.73	0.03	0.3
2003	7.67	0.09	1.2
2004	7.63	0.55	7.3
2005	8.92	1.27	14.2
2006	9.16	3.8	41.5
2007	9.4	6.2	66
2008	9.27	7.6	82
2009	9.64	8.4	87
2010	10.94	10.08	92
2011	11.8	11	93
2012	11.8	11.2	94.75

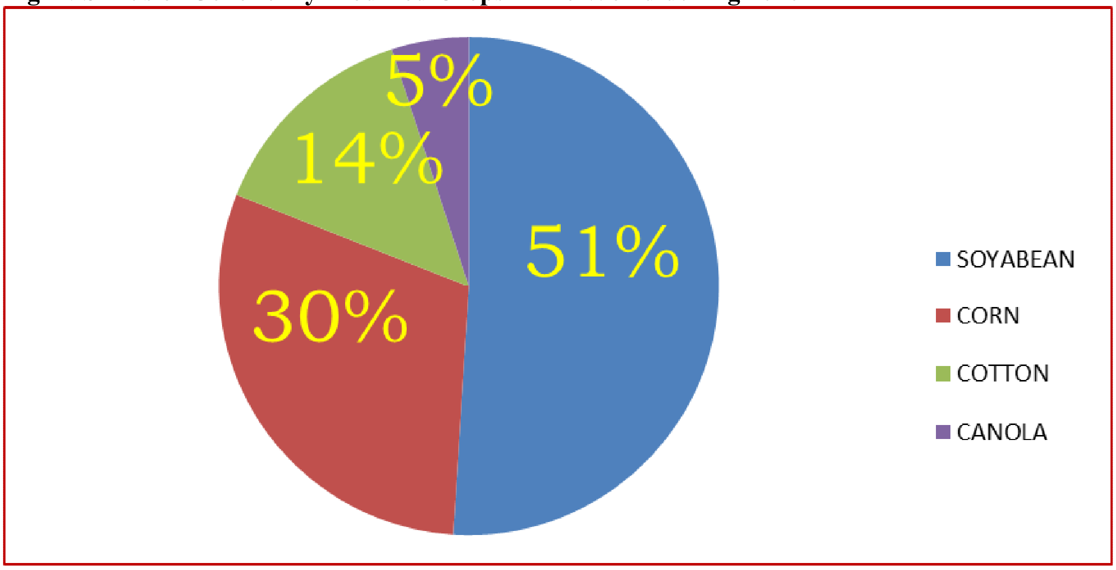
Table 3: Impact of using GM IR cotton on farm level income in India

Year	Cost Savings (Net After Cost Of Technology ($/ha)	Increase In Farm Income at National Level ($Million)	Increase in Farm Income as % of Farm Level Value of National Production
2002	12.42	3.69	0.26
2003	16.2	20.98	0.47
2004	13.56	96.68	1.86
2005	22.25	332.71	5.26
2006	12.52	839.89	14.04
2007	26.41	2,093.97	22.84
2008	24.28	1,790.10	24.27
2009	22.19	1,863.29	24.91

Table 4: GM crop farms income benefits during 2009: developing versus developed countries (million $)

Traits	Developed countries	Developing countries
GM HT soybeans	477.20	1,590.90
GM IR maize	3,485.00	426.50
GM HT maize	289.40	102.70
GM IR cotton	330.50	3,581.90
GM HT cotton	23.70	14.40
GM HT canola	362.50	0
GM virus resistant papaya and squash and GM HT sugar beet	84.70	0
Total	5,053.10	5,716.40

