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Status of GMO Crops in India

Introduction

Genetically modified crops (GM crops) are plants used in agriculture, the DNA of which has been modified using genetic engineering methods. Plant genomes can be engineered by physical methods or by use of Agrobacterium for the delivery of sequences hosted in T-DNA binary vectors. In most cases, the aim is to introduce a new trait to the plant which does not occur naturally in the species. Examples in food crops include resistance to certain pests, diseases, environmental conditions, reduction of spoilage, resistance to chemical treatments (e.g. resistance to herbicide), or improving the nutrient profile of the crop. Genetic engineering aims to transcend the genus barrier by introducing an alien gene in the seeds to get the desired effects.The alien gene could be from a plant, an animal or even a soil bacterium.

- E.g., Bt cotton has two alien genes from the soil bacterium Bacillus thuringiensis (Bt). It allows the crop to develop a protein toxic to the common pest pink bollworm.
- In Bt brinjal, a gene allows the plant to resist attacks of fruit and shoot borer.

Legal position of genetically modified crops in India

In India, the Genetic Engineering Appraisal Committee (GEAC) is the apex body that allows for commercial release of GM crops. In 2002, the GEAC had allowed the commercial release of Bt cotton. Use of the unapproved GM variant can attract a jail term of 5 years and fine of Rs 1 lakh under the Environmental Protection Act ,1989.

What is the status of transgenic crops in India?

- **Bt Cotton:** Bt cotton is the only commercially approved genetically modified crop in India. It has been widely adopted by Indian farmers since its introduction in the early 2000s. Bt cotton expresses a toxin derived from the bacterium Bacillus thuringiensis, providing resistance against certain pests.
- **Bt Brinjal:** Bt brinjal, genetically modified to resist the attack of fruit and shoot borer, has been developed in India. However, its commercial cultivation faced regulatory challenges.
- **GM Mustard (DMH-11):** Developed to enhance mustard crop yields, GM mustard faced debates and regulatory scrutiny. By 2022, it had received regulatory approval from the Genetic Engineering Appraisal Committee (GEAC) for environmental release and cultivation, but commercialization was pending further regulatory approvals.

- **GM Crops in Research**: Besides Bt cotton, ongoing research and development activities have focused on various genetically modified crops, including rice, chickpea, pigeon pea, and others. These crops are in different stages of development, with some undergoing field trials. Under Networking project on Transgenic in crops, ICAR scientists are involved in research, monitoring of field trials and regulatory evaluation of GM crops. More than 20 crops are under various stages of research and field trials for genetic modification in India, namely Cotton, Rice, Wheat, Maize, Brinjal, Potato, Sorghum, Mustard, Groundnut, Cauliflower, Okra, Chickpea, Pigeon pea, Castor, Sugarcane etc. for the trait's insect resistance, herbicide tolerance, drought tolerance, salinity tolerance, virus resistance, quantitative traits (yield increase), nutrition improvement etc.

  Current status of GM crops entered into the GMO regulatory system in India is summarized in. Few events of cotton, brinjal, mustard, maize and chickpea are in final stages of field trials and ready to be released commercially. The increasing cultivation of transgenic crops has raised several issues with respect to food safety, environmental effects, socio-economic issues and ethical issues. From the food and health perspective, the main concerns are related to possible toxicity and allergenicity of GM foods and products. Concerns about environmental risks of GM crops include the impact of introgression of the transgenes into the natural landscape, impact of gene flow, effect on non-target organisms, evolution of pest resistance and loss of biodiversity.

Why in news?

Agriculture being a state subject means that, in most cases, companies interested in testing their seeds need approvals from the States for conducting such tests. In the present case of Cry2Ai, only Haryana gave permission for such tests. The Cry2Ai seed had passed preliminary, confined trials and was recommended by the GEAC to be tested in farmer's fields at Telangana, Maharashtra, Gujarat and Haryana.

TABLE 1.

Status of GM crops entered into the GMO regulatory system in India.

S. No.	Crop	Trait	Event/*Gene*	Developer	Institutional Type	Status
1.	Cotton	Insect Resistance	MON531/*cry1Ac*	Monsanto	Private	Approved for environmental release
2.	Cotton	Insect Resistance	MON15958/*cry1Ac*	Monsanto	Private	Approved for environmental release
3.	Cotton	Insect Resistance	Event GFM/*cry1Ac-cry1Ab*	Nath Seeds	Private	Approved for environmental release
4.	Cotton	Insect Resistance	Event 1/*cry1Ac*	JK Agri Genetics	Private	Approved for environmental release
5.	Cotton	Insect Resistance	BNLA-601/*cry1Ac*	ICAR-CICR, Nagpur, UAS, Dharwad	Public	Approved for environmental release
6.	Cotton	Insect Resistance	MLS-9124/*cry1Ac*	Metahelix	Private	Approved for environmental release

