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India's Genome-Edited Rice Revolution: DRR Dhan 100 and Pusa DST Rice 1 for Precision breeding, Higher Productivity and Climate-Resilient Agriculture

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INTRODUCTION

Rice is a backbone of global food security and vital staple crop for billions of people across the world. However, rice production is increasingly constrained by water scarcity, drought, salinity, climate alteration and the depletion of natural resources (Lv et al., 2024). Overcoming these challenges requires advanced breeding tools that can simultaneously improve crop performance and adaptation to variable climatic conditions (Wang eta l., 2022). In a major development in this field, on 4 May 2025, Shri Shivraj Singh Chouhan, Union Minister for Agriculture and Farmers Welfare and President of the Indian Council of Agricultural Research, announced DRR Dhan 100 and Pusa DST Rice 1 as India's first genome-edited rice varieties (Figure 1). The varieties were officially unveiled at the Bharat Ratna C. Subramaniam Auditorium, NASC Complex, New Delhi, representing a historic milestone in the application of genome-editing technology for crop improvement in India. They were also distinguished as some of the earliest genome-edited rice varieties developed for commercial agricultural cultivation worldwide (ICAR-DKMA, 2025).

These rice varieties exemplify the integration of new generation genome-editing technology with conventional breeding methods, illustrating the potential of locus-specific gene modification to improve traits associated with key constraints in rice production. Collectively, these findings demonstrate how genome editing can be employed to address several breeding intentions via the site-specific manipulation of key genes and molecular pathways (ICAR-DKMA, 2025; ICAR-IIRR, 2025). A comparison of their specific breeding targets and desired traits underscores the importance of both Kamala and Pusa DST Rice 1 (Table 1; Figure 2). Jointly, these innovations represent a critical advancement in precision molecular breeding, supporting the enabling the development of high-yielding rice varieties with improved agronomic performance, efficient use of agricultural resources, and greater resilience to abiotic environmental stresses (PIB, 2025). Such advancements play a vital role in meeting the demands of climate-adaptive farming and offer a promising path toward long-term agricultural sustainability.



Figure 1: (A) General development pipeline for genome-edited rice varieties.
(B) Union Minister for Agriculture and Farmers Welfare, Shri Shivraj Singh Chouhan, announcing the development of two genome-edited rice varieties in India at the Bharat Ratna C. Subramaniam Auditorium, NASC Complex, New Delhi.
(C) Research team involved in the development of Kamala**.**
(D) Research team involved in the development of Pusa DST Rice 1**.**

Table 1: Comparative Features of India's Genome-Edited Rice Varieties (DRR Dhan 100 vs. Pusa DST Rice 1)

Feature	**DRR Dhan 100**	**Pusa DST Rice 1**
Developing institute	ICAR-IIRR, Hyderabad	ICAR-IARI, New Delhi
Lead scientist	Dr. Satendra Kumar Mangruthia	Dr. Chinnusamy Viswanathan
Parent/background	Samba Mahsuri (BPT 5204)	MTU 1010
Major edited gene	CKX2	DST
Main breeding objective	More grain number per panicle and productivity	Drought and salinity tolerance
Major advantage	Higher production + shorter duration	Stress resilience
Reported yield advantage	~19% over Samba Mahsuri	~9.66–30.4% under saline/ high soil pH conditions
Crop duration	~130 days	~120 days
Key contribution	Higher productivity, drought resilience, resource efficiency, and lower methane emissions	Kharif–Rabi adaptability and climate resilience