Fig 1 : Status of Genetically Modified Crops in the World during 2010



Source: ISAAA 2010

Fig-2:Global biotech crop plantings by main trait and crop: 2010

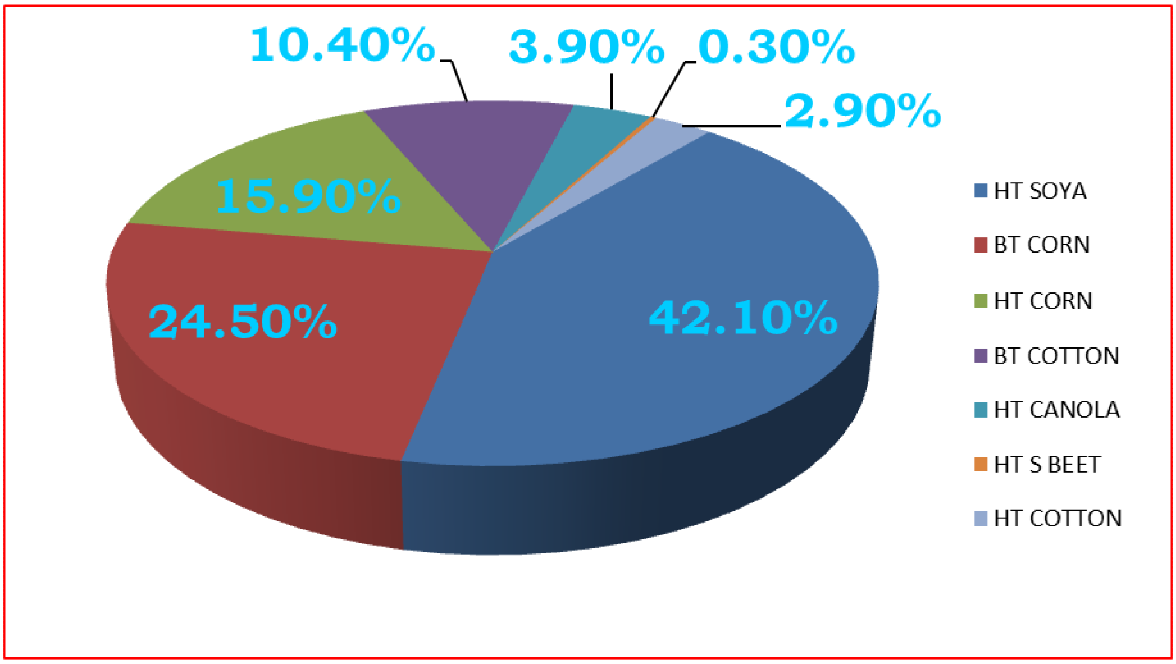
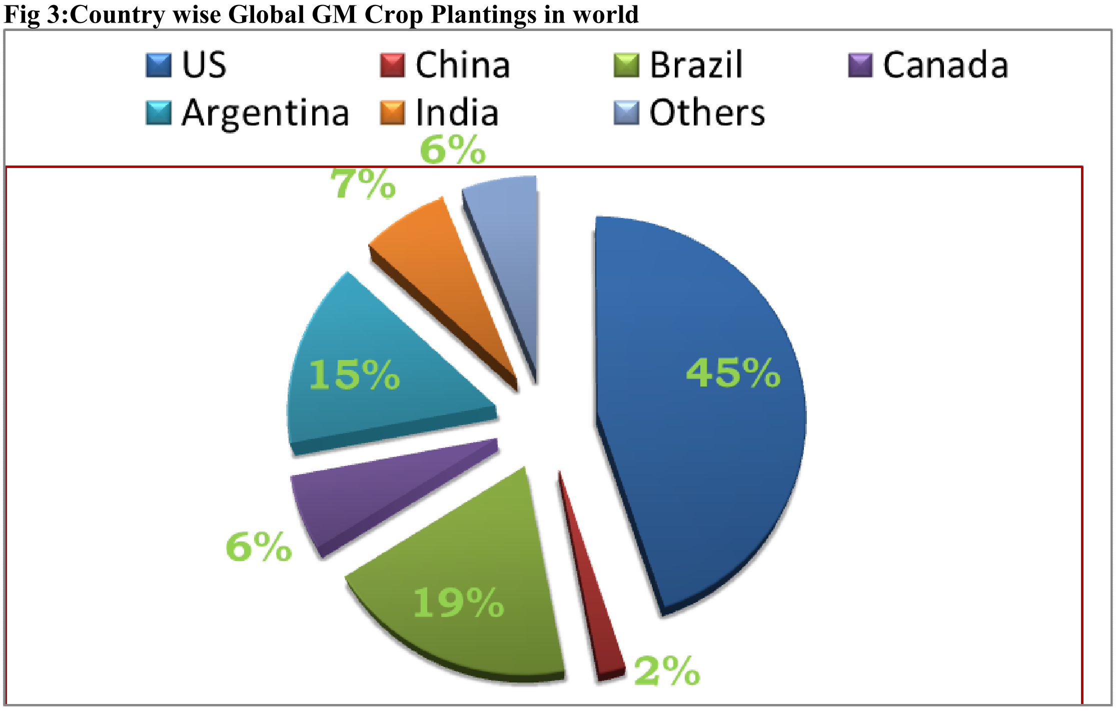


Fig 3:Country wise Global GM Crop Plantings in world



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