Biotech Crops for Indian Agriculture

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Challenges facing Indian Agriculture

- Climate change
- Shrinking availability of natural resources
  - Land
  - Water
- Emerging biotic and abiotic stress factors
- Malnutrition
- Sustainability in agricultural production

Population rising

Q: What is the solution and the way forward ?

A: Application of emerging tools of biotechnology to genetically improve crops

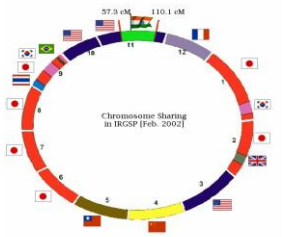
Agricultural Biotechnology in India

DBT, Govt. of India- 1986

APPROACHES

- Gene discovery
- Genomics
- Molecular markers
- Molecular marker assisted breeding
- Genetic engineering and GM crops
- Genome editing

- Infrastructure and institution building/ Capacity building/HRD
- R&D projects, network programmes, platforms, CoE
- Translational research platform for GM crops
- Public-Private Partnership
- Robust Bio-safety regulatory system



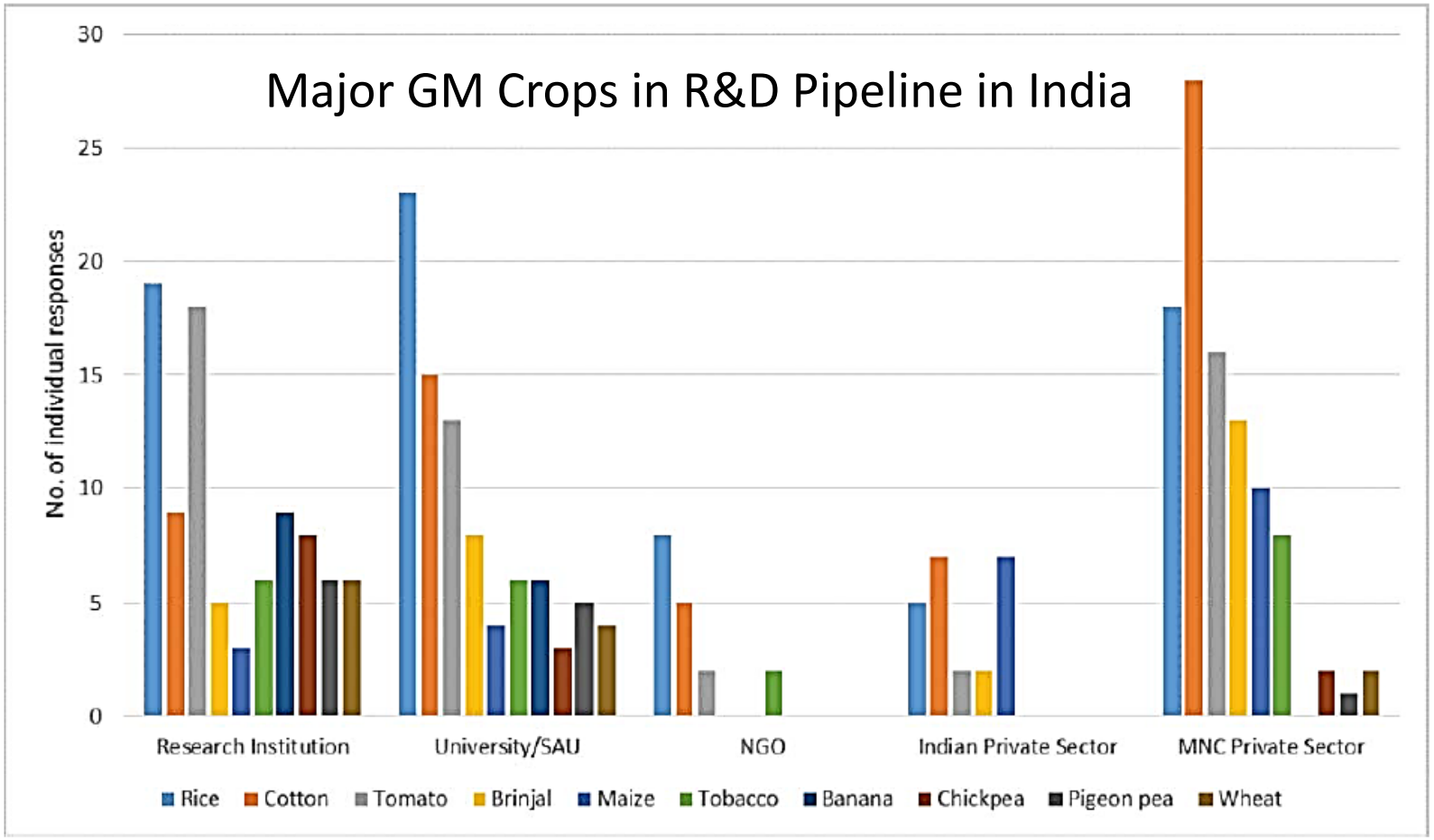
GM Crops Research in India

GM Crops : R&D efforts in India by public and private sectors

- 23 biotech crops being developed
- 67 biotech traits in different stages of development
- Developed by both public and private sectors
