

Present status of GM crops in India

R K Singh*, A Arunachalam and T Mohapatra

Indian Council of Agricultural Research, New Delhi 110 001

Keywords: Bt cotton, GM crop, Transgenic

TRANSGENIC crops are plants that have been genetically engineered, a breeding approach that uses recombinant DNA techniques to create plants with new characteristics and are identified as genetically modified crops (GM Crops). In most cases, the aim is to introduce a new trait to the plant that does not occur naturally in the species. For instance, the crops are modified for three main GM traits viz., (i) herbicide tolerance (57%), (ii) stacked traits (more than two gene e.g. provitamin A-beta carotene) (28%) and (iii) insect resistance (15%). Technically, the herbicide tolerance is achieved by any of the following four mechanisms, namely altered target site, enhanced metabolism, compartmentalization or sequestration or over-expression of the target protein through which the crop will withstand chemical spray. Likewise, for enhancing insect resistance, the Bt (*Bacillus thuringiensis*, a gram + bacteria) gene is isolated that is capable of killing certain insects. The Bt produces a crystal-shaped protein (Cry toxin) i.e. called as endotoxin protein. It is not toxic to humans or other mammals but is toxic to certain insects when ingested and kills them.

Global status of the GM crops

During the last 20 years, the world has witnessed the contribution of GM crops in forms of higher yields, increased production, and maximizing the incomes contributing to minimizing poverty, hunger and malnutrition. Around 18 million farmers worldwide from 30 countries have harvested the benefits of GM crops. Worldwide the area under GM crops is continuously increasing.

Spatially, the GM crops occupied 1.7 mha in 1996, 90 mha in 2005 and 189.8 mha during 2018. The major GM crops are soybean, cotton, maize and canola. Around 67 countries cultivate Biotech crops worldwide and the major countries are the USA, Brazil, Argentina, India, Canada and China. According to a report, the developing countries grew 53% of the global biotech hectares compared to 47% in the industrialized countries during 2017. Despite all these, about 108 million people in the developing countries globally are experiencing food insecurity.

This paper elucidates the present status of genetically modified (GM) crops with special reference to India.

GM crops in India with special reference to Bt cotton

Genetic engineering research started in India in the late 80s' in different crops viz. rice, wheat, maize, pulses, mustard, brinjal, cotton etc.. Now, India is the fourth largest country to have crop acreage worldwide and the area under GM crops is about 12.6 mha. Bt cotton is the only genetically modified (GM) crop approved for cultivation in India way back in 2002 by the Genetic Engineering Appraisal Committee of the Ministry of Environment, Forest and Climate Change, Govt. of India for commercial cultivation. There are two versions of Bt cotton hybrids i.e. BG I (*Cry1Ac*) and BG II (*Cry1Ac* + *Cry2Ab*). These genes conferred resistance to American bollworm, Pink bollworm and spotted

bollworm, which were the major problem for cotton cultivation. Monsanto is the custodian of these two genes. These genes are patented by Monsanto and they take royalty from users. However, *Cry1Ac* is out of patent regime and can be used by anyone. BG I and BG II cotton hybrids were released in 2002 and 2006, respectively for commercial cultivation. Till date, ~2000 Bt cotton hybrids have been recommended for commercial cultivation in the country. Most of the Bt hybrids are developed by private seed companies. Being hybrids, the farmers are forced to purchase Bt cotton seeds every year which increases the cost of cultivation, however, the farmers get the benefit of higher yield. However, it is now estimated that >90 % of total area is occupied by Bt Cotton.

Impact of Bt Cotton

Before the introduction of Bt cotton, the area under cotton cultivation declined during 2002-03 due to bollworm infestation. With the advent of Bt, the cotton acreage seems to increase steadily and the area under Bt cotton cultivation reached to 10.07 mha during 2017-18 from 7.8 mha during 2002-03. Cotton production in the country also recorded an exponential increase from 136 lakh bales in 2002-03 to a highest of 398 lakh bales in 2013-14, and then plateaued between 332 and 386 lakh bales. Likewise, the productivity increased from 307 kg/ha in 2002-03 to 510 kg/ha in 2013-14 and thereafter it ranged between 415 to 510 kg/ha.

Prior to introduction of Bt cotton in India, the total pesticide

consumption for cotton was more than 45% of the total pesticides used in country, as there are a large number of insect pest attack on cotton crop, and the American bollworms alone caused yield reduction up to 40–70 %. As of now, the genetic resistance is not available against the bollworms. Eventually, the Bt technologies played a major role for sustainability of cotton cultivation in the country. However, pink bollworm is now showing resistance to Bt cotton hybrids, while it is also manageable through application of IRM/IPM technology developed by ICAR–Central Institute of Cotton Research, Nagpur.

