

CHALLENGES AND OPPORTUNITIES OF GENETICALLY MODIFIED CROPS IN INDIA

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With 11.4 million hectares (mh) in 2017, India had the fifth-largest farmed area for genetically modified (GM) crops in the world. However, unlike other large growers, all of its GM crops are cotton, which incorporates genes from the *Bacillus thuringiensis* or Bt soil bacterium that code for resistance to the *Heliothis* bollworm insect pest (AICCIP annual report, 2017). Variety DMH-11 (Dhara Mustard Hybrid-11) has been made available for sale thanks to the Genetic Appraisal Committee (GEAC), which has the power to approve GM crop experiments and release. The Seed Act of 1966 and any associated rules and restrictions will apply to the commercial usage of DMH-11 hybrids. The commercial release of this first GM food crop in India has been approved. In 2006, the central government approved the commercial release of cotton Bollgard II. GM mustard is the first crop that has overcome regulatory and political hurdles to be allowed for release. The initial term of the permit is four years. After that, it will be renewed every two years based on a compliance report. Besides permitting the 'environ- mental release of GM mustard, the GEAC, at its October 18, 2022 meeting asked the Review Committee on Genetic Manipulation (RCGM) to permit field trials of genetically- engineered or GM potato, banana Mustard Cultivation and rubber.

Additionally, the GEAC has suggested that RCGM approve trials of 10 GM "cotton lines" at two Bioseed Research India Ltd. locations in Telangana and Maharashtra, both of which are located in Hyderabad, during the kharif 2023 season. The primary stage in this process is getting GEAC's approval for the field testing of GM mustard. The Centre for Genetic Manipulation of Crops, University of Delhi South Campus, will offer final permission for the commercial release for quantities beyond 2,000–2,200 kg. The commercial release of the GM variety will also include state governments.

Table: Top five countries and their area under Genetically Modified crops

Country	Available arable land (Mha)	Arable land used to farm GM plants (Mha)	% GM
USA	70,90	153.68	46.13
Brazil	44.20	71.88	61.49
Argentina	24.50	38.04	64.41
India	11.60	156.98	7.39
Canada	11.00	42.74	25.74

History of Genetically Modified crops

1922: The first hybrid corn is produced and sold commercially.

1940: Plant breeders learn to use radiation or chemicals to randomly change an organism's DNA.

1953: Building on the discoveries of chemist Rosalind Franklin, scientists James Watson and Francis Crick identify the structure of DNA.

1973: Biochemists Herbert Boyer and Stanley Cohen develop genetic engineering by inserting DNA from one bacteria into another.

1982: FDA approves the first consumer GMO product developed through genetic engineering: human insulin to treat diabetes.

1986: The federal government establishes the Coordinated Framework for the Regulation of Biotechnology. This policy describes how the U.S. Food and Drug Administration (FDA), U.S. Environmental Protection Agency (EPA), and U.S. Department of Agriculture (USDA) work together to regulate the safety of GMOs.

1992: FDA policy states that foods from GMO plants must meet the same requirements, including the same safety standards, as foods derived from traditionally bred plants.

1994: The first GMO produce created through genetic engineering—a GMO tomato—becomes available for sale after studies evaluated by federal agencies proved it to be as safe as traditionally bred tomatoes.

1990s: The first wave of GMO produce created through genetic engineering becomes available to consumers: summer squash, soybeans, cotton, corn, papayas, tomatoes, potatoes, and canola. Not all are still available for sale.

2003: The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations develop international guidelines and standards to determine the safety of GMO foods.

2005: GMO alfalfa and sugar beets are available for sale in the United States.

2015: FDA approves an application for the first genetic modification in an animal for use as food, a genetically engineered salmon.

2016: Congress passes a law requiring labelling for some foods produced through genetic engineering and uses the term “bioengineered,” which will start to appear on some foods.

2017: GMO apples are available for sale in the U.S.

2019: FDA completes consultation on first food from a genome edited plant.

2020: GMO pink pineapple is available to U.S. consumers.