  - 39 traits by public sector
  - 20 traits by private sector
  - 8 traits by autonomous Institutes

Source: Dr Ratna, FSII

GM Crops Research in India

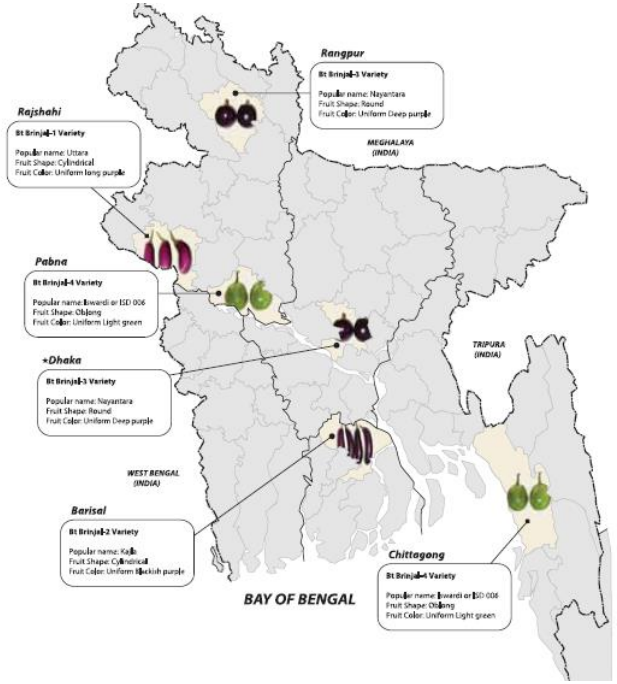


Source: Ranjini Warrier & Hem Pande (2016) Genetically engineered plants in the product development pipeline in India, GM Crops & Food, 7:1, 12-19

Fruit & Shoot Borer Resistant Transgenic (*Bt*) Brinjal

Genetic Transformation Laboratory	Transgenic Events/Genes	Trait	BRL-I/ BRL-II/ Event Selection	Source
Maharashtra Hybrid Seeds Company Ltd. *Technology transferred to TNAU, UAS (Dharwad), Sungro*	**EE1:** *cry1Ac* gene *(Commercialized in Bangladesh)**	IR	2006, 2007, 2009 (Event selection completed) **Approved in 2010**	http://igmoris.nic.in
NRC on Plant Biotechnology	*Bt* brinjal with *cry1Ab*	IR		http://www.nrcpb.org
	Event142: *cry1Fa1*	IR		
IIVR, Varanasi	*Bt* brinjal with *cry1Aa3*	IR		Rai et al., 2013a

Fruit & Shoot Borer Resistant Transgenic (*Bt*) Brinjal in Bangladesh



***Approval of *Bt* Brinjal Event EE1 in Bangladesh (2013)**

Source: ISAAA, 2014

- Significant reduction in pesticide use - by 28%
- Increased profit by 49% to farmers growing Bt brinjal