Bt Cotton hybrids/varieties developed by public sector

During 2003, Genetic Engineering Appraisal Committee (GEAC) of India approved three Bt hybrids MECH-12, MECH-162, and MECH-184 for cultivation in India, followed by another hybrid RCH-2 in 2004. Since then, over 2000 entries have been flooded by the private Bt hybrids. In the recent years, the Public Sector Institutions have taken initiative for introgression of Bt trait in popular varieties and hybrids and released 6 Bt hybrids (G-Cot-Hy-6 BG-II, G-Cot-Hy-8 BG-II, G-cot Hy-10 BG-II, G-Cot.Hy-12 BG-II, NHH 44 Bt and DCH 32 Bt) for commercial cultivation. Further, the public sector has taken IPR free Cry1Ac (MON 531) event/gene and developed and released 8 Bt varieties (ICAR-CICRBt-1, ICAR-CICRBt-2, ICAR-CICRBt-3, ICAR-CICR Bt-9, ICAR-CICR Bt-12, ICAR-CICR Bt-6, ICAR-CICR Bt-14 and PAU-Bt1) for commercial cultivation in different cotton growing zones. This effort might make a dent in the dominance of private sector. A changed scenario would facilitate cultivation of more varieties instead of hybrids, the seeds which the farmers can reuse for 3-4 years thereby bringing down hitherto cost of cultivation.

Other GM crops/event in India but not approved for cultivation

As of now, Bt cotton is the only GM crop approved by GEAC of the

Ministry of Environment, Forest and Climate Change (MoEF&CC), Govt. of India for commercial cultivation in the country after extensive evaluation and satisfying all regulatory requirements. The other GM crops/event viz., Brinjal, mustard and HT Cotton have not yet been given clearance for commercial cultivation. The other GM crops yet to be approved are:

- (i) GM brinjal is created by inserting a crystal protein gene (Cry1Ac). The Bt-brinjal has been developed to give resistance against lepidopteron insects, in particular the brinjal fruit and shoot borer (*Leucinodes orbonalis*). Mahyco, an Indian seed company based in Jalna, Maharashtra, developed the Bt brinjal.
- (ii) Dhara Mustard Hybrid-11 (DMH - 11) is a genetically modified hybrid variety of the mustard species *Brassica juncea*. It was developed by University of Delhi, with the aim of reducing India's demand for edible oil imports. DMH - 11 was created through transgenic technology, primarily involving the Bar, Barnase and Barstar gene system. The Barnase gene confers male sterility, while the Bar-star gene restores DMH - 11's ability to produce fertile seeds. The insertion of the third gene Bar, enables DMH - 11 to produce phosphinothricin-N- acetyl-transferase, the enzyme responsible for glufosinate resistance for weed control. This hybrid mustard variety has come under intense public scrutiny, mainly due to concerns regarding DMH - 11's potential to adversely affect the environment as well as consumer health. DMH - 11 did not pose any food allergy risks and demonstrated increased yields over the existing mustard varieties. Conflicting details and results regarding the field trials and safety evaluations conducted on DMH-11 have delayed its approval for commercial cultivation.
- (iii) HT Cotton is developed by MYHCO in collaboration of Monsanto, after inserting the *cp4-*

epsps gene (from *Agrobacterium* spp. strain CP4) into BG II cotton hybrids that is resistant to glyphosate. It is cultivated for management of weed along with bollworms in cotton but not recommended for commercial cultivation in the country.

Regulatory mechanism for approval of commercial cultivation of GM crops

There is a well-established regulatory framework for approval of GM crops as per “Rules for the Manufacture/Use/Import/Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989” under the Environment (Protection) Act, 1986 in the country. Evaluation of each application of GM crop is done on a case-to-case basis after a thorough examination of health, environment, food and feed safety assessment studies undertaken in a systematic and scientific manner as per prescribed guidelines, manuals and standard operating procedures stipulated by various regulatory agencies under the Rules, 1989 from time to time. The data generated by the applicants is reviewed at every step in the development process of GM crops by various Statutory Committees under the Rules, 1989 such as Institutional Biosafety Committee, Review Committee on Genetic Manipulation and Genetic Engineering Appraisal Committee.

Illegal cultivation of GM crops

Other GM crops including cotton for other traits (*e.g.* HT cotton for herbicide tolerance) have not been approved by GEAC but there are reports of its illegal cultivation in different cotton growing states such as Gujarat, Maharashtra, Andhra Pradesh, and Telangana since 2017 in large area. Besides, cultivation of Bt-Brinjal by a farmer in Distt. Fatehabad (Haryana), was also in media reports recently. Illegal cultivation of HT-cotton and Bt-brinjal is confirmed by ICAR-Central Institute for Cotton Research, Nagpur and ICAR-National Bureau of Plant Genetic Resources, New Delhi, respectively after testing of seed samples.