S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
7.	Cotton	Insect Resistance & Herbicide Tolerance	MON15985 x MON88913	Mahyco	Private	Confined field trials for BRL-II
8.	Cotton	Insect Resistance	cry1F gene, *cry1Ac gene*	ICAR-CICR, Nagpur	Public	Event selection trials
9.	Cotton	Insect Resistance	*cry1Ac gene* in *G. arboretum; cry1Ac gene* in *G. barbadense; cry1Ac gene* in *G. herbaceum* cv. Jayadhar; *cry1Ac* and *cry1F genes* in *G. hirsutum*	UAS, Dharwad	Public	Event selection trials
10.	Cotton	Insect Resistance & Herbicide Tolerance	MON 15985 x COT102 (BGIII), MON 15985 x COT102 x MON 88913 (BGIII RRF), COT102	Monsanto	Private	BRL-I trials
11.	Cotton	Virus Resistance	*cp gene* of TSV	Mahyco	Private	Confined field trials for event selection
12.	Cotton	Herbicide Tolerance	*cp4epsps gene*	Mahyco	Private	Confined field trials
13.	Cotton	Herbicide Tolerance	GHB614/*2mEPSPS*	Bayer Bioscience	Private	BRL-II trials

S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
14.	Cotton	Insect Resistance	Event 281–24-236 & Event 3006–210-23/*cry1F* & *cry1Ac*	Dow Agroscience	Private	BRL-II trials
15.	Cotton	Water Use Efficiency and Nitrogen Use Efficiency	*ipt* and *AlaAt gene*	Mahyco	Private	Confined field trials for event selection
16.	Cotton	Insect Resistance & Herbicide Tolerance	GHB119 (Cry2Ae/PAT) x T304-40 (Cry1Ab/PAT) x GHB614 (2mEPSPS) x Cot102 (vip3A)	Bayer Bioscience	Private	Confined field trials for BRL-I
17.	Cotton	Herbicide Tolerance	*synthetic EPSPS gene*	Metahelix	Private	Application for event selection trials is under investigation
18.	Cotton	Insect Resistance	*cry1Ac gene*	Metahelix	Private	Application for event selection trials is under investigation
19.	Brinjal	Insect Resistance	EE-1	Mahyco/TNAU/UASD/IIVR	Public-Private	Moratorium

S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
20.	Brinjal	Insect Resistance	Event-142/*cry1Fa1*	Bejo Sheetal	Private	BRL-II trials
21.	Brinjal	Insect Resistance	cry1Fa1, cry2Aa, stacked cry1Fa1 and cry2Aa	Global Transgenes	Private	Event selection trials
22.	Brinjal	Insect Resistance	ANK-19 event/Cry1Fa1 gene	Ankur Seeds	Private	BRL-I trials
23.	Brinjal	Insect Resistance	Cry1Fa1 gene	Rasi Seeds	Private	Event selection trials
24.	Mustard	Agronomic Performance	Event bn 3.6 and modbs 2.99/*barnase*, *barstar* and *bar genes*	CGMCP, University of Delhi	Public	Recommended by GEAC for environmental release but kept pending for further review
25.	Maize	Insect Resistance	MON89034	Monsanto	Private	BRL-I trials
27.	Maize	Insect Resistance	MON 89034 x NK603	Monsanto	Private	Confined field trials
28.	Maize	Herbicide Tolerance & Insect Resistance	TC1507/*cry1F*, TC1507 (DAS-01507–1)	Dow Agro Sciences	Private	Confined field trials for BRL-I

S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
29.	Maize	Herbicide Tolerance & Insect Resistance	TC1507xNK603	Pioneer Overseas Corporation	Private	BRL-II trials
30.	Maize	Herbicide Tolerance & Insect Resistance	TC15017xMON810xNK603	Pioneer Overseas Corporation	Private	BRL-I trials
31.	Maize	Insect Resistance & Herbicide Tolerance	Bt11, GA21 and Bt11 x GA21	Syngenta Biosciences	Private	Confined field trials
32.	Maize	Insect Resistance & Herbicide Tolerance	TC1507 x MON 810 x NK 603 (DAS-01570–1 x MON-00810–6 x MON-00603–6)/*cry1F*, *cry1Ab* and *cp4epsps* genes	Pioneer Hi-Bred	Private	BRL-I trials
33.	Maize	Herbicide Tolerance	cp4epsps	Metahelix	Private	Confined field trials for event selection
34.	Maize	Insect Resistance & Herbicide Tolerance	*cry1F* and *synthetic EPSPS gene*	Metahelix	Private	Application for event selection trials is under investigation
35.	Maize	Insect Resistance & Herbicide Tolerance	*cry1Ab* and *synthetic EPSPS gene*	Metahelix	Private	Application for event selection trials is under investigation