2020: Application for GalSafe pig was approved.

Genetically Modified crops in India

In 2002, the central government made the landmark decision to permit the growing of GM cotton. India has since prohibited the commercial release of any additional crops. BT brinjal field trials were attempted; however they were resisted by Jairam Ramesh, who was the environment minister at the time. The Parliamentary Standing Committee on Agriculture recommended ending all field trials in 2012. A technical committee of the Supreme Court proposed a 10-year moratorium on all GM agricultural trials the next year, pending the improvement of regulatory and oversight frameworks.

After Bt Cotton, no other GM-based crop types have entered the Indian market. Many GM cultivars are thought to be in various stages of development but have not yet been formally released. The Genetic Engineering Approval Committee (GEAC), India's biotech regulator under the Ministry of Environment and Forests, has approved GM Mustard, the newest GM crop in the field that is the subject of ongoing speculations. There are no safety or public health concerns with this crop. Many people think that conventional food and food made from GM crops are equally safe for human health. However, opponents have objected to GM crops on several grounds, including environmental concerns, safety of GM foods, the business interests behind GM crops, intellectual property laws etc.

The GEAC clearance for GM mustard has been given after due deliberations on the report of an expert committee and comments: received from the Department of Biotechnology (DBT) and the Department of Agricultural Research and Education (DARE). The Indian Council of Agricultural Research (ICAR) will be the authorised agency to accord necessary permissions

for the development of any other *Brassica juncea* (mustard) hybrids. All hybrids released using this technology shall also be regulated under Seed Act 1966.

History of Genetically Modified crops in India:

2002 – Bt cotton introduced in India.

2006 – Activists filed a PIL against GM crops in the Supreme Court.

2010 – The then environmental minister Jairam Ramesh blocked the release of Bt Brinjal until further notice owing to a lack of consensus among scientists and opposition from brinjal-growing states.

No objection certificates from states were made mandatory for field trials.

2012 – Parliamentary standing committee on agriculture, in its 37th report asked for an end to all GM field trials in the country.

2013 July – New crop trials have been effectively on hold since late 2012, after a supreme court-appointed expert panel recommended suspension for 10 years until regulatory and monitoring systems could be strengthened. Though the SC panel suggested moratorium on GM trails, there was no official verdict from the Supreme Court on this issue.

2013 July – Environment minister Jayanthi Natarajan put on hold all trials following SC panel suggestions.

2014 – Her successor, Veerappa Moili cleared the way for trails. (NB: Two of Manmohan Singh's own environment ministers had stalled GM trials earlier, but Veerappa Moili took an opposite stand and the process of approving the one-acre field trials restarted.)

2014 March – GEAC (UPA government) approved field trials for 11 crops, including maize, rice, sorghum, wheat, groundnut and cotton.

2014 July – 21 new varieties of genetically modified (GM) crops such as rice, wheat, maize and cotton have been approved for field trials by the NDA government in July 2014. The Genetic Engineering Appraisal Committee (GEAC) — consisting mostly of bio-technology supporters — rejected just one out of the 28 proposals up for consideration. Six proposals were rejected for want of more information.

2016: GEAC gave green signal to GM Mustard for field trial, but SC stayed the order and sought public opinion on the same. There are as many as 20 GM crops already undergoing trials at various stages.

2018: GEAC approves DMH-11 for field studies

2022: GEAC recommended the “environmental release” of the transgenic hybrid mustard DMH-11 for seed production.

Bt Brinjal- India’s First Vegetable Biotech Crop

The Maharashtra Hybrid Seeds Company (Mahyco) developed Bt Brinjal. Young cotyledons of brinjal plants were transformed by the firm using a DNA construct including the *cry1Ac* gene, a *CaMV 35S* promoter, and the selectable marker genes *nptII* and *aad*. In Mahyco's breeding programme, a single copy elite event known as *EE-1* was chosen and added to hybrid brinjal. Backcrossing between open-pollinated brinjal cultivars and the event *EE-1* had place. Bt brinjal cultivars expressing the *cryFai* gene have been created by the National Center for Plant Biotechnology (NRCPB). Following that, the technology was distributed to businesses including Bejo Sheetal, Vibha Seeds, Nath Seeds, and Krishidhan Seeds. The Indian Institute of Horticultural Research (IIHR) is also developing Bt brinjal using the *cry1Ab* gene. Scientists are also looking for ways to develop Bt brinjal in conjunction with other multiple and beneficial traits.