Action taken by India to stop illegal cultivation of GM Crops especially HT cotton

In the direction of PMO vide ID No.4706832/PMO/2017-ES.2 dated 10.10.2017, Field Inspection and Scientific Evaluation Committee (FISEC) was constituted by DBT in the Chairmanship of Dr. K. Veluthambi, Co-Chair, GEAC and members from different Ministries/ Departments of Central Govt. (MoEF&CC, GEAC, DAC&FW, CIB&RC, DARE, ICAR-CICR, DBT) and concerned States to stop the illegal cultivation of HT cotton especially.

The FISEC has made six immediate, five short term and four long term strategies and measures to be implemented by different stakeholders especially MoEF&CC, DAC&FW, CIB&RC, DARE, DBT and concerned state governments, whose actions as pivotal as the enforcement jurisdiction on the subject matter belongs to the state governments.

Acts, Rules & Regulation to control the illegal cultivation of GM crops in India

Cultivation of unapproved GM crops including HT Cotton and Bt Brinjal are illegal and punishable under Environment Protection Act, 1986; Seed Act, 1966; Insecticide Act, 1968; PPVF Right Act, 2001; National Biodiversity Act, 2002; National Seed Policy, 2002; Plant Quarantine (Regulation of Import into India) Order, 2003; Foreign Trade Policy, 2006 and Food Safety and Standards Act, 2006. The DAC&FW has issued strict instruction to all State Governments to stop illegal cultivation of HT cotton as well as Bt-Brinjal and deal culprits under the Environmental Protection Act of 1989, also taking cognizance of the Seed Act 1966 and the Cotton Act of 1957.

SUMMARY

While the modern biotechnology has been recognized to have a great potential for the promotion of human well-being,

adoption of biosafety protocol is necessary to protect human health and environment from the possible adverse effects of the products of genetic engineering. The debate between proponents and opponents of GM technology has created major obstacles in harnessing benefits of the technology. It has now become clear that the public will accept the transgenics only when doubts related with general risks and environmental safety are adequately dispelled. Thus, there is need to organize public awareness and present the benefits of transgenic crops to improve social attitude for their rational deployment. However, ICAR is working on innovative technologies including transgenic following above rules/regulations to ensure sustainability for the food, nutrition and health security of the people and adequately provision for income of the farmers *per se*.

Corresponding	author	e-mail:
arun70@gmail.com		

Success Story

Actualizing *in situ* crop residue management in Punjab, Haryana and Uttar Pradesh

The region of Punjab, Haryana and Western Uttar Pradesh is witnessing severe crop residue burning incidences. KVKs (60) were involved in implementation of the Information, Education and Communication (IEC) component of the Scheme on "Promotion of agricultural mechanization for *in situ* management of crop residue in the state of Punjab, Haryana, Uttar Pradesh and NCT of Delhi".

About 4,000 walls of prominent buildings and structures were painted; more than 10,000 posters, banners and hoardings were installed; more than 100 panel discussions and awareness programmes were telecast on DD Kisan and publicity materials were distributed to stakeholders to sensitize them about the harmful effect of residue burning, benefits of *in situ* residue management and government schemes to procure subsidized machines. Similarly, around 700 awareness programmes at village, block and district levels and 75 *Kisan Melas* with about 2 lakh participants, were organized. Likewise, about 40,000 students from 250 schools and colleges were involved to spread the message against residue burning. Environmentalists and religious saints like *Padma Shri* Baba Balbir Singh Seechewal and *Padma Shri* Baba Sewa Singh were roped into mobilize the stakeholders. Hands-on trainings for about 20,000 farmers, tractor owners and machine operators were organized. Frontline demonstrations in more than 12,000 ha area were organized. About 200 exposure visits, 250 field days and harvest days were also organized in which more than 10,000 farmers were exposed to the technologies. The festival of *Baisakhi* was celebrated as "no crop residue burning day".

The efforts also made 132 villages of Punjab and Haryana free from burning (<80–85% burning) in 2018 covering more than 45,000 ha area. The comparison between fire intensity classes suggest change of about 1.2% (Punjab), 5.5% (Haryana) and 4.6% (Uttar Pradesh) of fire event's intensity from very high to low. Wheat area under Zero tilled/ Happy Seeder sown wheat in Punjab and Haryana increased to 8 lakh ha. The data for Punjab depicts improvement in the Air Quality Index (AQI).

Source: DARE-ICAR Annual Report 2019-20