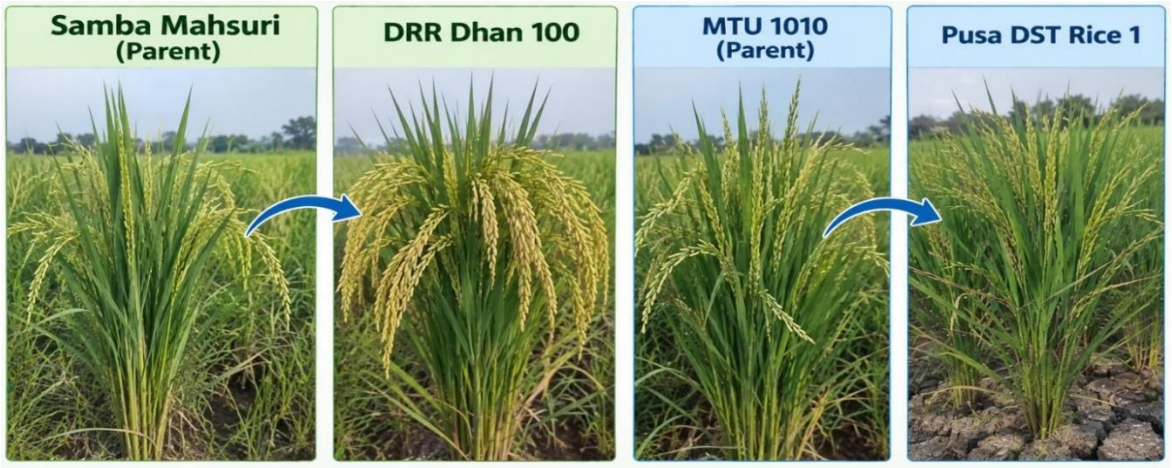


Figure 2: Phenotypic comparison of genome-edited rice varieties and their respective parental lines.

What is genome editing?

Traditional plant breeding improves crop productivity and associated yield components through hybridization, genetic recombination and successive selection of desirable plants based on specific traits. However, incorporating a specific trait through conventional breeding is often time-consuming and may also result in linkage drag the unintended transfer of undesirable background genes (Arya et al., 2020; Lamichhane et al., 2022). In contrast, precision gene editing enables breeders and researchers to introduce site-specific modifications directly at specific genomic loci, bypassing of unwanted linked traits. Among available gene-editing platforms, the CRISPR-Cas system has become an important tool for targeted crop trait improvement (Lamichhane et al., 2022; Wang et al., 2022). Unlike conventional genetic modification (transgenesis), precision genome editing can modify the activity of genes already present in a crop without necessarily introducing non-native DNA from non-host species (Cai et al., 2025). Developing a genome-edited line merely the initial step; a successful variety must undergo rigorous multi-location evaluation and phenotypic assessment prior to available farmers release (Figure 1). In DRR Dhan 100 and Pusa DST Rice 1, CRISPR-Cas-based approaches were used to modify genes influencing grain yield components and abiotic stress responses. According to ICAR, these cultivars were developed without introducing foreign DNA, illustrating the potential of genome edited crops for drive productive, resource-efficient, climate-resilient and sustainable agriculture (ICAR-DKMA, 2025).

DRR Dhan 100

Kamala is a new-generation high-yielding rice cultivar developed at ICAR–Indian Institute of Rice Research (ICAR-IIRR), Hyderabad**,** using Samba Mahsuri (BPT 5204) as the genetic background. The variety was developed by a team comprising Dr. Satendra Kumar Mangruthia, Dr. R. M. Sundaram, Dr. R. Abdul Fiyaz, Dr. C. N. Neerja, and Dr. S. V. Sai Prasad (PIB, 2025; ICAR-IIRR, 2025; Figure 1)**.** CRISPR-Cas genome editing was applied to modify the CKX2 gene, boosting productivity-related traits such as grains per panicle while retaining Samba Mahsuri's premium grain quality characteristics.

Why Was the CKX2 Gene Targeted?

