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Regulation of Genetically Modified Crops in India: Ensuring Safety Through Science

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Every year, scientists develop new crop varieties to help farmers deal with insect pests, disease, drought, salinity, and falling yields. Genetically modified (GM) crops are one result of that work: by inserting a specific gene into a plant, scientists can add traits such as insect resistance, herbicide tolerance, disease resistance, better nutrition, or tolerance to environmental stress. Conventional breeding combines traits by crossing related plants over many generations. Genetic engineering transfers a single gene with more precision. But because it introduces a deliberate genetic change, a fair question follows: how do we know a GM crop is safe before it reaches a farmer's field?

The answer is a biosafety regulatory system. A GM crop doesn't move from the lab straight to a farmer's field. Before that happens, it goes through years of laboratory research, confined field testing, scientific evaluation, and regulatory review, each stage checking for risks to human health, animal health, or the environment.

India built a dedicated biosafety framework early, notifying the Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989, under the Environment (Protection) Act, 1986. The system has since grown to include detailed guidelines for lab research, field trials, food safety, and environmental risk assessment.

Bt cotton, introduced in 2002, remains the only GM crop approved for commercial cultivation in India. It now covers more than 90% of the country's cotton area, while maize, chickpea, pigeonpea, and sugarcane are still under research and field evaluation. More than two decades on, GM crops are still widely misunderstood. This article follows the path a GM crop takes in India, from the research lab to the farmer's field: why regulation exists, how scientists get permission to do the research, how biosafety gets assessed at each stage, and how regulators decide what's ready for cultivation.

Why Do GM Crops Need Regulation?

Take a farmer whose cotton is repeatedly damaged by insect pests despite regular spraying. Conventional breeding might eventually produce a resistant variety, but that can take years and the trait might not exist in related plants at all. Genetic engineering offers a faster route for inserting the specific gene that gives the desired trait. GM crops today are being developed to handle insect pests, disease, drought, salinity, herbicide tolerance, and nutritional gaps, traits that can cut crop losses, reduce pesticide use, and improve yield and food quality.

But every GM crop is different. One built for insect resistance isn't evaluated the same way as one built for better nutrition or drought tolerance, and because each carries its own genetic change, safety can't be assumed, but it has to be tested.

That's the role of biosafety regulation, not to slow innovation, but to check each crop before it reaches farmers or consumers. Scientists have to show the crop is as safe as its conventional counterpart for human health, animal health, and the environment. Could the gene affect bees? Could it spread to wild relatives? Is the new protein safe to eat? Does the crop still have normal nutritional value? Those questions need actual studies, not assumptions.

In India, we have a step-by-step system that includes lab research first, then confined field trials, before any crop is cleared for commercial cultivation.

India's Biosafety Regulatory Framework

Building a GM crop is only half the job, the other half is making sure it's safe before it leaves the lab. India set up a dedicated regulatory framework early: the Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989, notified under the Environment (Protection) Act, 1986. These rules cover every activity involving GM organisms, from lab research and field testing to import, export, storage, and commercial cultivation.

The system is run jointly by the Ministry of Environment, Forest and Climate Change (MoEFCC), the Department of Biotechnology (DBT), and state governments, through six committees, each handling a different stage of approval.

The Recombinant DNA Advisory Committee (RDAC) gives scientific guidance on biotechnology and biosafety. Every institution working with GM organisms needs an Institutional Biosafety Committee (IBSC), which reviews research proposals and checks that lab experiments follow national biosafety guidelines. Once lab research is done, the Review Committee on Genetic Manipulation (RCGM) reviews the data and decides whether the crop can move to field testing. Larger field trials and environmental release go to the Genetic Engineering Appraisal Committee (GEAC), the apex body for approving GM crops in India.
Two more committees work at the state and district level: the State Biotechnology Coordination Committee (SBCC) and the District Level Committee (DLC) monitor research activity and confined field trials to make sure biosafety measures are actually followed on the ground.