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36.	Wheat	Salt Tolerance	*OsNHX1 gene*	Mahyco	Private	Confined field trials for event selection
37.	Wheat	Herbicide tolerance	event MON 71800/*cp4epsps gene*	Mahyco	Private	Confined field trials
38.	Cauliflower	Insect Resistance	Event CFE4	Sungro Seeds	Private	Confined field trials
39.	Okra	Insect Resistance	*cry1Ac gene*	Mahyco, Sungro Seeds	Private	Confined field trials
40.	Potato	Reduced Cold Induced Sweetening	KChipInvRNAi-2214	CPRI, Shimla	Public	BRL-I trials
41.	Potato	Agronomic Performance	*GA20 Oxidase 1gene*	CPRS – CPRI, Jalandhar	Public	Confined field trials for event selection
42.	Potato	Fungal Resistance	*RB gene*	CPRI, Shimla	Public	Event selection trials
43.	Groundnut	Drought Tolerance	*rd29A gene (DREB1A)*	ICRISAT, Hyderabad	Private	Confined field trials for event selection

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44.	Rice	Insect Resistance and Herbicide Tolerance	*dual Bt (Cry1Ab & Cry1Ca)* and *bar genes, Cry1Ab* & *Cry1Ca* and *Cry 2 Ad gene*	Bayer Biosciences	Private	Confined field trials for event selection
45.	Rice	-	-	BASF	Private	Elite event selection trials
46.	Rice	Nutritional Enhancement	*ferritin gene*	Department of Botany, University College of Science, University of Calcutta	Public	Event selection trials
47.	Rice	Salt Tolerant	*OSnhx1 gene*	Mahyco	Private	Event selection trials
48.	Rice	Water use efficiency	*ipt gene*	Mahyco	Private	Event selection trials
49.	Rice	Nitrogen use efficiency	*AlaAt gene*	Mahyco	Private	Event selection trials
50.	Rice	Insect Resistance	*cry1Ab (DG) gene*	Devgen Seeds & Crop Technology	Private	Event selection trials

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51.	Rice	Drought and Salinity tolerance and Nutrition stress	-	Bioseed Research	Private	Confined field trials for elite event selection
52.	Rice	Insect Resistance	*cry2Aa2*	Rasi Seeds	Private	Confined field trials for event selection
53.	Rice	Drought and Salinity tolerance	B6 and C15/*gly I* and *gly II*	Bioseed Research	Private	BRL-I trials
54.	Rice	Drought Tolerance	T I-3 and T I-5/*DREB*, LEA-11, LEA-20 and LEA-21/*lea*	Bioseed Research	Private	BRL-I trials
55.	Rice	Hybrid Rice SPT Maintainer	*Os-MSCA1, Zm-AA1,DsRed2*	Pioneer Overseas Corporation	Private	Confined field trials for event selection
56.	Rice	Insect Resistance	Cry1Ab and Cry2Ad genes, Cry1C and Cry1Ab genes	Pioneer Overseas Corporation	Private	Event selection trials
57.	Rice	Insect Resistance	*cry1Ab* and *cry1Ac, cry1Ab*	Metahelix	Private	Confined field trials for Event selection

S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
58.	Rice	Insect Resistance	JKOsE081/*cry2Ax1* JKOsE016/*cry1Ac* JKOsE081xE016/*cry2Ax1* and *cry1Ac*	JK Agri Genetics	Private	BRL-I trials
59.	Rice	Herbicide Tolerance	event OS_A17314/*cp4epsps gene*	Mahyco	Private	BRL-I trials
60.	Golden Rice	Nutritional Enhancement	GR-2	ICAR-IIRR Hyderabad, IARI New Delhi, TNAU Coimbatore	Public	Confined field trials
61.	Chickpea	Insect Resistance	-	AAU Jorhat	Public	Confined field trials
62.	Chickpea	Insect Resistance	SSL-3/*cry1Ac*	Sungro Seeds	Private	Confined field trials
63.	Chickpea	Insect Resistance	SSL-6/*cry2Aa*	Sungro Seeds	Private	BRL-I trials
64.	Chickpea	Insect Resistance	*cry1Ac/cry1Aabc*	ICAR-IIPR, Kanpur	Public	Confined field trials for event selection
65.	Pigeonpea	Insect Resistance	*cry1Ac/cry1Aabc*	ICAR-IIPR, Kanpur	Public	Confined field trials for event selection

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S. No.	Crop	Trait	Event/Gene	Developer	Institutional Type	Status
66.	Sorghum	Insect Resistance, Drought and Salinity Tolerance	Event-4/19	ICAR-IIMR, Hyderabad	Public	Confined field trials
67.	Sorghum	Drought Tolerance	-	CRIDA, Hyderabad	Public	Event selection trials
68.	Castor	Insect resistance	*Cry1EC and Cry1Aa genes*	ICAR-IIOR, Hyderabad	Public	Confined field trials for event selection