Field Trials of 18 GM Crops in India - 2015

Field trials (BRL-I and II): **GM events of 18 crops**, namely, brinjal, cotton, corn (maize), cabbage, castor, cauliflower, chickpea, groundnut, mustard, okra, papaya, potato, rice, rubber, sorghum, sugarcane, tomato, watermelon, have been under field trials since 2006

Kumar S (2015) Nature (News) 521:138–139

Status of Bio-safety Research Trials of Biotech Crops in India - 2016

Crop	Gene(s)/Event	Developer	Status
Chickpea	cry7Ac, cry1Aabc/ IPCa2 & MP9	ICAR-Indian Institute of Pulses Research, Kanpur	BRL-I
Cotton	GHB 614 (Glytol)	Bayer Biosciences Pvt. Ltd., Hyderabad	BRL-II
Cotton	WideStrike	Dow Agro Science Pvt. Ltd	Hybrid Seeds Production
Maize	NK603	Monsanto	BRL-II
Maize	cry7F, cry1Ab and cp4EPSPSgenes/ TC1507 x MON 810 x NK 603 (DAs-01570-1 x MON-00810-6 x MoN-00003-6	Pioneer Hi-Breed Private Limited, Hyderabad	BRL-I
Maize	TC1507 x MON810	Pioneer Hi-Breed Private Limited, Hyderabad	BRL-I
Mustard	Bar, barnase& barstar/ events bn 3.6 and modbs 2.99	Delhi University	Environmental release
Pigeonpea	cry1Ac, cry1Aabc/IOCc2 & SS5	ICAR-Indian Institute of Pulses Research, Kanpur	Event Selection
Rice	Abiotic stress tolerance namely drought & salinity and nutrition stress	Bioseed Research India pvt. Ltd., Hyderabad	Event selection
Rice	cry2Aa2a	RasiSeeds Research Farm, Telangana	Event selection
Sugarcane	DREB	Sugarcane Research Institute, U.P Council of Sugarcane Research (UPCSUR), Shahjahanpur	Event Selection

Source: MOEF&CC, 2016; Analyzed by ISAAA, 2016

GM Mustard Hybrid in India

Seed Yield of GM Mustard Hybrid DMH-11= 27- 37% more

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Maize	Transgenic Maize Event NK 603	Ms. Monsanto India Pvt. Ltd	BRL-II (North, Central and South Zones)	130th GEAC (11.08.2016) http://www.geacindia.gov.in/Uploads/MoMPublished/2016-geac-130.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Cotton	Roundup ready flex cotton hybrids containing *cp4epsps* gene	M/s Maharashtra Hybrid Seeds Co. Ltd.	Confined Field Trial (to evaluate weed control efficacy of Roundup 41% SL (IPA salt) along with residue analysis and effect on succeeding crop)	133rd GEAC (11.05.2017) http://www.geacindia.gov.in/Uploads/MoMPublished/2017-geac-133.pdf
Chickpea	Transgenic lines with *CrylAc/ CrylAabc* gene	ICAR-Indian Institute of Pulses Research (ICAR-IIPR)	Confined Field Trial for Event Selection (IIPR, Kanpur)	131th GEAC (13.01.2017) http://www.geacindia.gov.in/Uploads/MoMPublished/2017-geac-131.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Rice	Marker free transgenic rice events with single gene - W2-MF-004, W2-MF-010, O1-MF-006, O1-MF-010 and two gene stacks - W2-MF-004 x O1-MF-010 and W2-MF-010 x O1-MF-010	M/s. Bioseed Research India	Elite Event Selection	134th GEAC (21.03.2018) http://www.geacindia.gov.in/Uploads/MoMPublished/2018-geac-134.pdf
Wheat	Salt tolerant transgenic wheat events (MAH-31501 to MAH31525) containing *OsNHX1* gene	M/s. Maharashtra Hybrid Seeds Co. Pvt. Ltd.	Event Selection (ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch, Gujarat)	133rd GEAC (11.05.2017) http://www.geacindia.gov.in/Uploads/MoMPublished/2017-geac-133.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Cotton	GM events with *cry1Ac*; GM events with synthetic *epsps;* GM events with *cry1Ab* and synthetic *epsps;* GM events with *cry1F* and synthetic *epsps* GM events with *cry1F*	M/s. Metahelix Life Sciences Ltd.	Event Selection (Bangalore, Aurangabad, Hyderabad and Dehgan)	135th GEAC (25.07.2018) (http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20180830201015.pdf)
Rice	Yellow Stem Borer resistant marker free transgenic rice events (31 Events) expressing *cry 2 Aa2* gene	Ms. Rasi Seeds Pvt. Ltd	Event Selection (Telangana)	134th GEAC (21.03.2018) http://www.geacindia.gov.in/Uploads/MoMPublished/2018-geac-134.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Mustard *Brassica juncea*	Frost tolerant lines (CBF1and CBF3 genes); Lines with Wrinkled 1 (WRI1) and Diacylglycerol Acylatransferase 1 (DGAT1) genes; High oleic and low linoleic transgenic line (event HO 3.18) developed by antisense suppression of fad2 gene Transgenic plants with *CP4 EPSPS* and *ALS* (acetolactate synthase) genes	University of Delhi South Campus	Confined field trial for event selection (Bawana, Delhi)	137th GEAC (20.03.2019) http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20190418142240.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