However, because brinjal was a food crop, there was a huge uproar around granting approval for field experiments. Despite the company's assertions that it has completed all biosafety tests, there have been worries about potential health risks and the issue of terminator seed in Brinjal. A Supreme Court-appointed expert committee advised a 10-year moratorium on field trials of all genetically modified (GM) food crops and a total ban on field trials of transgenics in crops of Indian origins once the issue reached the court. As a result, field tests of Bt Brinjal were suspended by the government in 2010.



Fig: Genetically Modified Brinjal

Mustard cultivation

Over 6 million farmers in the states of Rajasthan, Haryana, Punjab, and Madhya Pradesh grow mustard on an estimated 6-7 million hectares of land. It has been demonstrated that DMH-11 produces 30% higher yields than common cultivated varieties. The current mustard cultivars yield an average of 1,000 to 1,200 kilogrammes per hectare, compared to 2000 to 2200 kg globally. The Delhi University's Centre for Genetic Manipulation of Crop Plants created the mustard variety known as Dhara Mustard Hybrid-11, or DMH-11 using "barnase / barstar" method for genetic modification. This crop is herbicide-tolerant (HT). This will be the country's first transgenic food crop and the second GM crop after Bt cotton if the Center grants its approval. The government's acceptance of GM mustard has faced vehement resistance from a number of groups as well as from within.

A similar approval had to be revoked in 2017 due to protest from people from all sides of the political aisle. However, pro-GM organisations are optimistic that the release of the GEAC meeting minutes would prove to be a significant step towards the commercialization of the variety.

The issue of allowing genetically modified crops in India has been rather controversial and politically sensitive one with many activists and farmer groups strongly opposing to it on grounds that such crops adversely impact human and animal health. Activists, working against the introduction of GM crops in the country, oppose any move in this matter on following grounds:

- One is anti-GM activists trying to up the ante and preventing any development of GM crops. In 2009, the anti-GM activists were mainly behind the various hurdles that field trials of GM Brinjal faced. The move is expected to face stiff opposition from environmental activists and groups like the Swadeshi Jagran Manch (SJM), an affiliate of the Rashtriya Swayamsevak Sangh
- The other issue is the free pricing of the technology. The Centre fixing a cap on the royalty to be paid for the technology discourages companies involved in developing the new technologies from sharing them with Indian firms.

"This GM mustard variety is not swadeshi as was claimed in 2017 (when the first GEAC nod came), nor is it safe. The facts that were there in 2017 haven't changed a bit, Ashwini Mahajan, co-convener of Swadeshi Manch (SJM), claimed. Terming the variety extremely dangerous to

public health and farmers, Mahajan said the SIM would continue to oppose it, and urged the government to not "fall into such a rap and give heed to such recommendations of the GEAC".

Meanwhile, the Coalition for GM-Free India said that the approval was shocking. It said GM mustard got to this stage because of collusion between the regulatory body and cop developers in circumventing safety assessment in numerous ways. However, the report put out in public domain says in its conclusion that "the risk assessment performed after examining and considering the exhausting information in literature and data provided in the dossier submitted by the developers, against the background of available knowledge in the subject areas, it is clear that GE mustard lines *Varuna bn 3-6*, *EH-2 modbs 2.99* and the hybrid DMH- 11 do not pose any risk of causing any adverse effects on human and animal health and safety":



Fig: GM Mustard DMH-11 released in India

Table: List of commercially released GM crops in the world

Crop	Use	Countries approved	Approved in
Cotton (Herbicide tolerant)	Fiber, Cottonseed	USA Argentina Australia India Brazil	1994 2001 2002 2002 2008

