



Increasing Milk Production in Cattle through Genetic Improvement

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The Indian dairy sector has experienced remarkable growth since independence, with India now ranked as the world's leading milk-producing nation. In 2023–2024, India achieved an annual milk production of 239.30 million tonnes. Crossbred cows contribute significantly to milk production in India, accounting for 31.11% of total milk production and 56.89% of total cow milk production. According to the 20th livestock census, the total cattle population in India is 193.46 million. Exotic and crossbred cattle constitute approximately 26.5% of the total cattle population, with crossbred Jersey holding the largest share at 49.3%, followed by crossbred Holstein Friesian (HF) at 39.3%. The crossbreeding initiatives in India aimed to exploit the milk production potential of exotic breeds while harnessing the disease-resistance traits of indigenous cattle, which are native to the breeding region. In the studied region, Vechur cattle is the indigenous breed, which was primarily used as the recipient breed in which exotic inheritance was introgressed. This was carried out to enhance the milk production potential of the native breed (6).

Genetic improvement programs have significantly influenced cattle milk production in India, particularly within smallholder systems. However, the practical outcomes are shaped by a complex interplay of genetic, environmental, and infrastructural factors (1).

1. Genetic Improvement Programs

- **Progeny Testing and Pedigree Selection:** This program aims to produce high genetic merit bulls, including bulls of indigenous breeds. Progeny testing is implemented for Gir, Sahiwal breeds of cattle, and Murrah, Mehsana breeds of buffaloes. Under the Pedigree selection programme Rathi, Tharparkar, Hariana, Kankrej breed of cattle and Jaffarabadi, Nili Ravi, Pandharpuri and Banni breed of buffalo are covered. So far 3,988 high genetic merit bulls have produced and inducted for semen production. Initiatives like the National Dairy Plan (NDP) have implemented progeny testing (PT) and pedigree selection (PS) programs. Between 2012 and 2018, these programs tested

approximately 2,000 bulls, supplying 1,720 young bulls and replacing about 40% of AI bulls in the country. This has led to measurable improvements in milk yield and reproductive traits (1). Progeny Testing and Pedigree Selection have quantitatively improved milk yields in India, with annual genetic gains ranging from **1% to 1.5%** in organized herds. These programs have been instrumental in transforming India into the world's largest milk producer.

- **Crossbreeding Strategies:** Crossbreeding indigenous breeds with high-yielding exotic breeds, such as Holstein Friesian and Jersey, has been a common practice. For instance, the Frieswal project, a cross between Holstein Friesian and Sahiwal, aims to produce cattle yielding over 4,000 kg of milk with 4% butterfat in a 300-day lactation period (2).
- **Sex-Sorted Semen Production:** The Department has established sex sorted semen production facilities at 5 government semen stations located in Gujarat, Madhya Pradesh, Tamil Nadu, Uttarakhand and Uttar Pradesh. 3 private semen stations are also producing sex sorted semen doses. So far 1.12 crore sex-sorted semen doses from high genetic merit bulls have been produced and made available for Artificial Insemination.
- **Multi-purpose Artificial Insemination Technicians in Rural India (MAITRIs):** Under the scheme MAITRIs are trained and equipped to deliver quality Artificial Insemination services at farmers' doorstep. During the last 3 years 38,736 MAITRIs have been trained and equipped under Rashtriya Gokul Mission.

2. Advanced Genomic Selection

- **Genomic Evaluation Models:** Studies have optimized genomic evaluation models for crossbred cattle in India. For example, research involving 17,650 cows utilized various statistical methods, with heritability estimates for milk yield ranging from 0.20 to 0.43. The single-step genomic best linear unbiased prediction (ssGBLUP) method provided more accurate and less biased genomic estimated breeding values (GEBVs) (4).
- **Genome-Wide Association Studies (GWAS):** GWAS on Vrindavani crossbred cattle identified 70 single nucleotide polymorphisms (SNPs) associated with traits like total lactation milk yield, lactation length, and peak yield. These findings offer potential biomarkers for enhancing production performance (3).

3. Implementation

- **Livestock Health and Disease Control (LH & DC)** is implemented for providing assistance for control of animal diseases like Foot and Mouth Disease, Brucellosis and also to provide assistance to State Governments for Control of other infectious diseases of livestock including dairy animals. Mobile Veterinary Units are established under the scheme to deliver quality livestock health services at farmers doorstep. Under the vaccination programme: (i) more than 99.38 crore vaccinations have been done against FMD including 27.92 crore vaccination performed during current year; and (ii) about 4.36 crore calves vaccinated against Brucellosis under brucellosis control programme

including 1.27 crore calves vaccinated during current year. Under the component of Establishment and Strengthening of Veterinary Hospitals and Dispensaries (ESVHD-MVU), 100% financial assistance is provided towards procurement & customization of Mobile Veterinary Units (MVUs) with recurring operational expenditure in the ratio of 90:10 for North Eastern & Himalayan States; 60% for other States, and 100% for UTs for delivery of veterinary healthcare services through Mobile Veterinary Units (MVUs) through a Toll-Free Number (1962) at farmers' doorsteps which include disease diagnosis, treatment, vaccination, minor surgical interventions, audio-visual aids and extension services. So far 4016 MVUs are operational in 28 states and 58.38 lakh farmers benefitted.

- **Kisan Credit Card (KCC) Facility:** The Government has extended the KCC facility to Animal Husbandry and Fisheries farmers for their working capital requirements. This facility is available to individual or joint borrowers, Joint Liability Groups, or Self-Help Groups, including tenant farmers with owned, rented, or leased sheds.
- **Implementation of In-Vitro Fertilization (IVF) Technology:** To propagate elite animals of indigenous breeds, the Department has established 22 IVF laboratories and has produced 22,896 viable embryos, with 12,846 embryos transferred and 2019 calves born.
- **Data Collection and Management:** Accurate phenotypic and genotypic data are crucial for effective genetic improvement. However, in low-input production systems, data collection is often inconsistent, hindering the accuracy of selection programs (7).

4. Technological and Policy Interventions

- **Digital Livestock Management:** The integration of IoT and AI-based solutions helps farmers monitor cattle health, fertility cycles, and milk yield. Real-time data tracking and mobile applications guide farmers on breeding windows, disease alerts, and feed optimization, enhancing breeding efficiency (5).
- **Government Schemes:** Programs like the Rastriya Gokul Mission and Kamdhenu Yojna provide interest-free loans and subsidies to establish high-yielding animal units, promoting genetic improvement at the grassroots level (4).

5. Future Directions

- **Customized Genomic Tools:** Development of breed-specific genomic chips, such as INDUSCHIP for cattle and BUFFCHIP for buffaloes, aims to enhance the accuracy of genomic selection tailored to indigenous breeds (7)
- **Sustainable Breeding Programs:** Emphasis on community-based breeding programs and conservation of indigenous breeds ensures genetic diversity and adaptability to local environments, contributing to long-term sustainability.

In summary, while genetic improvement initiatives have positively impacted milk production in Indian cattle, especially through crossbreeding and genomic selection, challenges persist in smallholder systems. Addressing these requires a multifaceted approach involving technological advancements, policy support, and community engagement to ensure sustainable and equitable improvements in dairy productivity.

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