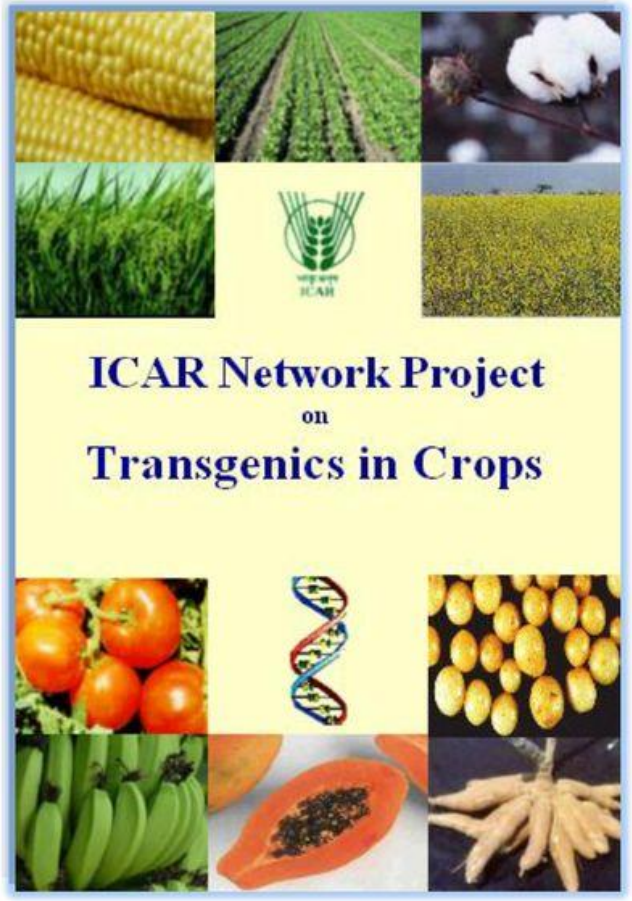
Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Cotton	Transgenic lines with synthetic *Cry2Ai* gene for pink bollworm resistance Transgenic lines expressing *asal* gene from *Allium sativum* exhibiting insecticidal property against sap-sucking pest	M/S. Bioseed Research India	Event selection	137th GEAC (20.03.2019) http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20190418142240.pdf
Cotton	*Bt* Cotton event no. 78 with *cry1Ac* gene	University of Agricultural Sciences (UAS), Dharwad	BRL-1 Dharwad	137th GEAC (20.03.2019) http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20190418142240.pdf

GM crops approved for field trials by GEAC during last five years (2016-2020)

