



Editing the Seed, Rewriting the Rules: The Economics of India's Gene-Edited Crop Revolution and its Regulatory Shift

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In 2022, India exempted two categories of genome-edited plants (SDN-1 and SDN-2) from the stringent rules that govern genetically modified (GM) crops. In 2025, the country released the world's first genome-edited rice varieties for farmers. This article explains the technology in plain language and examines its economic promise: higher yields, lower input costs, faster varietal turnover and reduced import dependence. It also asks the harder questions of who captures the gains, whether smallholders will have access, and what lessons Bt cotton offers. We argue that the regulatory shift is a necessary but not sufficient condition for success; farmer welfare will depend on seed pricing, public-sector capacity, intellectual property arrangements and public trust.

Keywords: Genome editing, CRISPR, SDN-1 and SDN-2, Biosafety regulation, Seed Economics, Food Security.

Introduction

Indian agriculture faces a squeeze from three sides. Climate stress is making yields less predictable, soils are degrading under heavy fertilizer use, and farm holdings are shrinking, with more than four in five farmers cultivating less than two hectares (Ministry of Agriculture & Farmers Welfare [MoAFW], 2019). At the same time, the country must feed a growing population and cut its heavy dependence on imported edible oils and pulses. Conventional breeding alone is slow: a new variety can take ten to fifteen years from cross to release. Genome editing offers a shortcut. Tools such as CRISPR-Cas9 act like a molecular word processor, allowing scientists to change a few letters in a plant's own DNA to switch a trait on or off. Unlike transgenic GM crops, the product can be indistinguishable from a plant that arose through natural mutation. India's policy makers recognised this difference in 2022 and, in May 2025, the Indian Council of Agricultural Research (ICAR) released two genome-edited rice varieties (ICAR, 2025). For an economist and a biotechnologist writing together, the moment is instructive: the science has moved quickly, and now the economics will decide whether it reaches the farmer's field.

From GM to Gene Editing: What changed in the Rules?

India's biosafety framework dates to the rules of 1989 under the Environment Act, with the Genetic Engineering Appraisal Committee (GEAC) as the main regulator. In practice, it has approved only one GM food-and-fibre crop for commercial cultivation, Bt cotton in 2002. Bt brinjal was placed under moratorium in 2010, and GM mustard (DMH-11) has been caught in litigation, with the Supreme Court delivering a split verdict in 2024 and asking the government to frame a national policy on GM crops (Supreme Court of India, 2024). In March 2022, the Ministry of Environment, Forest and Climate change exempted SDN-1 and SDN-2 genome-

edited plants, which contain no foreign DNA, from the most demanding provisions of the 1989 Rules. The Department of Biotechnology followed with guidelines for safety assessment. India thus joined a group of countries, including Argentina, Japan and the United States, that regulate edited plants by the product rather than the process. SDN-3 products, which involve inserting foreign genetic material, remain regulated like GM crops.

Table: How India now treats GM and genome-edited crops

Feature	Transgenic (GM) crops	SDN-1/ SDN-2 genome-edited	SDN-3 genome-edited
What changes	Foreign gene inserted (e.g., Bt)	Small edit or precise swap using the plant's own DNA; no foreign DNA in final plant.	Larger intersection of foreign DNA
Regulation	Full biosafety review (GEAC) field trials, state consultations	Exempt from GM rules (2022); simple DBT/ICAR-led check	Treated like GM
Time to market	Often 10+ years; some never approved	Potentially 5-7 years	As for GM
Public debate	Intense, litigated	Emerging, softer	Intense

Source: Authors' summary of MoEFCC (2022) and DBT (2022) guidelines.

The economic effect of this is to lower regulatory cost and time, which are among the largest barriers for public institutions and small seed companies. Regulatory cost is a recognised barrier to innovation: approval of a GM trait for global markets can cost tens of millions of dollars, which only multinational firms can usually afford, and expert estimates suggest that proportionate rules for edited crops would cut this burden sharply. A higher pathway opens the door to a wider set of innovators.