India also maintains detailed biosafety guidelines for lab research, confined field trials, food and feed safety, and environmental risk assessment, updated as the science and international practice move forward. So, the journey of a GM crop from lab to field passes through several stages, each answering a different safety question.

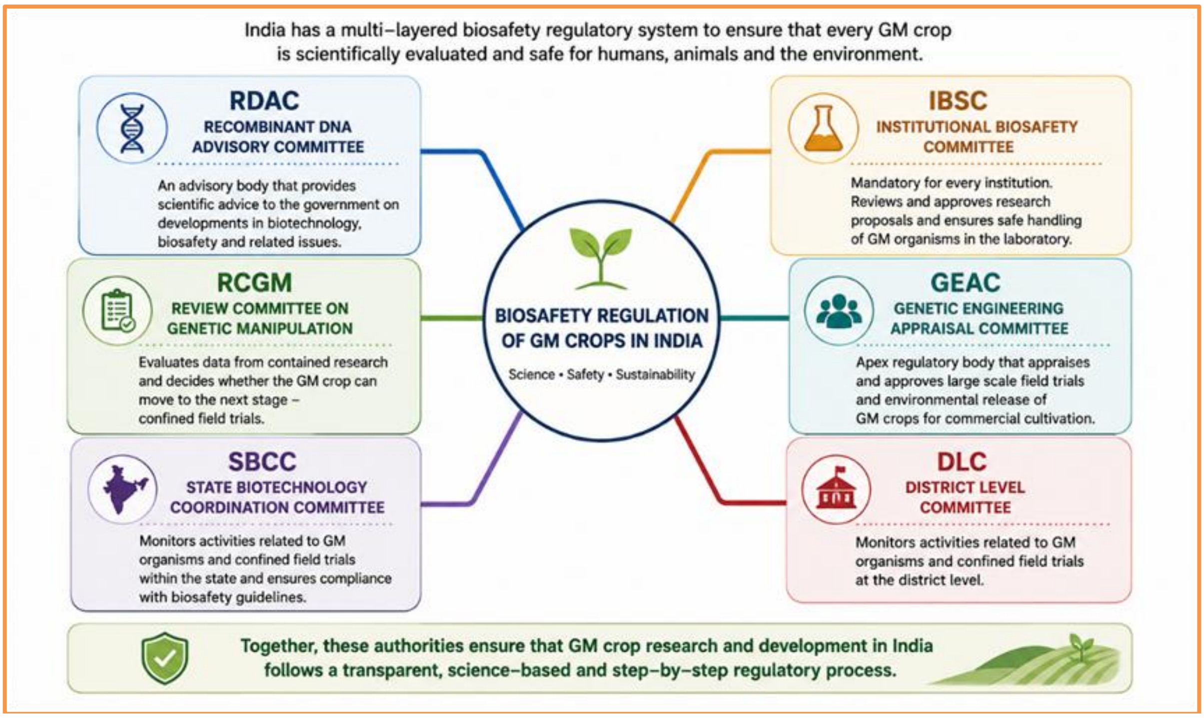

Fig. 1: Regulatory authorities involved in the development of GM crops in India

From Laboratory to Farmer's Field: How a GM Crop Gets Approved

Getting a GM crop approved takes several years of research, testing, and evaluation, with the same objective at every stage: making sure the crop is safe for people, animals, and the environment.

It starts in the lab, where scientists identify and insert a useful gene into a crop plant, but only after their institution's Institutional Biosafety Committee (IBSC) approves the research and confirms it follows national biosafety guidelines. Once the lab data is in, the Review Committee on Genetic Manipulation (RCGM) reviews it. If the results hold up, the crop moves to Confined Field Trials (CFTs). These are small, tightly monitored experiments designed to answer questions that cannot be addressed in a laboratory or greenhouse, such as how the crop behaves in real field conditions, whether it affects beneficial insects, whether the inserted gene stays stable, and whether it could spread to related plants.