Crop	GM lines/events	Developer/ Applicant	Approval	Ref.
Rubber	Events L1 and L2 modified with manganese superoxide dismutase (*MnSOD*) gene to confer tolerance to abiotic stress	Rubber Board	BRL-1	140th GEAC (29.07.2020) http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20200910170648.pdf
Brinjal	*Bt* Brinjal Hybrids (Janak and BSS-793) containing *Bt Cry1Fa1* gene (Event 142) by	M/s. Beejsheetal Research Private Limited, Jalna.	BRL-II Madhya Pradesh, Karnataka, Bihar, Chhattisgarh Jharkhand, Tamil Nadu, Odisha and West Bengal	139th GEAC (19.05.2020) http://www.geacindia.gov.in/Uploads/MoMPublished/MoMPublishedOn20200615165821.pdf

ICAR's National Project on Transgenics in Crops

Coordinators: KC Bansal and NK Singh



Insect/pests
- ✓ Rice
- ✓ Sorghum
- ✓ Maize
- • Pod Borer
- ✓ Pigeon pea
- ✓ Chick pea
- • Boll worm
- ✓ Cotton
- • Fruit borer
- ✓ Tomato
- ✓ Brinjal
- • Aphid
- ✓ Brassica

. Capsule borer
✓Castor
. Insect/pests
✓Groundnut

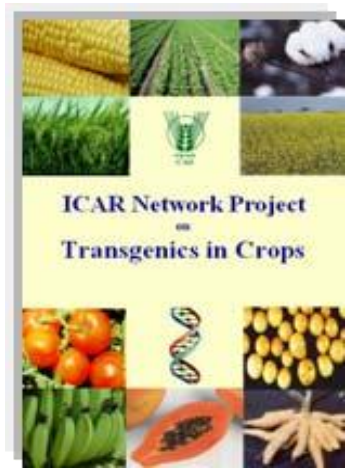
Drought and salinity stress
- ✓Brassica
- ✓Tomato
- ✓Rice
- ✓Sorghum
- ✓Chickpea
- ✓Groundnut
- ✓Potato

Virus resistance
- ✓Cotton
- ✓Soybean
- ✓Tomato
- ✓Potato
- ✓Banana
- ✓Papaya
- ✓Cassava

Transgenics

Delayed ripening
- ✓Tomato

Fungal resistance
- ✓Rice
- ✓Banana



ICAR Network on Transgenics in Crops (NPTC)

ABIOTIC STRESS TOLERANCE

Coordinator: KC Bansal

TOMATO
- NRCPB
- IIVR
- IIHR

MUSTARD
- NRCPB
- NRCRM

RICE
- NRCPB
- DRR
- CRRI

Abiotic Stress Tolerance

CHICKPEA
- NRCPB
- IIPR

GROUNDNUT
-NRCG
-NRCPB

COTTON
-CICR
-NRCPB

WHEAT
- NRCPB

NPTC-Transgenic Crop Development for Abiotic Stress Tolerance

S. No	Crop	Gene	Centre	Reference
1.	**Wheat**	AtDREB1a	**NRCPB**, New Delhi	**Biotechnology Lett**. 36 :1037-41
2.	**Wheat**	BcZF1	**PAU**, Ludhiana	**J Wheat Research** 8:19-25.
3.	**Rice**	AtDREB1a	**NRCPB**, New Delhi	**Plant Cell Tissue Organ Cult,** 136, 173–188
4.	**Rice**	BcZF1	**PAU**, Ludhiana	**Applied Biol. Res.** 18: 208-213.
5.	**Rice**	AtDREB1a	**DRR**, Hyderabad	**Transgenic Res** 23:421–439
6.	**Rice**	AtDREB1a	**CRRI**, Cuttack	**J Rice Res** 7: 208.
7.	**Mustard**	At DREB1a BcZF1	**NRCPB**, New Delhi	**J Plant Biochem. Biotechnol**. 17: 197–200 **Plant Omics J**. 6: 208-214
8.	**Chickpea**	AtDREB1a	**IIPR**, Kanpur	Paper under review
9.	**Groundnut**	AtDREB1a	**DGR**, Junagadh	**Front. Plant Sci.** 7:935. **PLoS One** 9(12): e110507
10.	**Tomato**	BcZF1	**IIVR**, Varanasi	**Phytochemistry** 95: 109
11.	**Tomato**	AtDREB1a	**IIVR,** Varanasi	**Plant Physiol Biochem** 69:90–100
12.	**Cotton**	AtDREB1a	**CICR,** Nagpur	-
13.	**Sugarcane**	BcZF1	**TNAU,** Coimbatore	**Int. J. Curr. Microbiol. App. Sci** 7: 1594-1613