The CKX2 gene plays an important role in cytokinin metabolism, a process that regulates various aspects of plant growth and development, including reproductive development, and grain production. Modulation of CKX2 activity can alter cytokinin levels within the plant and subsequently influence reproductive attributes such as number of grains per panicle (ICAR-DKMA, 2025)**.**

Key Advantages of DRR Dhan 100

In field trials, Kamala recorded approximately 19% higher grain production than Samba Mahsuri**,** with an average yield of 53.7 q/ha and a maximum reported yield of 88.96 q/ha**,** along with improved plant architecture. It matures in about 130 days, approximately 15–20 days earlier than Samba Mahsuri**,** potentially reducing irrigation requirements, nitrogen demand, cultivation costs, and exposure to late-season climatic risks (ICAR-IIRR, 2025). Its shorter duration may also support greater cropping intensity and reduce methane emissions by 20% (32,000 tonnes) associated with prolonged flooded conditions. The variety has additionally been reported to show improved tolerance to moisture deficit and saline stresses, while retaining the desirable grain-quality characteristics of Samba Mahsuri. Its wider adoption could therefore contribute to substantial resource savings, including an estimated 7,500 million cubic metres of irrigation water (Kumar et al., 2025; PIB, 2025)**.**

Pusa DST Rice 1

The second considerable success**,** Pusa DST Rice 1**,** was developed at the ICAR–Indian Agricultural Research Institute (ICAR-IARI), New Delhi**,** using the popular fine-grain rice genotype MTU 1010 as the parental genetic background. Scientists engaged CRISPR-mediated genome editing to alter the DST (Drought and Salt Tolerance) gene**,** with the aim of improving the crop's ability to withstand adverse environmental conditions, especially water deficit, soil salinity, and high soil pH**.** The development of Pusa DST Rice 1 involved the collaborative efforts of Dr. Vishwanathan C, Dr. Gopal Krishnan S, Dr. Santosh Kumar, Dr. Shivani Nagar, Dr. Archana Vats, Dr. Soham Ray, Dr. Ashok Kumar Singh, and Dr. Pranjal Yadav at ICAR-IARI (PIB, 2025; Figure 1). According to ICAR, Pusa DST Rice 1 significantly outperforms MTU 1010 in productivity across saline and alkaline conditions while preserving its desirable grain quality characteristics. By sustaining output in soils where high salinity and high soil pH hinder nutrient balance and water intake, this resilient variety plays a vital role in advancing climate-smart, sustainable agriculture.

Why Is the DST Gene Important?

The targeted DST gene encodes a zinc-finger transcription factor involved in regulating plant responses to drought and salinity stress. Site-specific alteration of this gene through precise genome editing can enhance water and salt-stress tolerance. Pusa DST Rice 1 has considerable potential for cultivation in rice-growing areas where moisture deficit and soil salinity, and alkalinity are major constraints to rice production (ICAR-DKMA, 2025).

Major Benefits of Pusa DST Rice 1

Pusa DST Rice 1 boosts productivity under saline and alkaline soil conditions**,** with reported yield gains of approximately 9.66–30.4%**,** depending on the environment and evaluation situations. It is designed for both Kharif and Rabi seasons and has potential for cultivation in inland, Scientists engaged CRISPR-mediated genome editing to alter the DST (Drought and Salt Tolerance) gene**,** with the aim of improving the crop's ability to withstand adverse environmental conditions, especially water deficit, soil salinity, and high soil pH, and coastal salt-affected rice-growing areas, while retaining the premium grain quality features of MTU 1010 (Kumar et al., 2025; PIB, 2025).

Why is this achievement important for Indian agriculture?

India is striving to increase food production while simultaneously promoting the sustainable use of natural resources. Rice cultivation highly water-intensive and further expanding the frequency and rigidity of abiotic stresses. To address these challenges, ICAR initiated genome-editing research in 2018 under the National Agricultural Science Fund (NASF), focusing on the improvement of two significant

rice varieties, Samba Mahsuri and MTU 1010. The subsequent introduction of DRR Dhan 100 and Pusa DST Rice 1 demonstrates synergistic integration of conventional breeding and precision biotechnology (Kumar et al., 2025; ICAR-IIRR, 2025; PIB, 2025). Scientists used these elite varieties as genetic backgrounds and applied next generation genome editing tools to change specific agronomic traits while retaining their key background varietal characteristics. ICAR has indicated that such advanced technologies could contribute to elevated grain output, water conservation, and the mitigation of agricultural greenhouse gas emissions.