Maize (Herbicide tolerant)	Oil, Animal feed	USA Canada Argentina European Union	1995 1996 1998 1998
Soybean (Herbicide tolerant)	Except in India, where Cottonseed oil used for human consumption	USA Canada Argentina Brazil	1993 1995 1996 1998
Sugarbeet (Herbicide tolerant)	Animal feed, high-fructose, corn syrup,	USA Canada	1998 2001
Cotton (Insect resistance)	Corn starch	USA Argentina Australia India Brazil Pakistan	1995 1998 2003 2002 2005 2010
Alfalfa		USA	2011
Eggplant (Insect resistance)	Animal feed, Soybean oil	Bangladesh	2013
Maize (Insect resistance)	Food	USA Mexico South Africa Argentina Brazil	1995 1996 1997 1998 2005
Papaya (Virus Resistance)	Food	USA China	1996 2006
Potato (Virus Resistance)	Fiber, Cottonseed	USA Canada	1997 1999
Sugarcane (Drought tolerance)	Oil, Animal feed used for human consumption	Indonesia	2013



(a) Genetically Modified Potato plant



(b) Genetically Modified Cotton



(c) Genetically Modified Sugarcane



(d) Genetically Modified Sugarbeet



(e) Genetically Modified Papaya



(f) Genetically Modified Alfalfa

Future of GM Crops in India

Notably in India, GM crops have been a divisive topic. While one group believes it may reduce food and commodity prices and alleviate hunger-related issues, the other faction claims that it is harmful to the environment and the inhabitants' health. Now with the global scientists' consent on such crops, the government should move a step forward. It is indisputable that a nation with only 2.3 percent of the world's land area and an inability to provide for 17.5 percent of the population must prioritise food security. Given this, the time to legalise GM crops in the nation could well have arrived. Numerous studies have demonstrated the advantages, which include increased yields and insect resistance as well as no negative impacts on people or the environment. Thus, the development of biotechnology in India depends on the establishment of the Biotechnology Regulatory Authority of India (BRAI) as an independent regulatory body. Due to a negative public perception that was fostered by a part on GM crops, the BRAI law has been on life support for a number of years. It's time for the government to take a strong stance and lay the groundwork for a gradual and thoroughly studied rollout of GM crops. Bt mustard and Bt brinjal may be seriously evaluated for introduction into the nation. In addition to passing the BRAI bill, IPR concerns that have resurfaced due to the Andhra Pradesh government's fight against Monsanto and its request for forced licencing or cancellation of the Bt cotton technology patent must be handled. In order to allay doubts, it is also required to organise an expert conference. International specialists with a connection to the situation might also be asked for their opinions in order to help the administration make a wise choice. The introduction of GM crops may eventually be helpful, keeping in mind the issue of food security, which is of significant concern for a populous country like India.

Productivity of many crops has reached at saturation point. Given the growing population of the nation, demand for food crops and other commercial crops is most likely to rise in the upcoming years. Traditional cultivation techniques won't be enough to supply the rising demand. The government should prioritise the introduction of new varieties of food crops, including grains, legumes, oilseeds, vegetables, and fruits. As the field has been expanded, allowing GM technology will aid in the future development of superior types not only will it open doors for mustard, but also for other crops, according to P.K. Rai, director of the ICAR's Directorate of Rapeseed-Mustard Research in Bharatpur.

The current decision, along with the following steps, is a welcome move:

- The GEAC advised RCGM to permit confined field trials of GM potato (BRL-1) by ICAR- Central Potato Research Centre, Shimla, in Shillong, as the institute has got a no objection certificate (NOC) from the Meghalaya government.
- The National Technology Institute, Mohali, will hold event selection trials of five GE banana lines during 2022-24 in Mohali, Tiruchi Coimbatore, Navsari and Assam's Dubri.
- The GEAC has permitted the Rubber Research Institute of India, Kottayam in Kerala, to conduct field trials Guwahati campus for 15 years starting 2023 with a gene derived from tobacco.