More than 20 years of data on GM food safety and environmental safety – All safe

www.nature.com/scientificreports

OPEN

1996- 2017

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Published online: 15 February 2018

Impact of genetically engineered maize on agronomic, environmental and toxicological traits: a meta-analysis of 21 years of field data

Elisa Pellegrino[1], Stefano Bedini[2], Marco Nuti[1,2] & Laura Ercoli[1]

Results provided strong evidence that GM maize performed better than its near isogenic line:

1. **Grain yield was higher: 5.6 to 24.5%**
2. **Lower concentrations of mycotoxins (–28.8%), fumonisin (–30.6%) and thricotecens (–36.5%)**

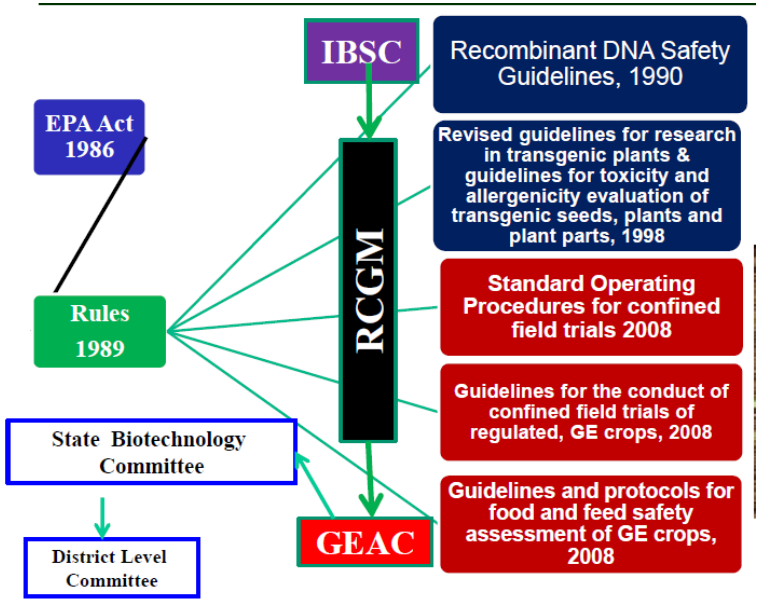
Mycotoxins are toxic and carcinogenic for humans and animals

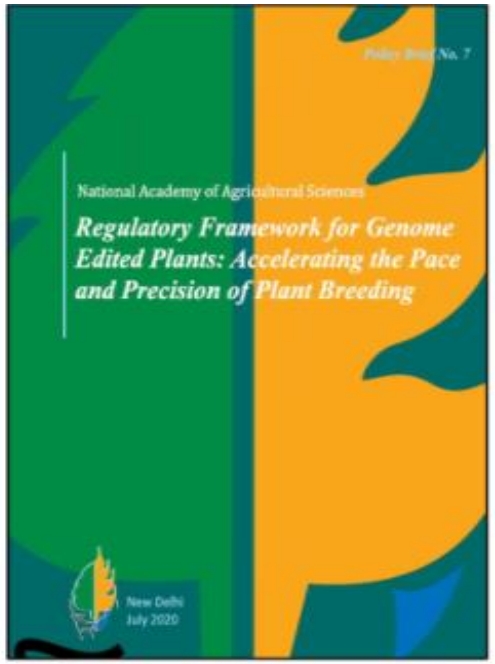
Indian Regulatory System

GM crops to be an integral component of Self-reliant India

- A clear policy needed
- Existing regulatory approval process to be accelerated
- Approval from States for field trials without delay
- Political support needed in favour of relevant GM crops
- SDN 1 and SDN 2 products (without foreign DNA) to be treated as non-GMO