That field data then goes to the Genetic Engineering Appraisal Committee (GEAC), the apex body for approving environmental release of GM crops in India. Only after GEAC reviews all the biosafety data, then a crop can be considered for commercial cultivation. Each stage adding a layer of scrutiny before the last.

Fig. 2: Journey of a GM crop from laboratory to farmer's field.

How Do Scientists Know a GM Crop Is Safe?

Approving a GM crop takes more than checking whether it grows well. Scientists have to show it's safe to eat and doesn't pose an unacceptable risk to the environment. India assesses each crop individually, since every one carries a different gene and serves a different purpose. A crop built for insect resistance is judged on different grounds than one built for better nutrition or drought tolerance.

Before approving a GM crop, scientists seek answers to three simple questions: First, the gene itself: is it stable, does it function as expected, and does it produce only the intended trait? Second, food and feed safety: could the new protein be toxic or allergenic, and does the crop's nutritional makeup still match its conventional counterpart? Third, environmental safety, tested through confined field trials, does the crop harm bees or other beneficial insects, change soil microorganisms, turn weedy, or pass its genes to related plants?

Only when all three checks show the crop is as safe as its conventional counterpart does it move toward approval. If the evidence falls short, regulators can ask for more studies before deciding anything. None of this rests on a single experiment. It's built from years of evaluation across all three areas.

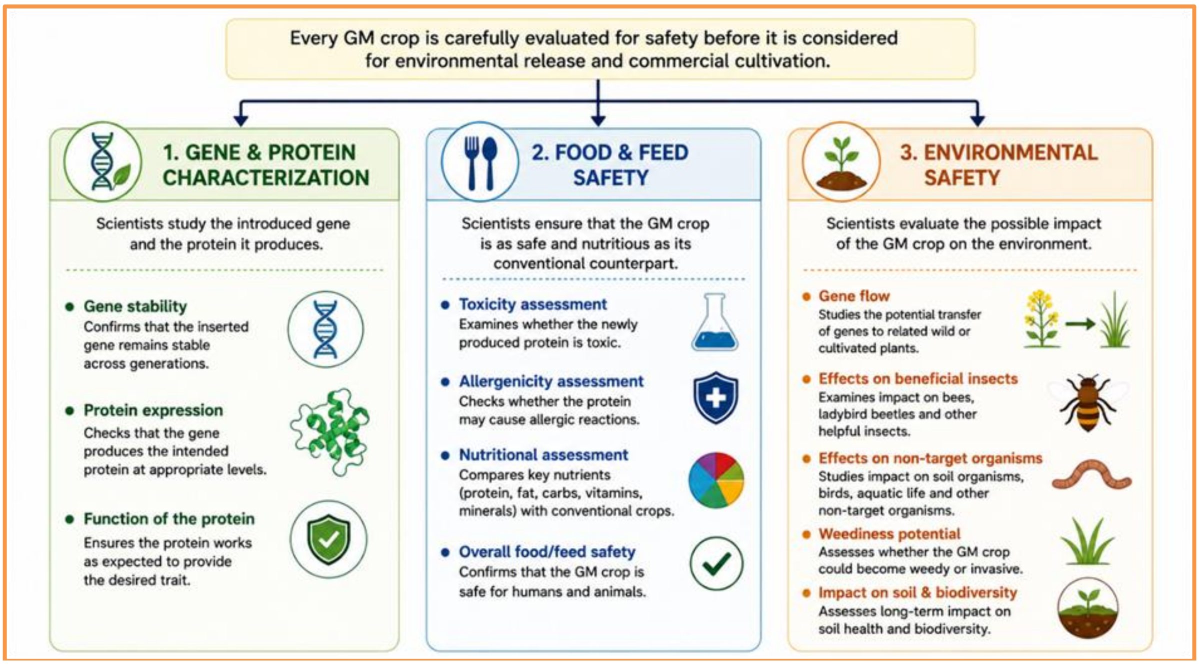

Fig. 3: Three pillars of biosafety assessment for GM crops

Frequently Asked Questions About GM Crops

Even after decades of research and oversight, GM crops still attract misconceptions. Here's what the evidence actually shows.