The Science in Brief

Genome editing uses a guide RNA to lead and enzyme to a precise spot in the genome, where it makes a cut. In SDN-1, the plant repairs the cut imperfectly, producing a small change that can silence a gene. In SDN-2 a supplied template guides the repair to produce a specific, known edit. The 2025 rice releases show both the promise and the diversity of applications.

DRR Dhan 100 (Kamala), developed by ICAR-Indian Institute of Rice Research from Samba Mahsuri, edits a gene involved in grain number (CKX2), and is reported to give around 19 percent more yield under trials while maintaining the parent's quality.

Pusa DST Rice 1, developed by ICAR-IARI from MTU 1010, edits the DST gene to improve tolerance to salinity and alkalinity, a quiet but costly problem on millions of hectares.

The Economic Promise

I. Productivity and farm income: Yield and stress tolerance are the clearest benefits. In coastal and delta regions of state like Odisha, salinity ingress and cyclone-driven flooding already reduce rice returns. Meta-analyses of earlier GM crops found average yield gains of 22 % and farmer profit gains of about 68 % and edited crops are yet to build such a record, even a modest yield advantage of 10-20%, if sustained, can be a significant share of net income for a smallholder whose margins are thin. The salt-tolerant trait is likely to be most valuable where alternatives are limited: reclaiming land through gypsum and drainage is costly and slow.

II. Input savings and environmental gains: Editing for disease resistance, nitrogen-use efficiency or drought tolerance can reduce spending on pesticides, fertilizers, and irrigation. With India's fertiliser subsidy bill running into lakhs of crores of rupees each year, traits that deliver the same yield with less nitrogen have a double dividend: lower private cost and lower fiscal burden.

III. Faster breeding and lower R&D cost: By shortening development time and reducing regulatory expenditure, genome editing improves the return on public research. The benefit-

cost logic is straightforward: when development takes five to seven years rather than fifteen, the stream of benefits begins earlier, and discounting works in favour of the technology.

IV. Trade and import substitution: India imports well over half of its edible oil and a large share of pulses. Gene-edited oilseeds with higher yield or better oil profiles could help close this gap without the political baggage that has stalled GM mustard.

Who Captures the Gains? Seeds, Patents and Smallholders

I. Intellectual property: Foundational CRISPR patents are held by a few institutions and licensed through arrangements involving large seed companies. Indian public institutions and start-ups may face licensing costs or freedom-to-operate constraints, even if the regulatory barrier has fallen.

II. Seed pricing and market structure: If genome-edited traits flow mainly through private hybrids, farmers must buy seed every season, and the innovator can charge a premium. Public-sector varieties, such as the rice releases, can be saved and re-used, which keeps costs low but weakens the commercial incentive for rapid seed multiplication.

III. Access and extensions: Adoption economics depends on seed availability, credit, awareness and trust. Past experience shows that technology adoption is uneven when seed supply chains are weak in eastern and rain-fed regions.

A Policy Roadmap

To turn regulatory relief into farm-level impact, we suggest five priorities:

I. Strengthen public-sector breeding and seed multiplication for edited varieties.

II. Create licensing and freedom-to-operate support for public institutions and start-ups

III. Design transparent trait-free and seed-pricing norms before commercialisation, informed by the Bt cotton experience

IV. Invest in extension, farmer demonstration and consumer communication.

V. Build an independent monitoring system that tracks yield, input use, farmer incomes and ecological indicators.

Conclusion

India's decision to treat SDN-1 and SDN-2 genome-edited crops differently from transgenic GM crops marks a notable shift from a precautionary to a more proportionate, product-based approach. The 2025 rice releases show that the technology can move from the laboratory to the policy pipeline within a few years. But the regulatory change has only opened the door. Whether genome editing delivers higher incomes, resilient farms and food security will depend on the economics: who owns the technology, how seeds are priced and delivered, and whether smallholders in places like coastal Odisha can actually benefit. The best outcome requires scientists and economists to work together, so that the same rigour applied to editing the genome is applied to evaluating its impact. If lessons from Bt-cotton are heeded, gene-edited crops can become a public good and not simply another proprietary product.

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