Targeted States and Agro-Climatic Zones

These varieties are intended for cultivation across several rice-growing geographical zones of India, including Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Puducherry, Kerala (Zone VII), Chhattisgarh, Maharashtra, Madhya Pradesh (Zone V), West Bengal (Zone III), Odisha, Jharkhand, Bihar and Uttar Pradesh (ICAR-DKMA, 2025; Kumar et al., 2025).

Genome editing is not the same as conventional GM technology

An important distinction that is often misunderstood is the difference between genome-edited crops and genetically modified (GM) crops. In conventional transgenic GM technology, genetic material from another organism may be introduced into a crop. In contrast, genome editing can make a precise modification to the plant's existing genetic material (Cai et al., 2025; ICAR, 2025). The site-specific genome editing through SDN-1 and SDN-2 approaches, these rice varieties, are exempt from no foreign DNA insertion and are regulated under India's framework for genome-edited plants, subject to appropriate biosafety evaluations and regulatory monitoring (ICAR-DKMA, 2025; PIB, 2025).

CONCLUSION

The release of DRR Dhan 100 and Pusa DST Rice 1 marks a significant breakthrough in India's application of next generation genome editing tools for crop improvement. By merging conventional breeding with targeted gene editing, these newly developed cultivars address distinct production constraints related to crop performance, resource-use efficiency, water-deficit and salinity under adverse climate conditions. These advances highlight the ability of precision breeding to accelerate the improvement of elite rice varieties without sacrificing their core agronomic and grain-quality related traits. With appropriate evaluation, regulatory oversight, and farmer adoption, genome-edited crops promise to strengthen India's long-term agricultural sustainability, climate-resilient, and resource-efficient rice farming system.

REFERENCES

Arya DK, Saini DK, Kumar A, 2020. Transgenic Crops: Better Die a Satisfied Appetite than an Empty Stomach, Agriculture & Food, ISSN: 2581-8317.

Cai, R., Chai, N., Zhang, J., Tan, J., Liu, Y.G., Zhu, Q. and Zeng, D., (2025). CRISPR/Cas system-mediated transgene-free or DNA-free genome editing in plants. *Theoretical and Applied Genetics*, 138(9), 210.

ICAR-IIRR, 2025. *DRR Dhan 100 (Kamala): Novel allele of OsCKX2 for high grain yield, strong culm and early maturity traits*. ICAR-Indian Institute of Rice Research, Hyderabad, India. Available at: ICAR-IIRR Success Story

Indian Council of Agricultural Research, (2025). *Union Agriculture Minister Shri Shivraj Singh Chouhan announces two genome-edited rice varieties developed in India*. Press release, 4 May 2025. Directorate of Knowledge

Management in Agriculture, ICAR, New Delhi, India.

Kumar, N., Singh, A., Sarkar, P.R., Sharma, B., Kumar, S., Aggarwal, N. and Arya, A., (2025). India biotech revolution: The approval of genome-edited rice. *The Bioscan*, **20**(3), pp. 893–897.

Lamichhane, S. and Thapa, S., (2022). Advances from conventional to modern plant breeding methodologies. *Plant Breeding and Biotechnology*, **10**(1), pp. 1–14.

Lv, P., Su, F., Chen, F., Yan, C., Xia, D., Sun, H., Li, S., Duan, Z., Ma, C., Zhang, H. and Wang, M., (2024). Genome editing in rice using CRISPR/Cas12i3. *Plant Biotechnology Journal*, **22**(2), pp. 379–385.

The official PIB press release, dated 4 May 2025, is titled "Union Agriculture Minister Shri Shivraj Singh Chouhan Announces Two Genome-Edited Rice Varieties Developed in India."

Wang, Y., Zafar, N., Ali, Q., Manghwar, H., Wang, G., Yu, L., Ding, X., Ding, F., Hong, N., Wang, G. and Jin, S., (2022). CRISPR/Cas genome editing technologies for plant improvement against biotic and abiotic stresses: Advances, limitations, and future perspectives. *Cells*, **11**(23), 3928.