Reason: Sustainability and profitability of small holder farmers

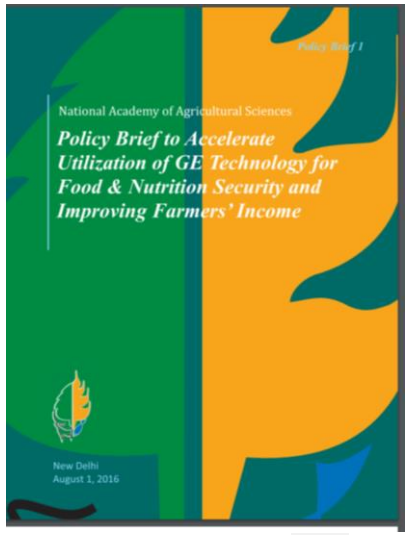




Source: NAAS Policy Brief No. 7
http://naasindia.org/page.php?pageid=81

Role of NAAS in Promoting GM Crops

- NAAS intervention in Supreme court case
- NAAS Policy papers in favour of GM crops
- Letter to Hon'ble PM of India signed by 50 eminent scientists



February 12, 2015

To
The Prime Minister of India
7, Race Course Road
New Delhi

Subject: Adoption of GM crops in India for Sustainable Agriculture

Hon'ble Prime Minister Shri Narendra Modi,

Since independence, the national progress has largely been associated with science-led agricultural growth. Till mid-1960s, country relied on large scale imports and food aid to meet our domestic requirements. However, the Green Revolution in India paved the way for the development and adoption of high yielding, disease resistant wheat and rice varieties. These, combined with higher inputs and good agricultural practices contributed to significant

+ 38 more signatories

ThePrint

India Governance

Modi govt wants NITI Aayog to play peacemaker in GM row

- NIT

RAJGOPAL SINGH 30 April, 2018 4:22 pm IST

The idea is to bring supporters and opponents into the same room and sort their differences out, sources said. This includes groups such as the Bharatiya Kisan Sangh, an RSS affiliate, which has been leading the opposition to GM technology.

The invitees also include farm experts such as Kapil Bhai Saha who is opposed to GM and scientists such as Dr K.C. Bansal and Dr Deepak Pental who support GM.

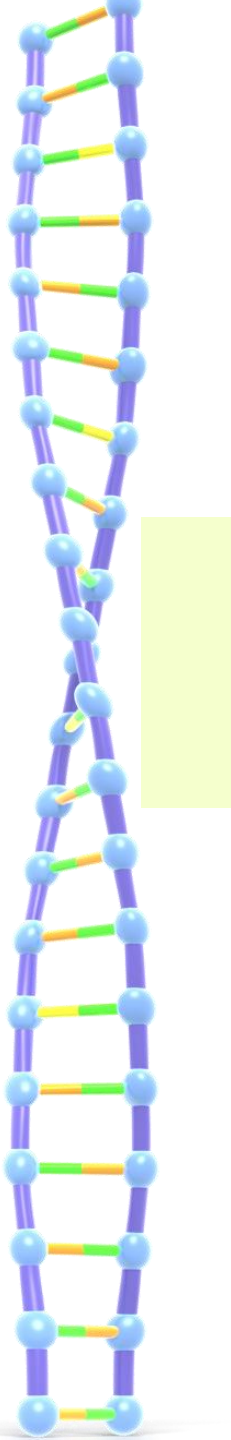
GM crops to derive benefits for farmers

K C BANSAL,
Former Director, National Bureau of Plant Genetic Resources

India should derive as much benefit as possible by permitting the cultivation of the already developed genetically modified/engineered (GM) crops. Globally, 20 years of testing for health and environmental biosafety has verified that GM crops are safe.

My Dream 11 + 2/3

- Bt Brinjal
- GM Mustard
- HT-Bt Cotton
- Virus resistant Cotton
- NUE Cotton
- DST Cotton
- HT-Bt Maize
- Bt Chickpea
- Bt Pigeon pea
- Bt Rice
- DST/HT Rice
- Salt tolerant Wheat
- LB resistant Potato



Thank You

A science-led approach only can provide a secure, economically and environmentally sound, and sustainable global food system