Are GM crops really tested before approval?

Yes. Every GM crop goes through step-by-step evaluation before cultivation. The gene itself, food and feed safety, and environmental impact are all assessed through lab studies and confined field trials. Regulators check the data at multiple stages and can ask for more studies if the evidence isn't enough.

Why are field trials necessary?

A lab can't fully replicate real field conditions. Confined Field Trials (CFTs) let scientists see how a crop actually performs. Gene stability, effects on beneficial insects, gene flow to related plants, weediness, and overall environmental safety are observed under strict regulatory supervision.

Are GM foods safe to eat?

Only after detailed food safety studies. Scientists compare the GM crop's nutritional makeup with its conventional counterpart and check whether the new protein could cause toxicity or allergic reactions. Approval follows only if the evidence shows it's as safe as conventional varieties.

Do GM crops harm bees and other beneficial insects?

Scientists check this before approval, looking at bees, butterflies, predators, earthworms, and soil microorganisms. The Bt protein in Bt cotton, for instance, targets specific pests by acting on receptors found only in their digestive system. Beneficial insects don't have such receptors, so they're generally unaffected.

Can GM crops create "superweeds" or spread uncontrollably?

Gene flow between plants happens naturally, in conventional crops too. Biosafety evaluation checks whether the introduced gene could spread to related species and whether that would create any environmental risk, comparing how the GM crop behaves against its conventional counterpart before approval.

The point of these evaluations isn't to wave new technology through; it's to make sure each decision is backed by evidence. That's why India assesses every GM crop case by case before it reaches a farmer's field.

Present status and future of GM crops in India

India approved Bt cotton commercially in 2002, and it's still the only GM crop cleared for cultivation. Now covering more than 90% of the country's cotton area. Maize, chickpea, pigeonpea, and sugarcane are at various stages of research and field evaluation. Climate change, new pests, shrinking natural resources, and rising food demand are pushing biotechnology toward new traits: drought tolerance, disease resistance, better nutrition, and adaptation to a changing climate, alongside insect resistance. Whatever the trait, the principle doesn't change: every GM crop still has to clear rigorous scientific evaluation before cultivation. As research moves forward, India's regulatory system will keep balancing innovation against human and environmental safety.

Conclusion

GM crops can help farmers deal with pests, disease, and climate stress, but only if they're actually safe, which is the whole point of India's regulatory system: testing, expert review, and oversight at every stage, from the lab to confined field trials to final approval. None of it runs on assumption. As biotechnology keeps advancing, that evidence-based approach, paired with public understanding and transparent regulation, is crucial. Ultimately, public confidence in biotechnology depends not only on scientific innovation but also on a transparent regulatory system that places safety first.

References

1. Ahamad, S. and Krishna, R., 2026. The genetically modified crop debate: India’s dilemma and way forward. *Food, Nutrition and Health*, *3*(1), p.17.
2. Hasan, M.G., 2025. Impact of genetically modified organisms on meat quality. Open Veterinary Journal, 15(4), p.1536.
3. Ministry of Environment, Forest and Climate Change (MoEFCC) and Biotech Consortium India Limited (BCIL), 2019. *Genetically Modified Crops and Regulations in India: Myths vs Facts*. New Delhi: Government of India.
4. Shukla, M., Al-Busaidi, K.T., Trivedi, M. and Tiwari, R.K., 2018. Status of research, regulations and challenges for genetically modified crops in India. *GM crops & food*, *9*(4), pp.173-188.
5. Yahaya, U., Suleiman, R.A., Hussaini, Y., Hamidu, S.T., Odey, B.O. and Adaaja, B.O., 2025. Environmental risk and biosafety of genetically modified plants. *Nigerian Journal of Biotechnology учредители: African Journals Online (AJOL)*, *41*(2), pp.104-108.