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# Innovations in Breeding and Biofortification for Advancement in Finger Millet (*Eleusine coracana* L.) Production and Nutritional Enhancement

*Masoom Ankit Patel[1], Chaitanya Tiwari[1], Pragnya Rout[2] and Sonali Rajput[1]
[1]Department of Seed Science and Technology, Hemvati Nandan Bahuguna Garhwal University, Srinagar, Garhwal, Uttarakhand, India
[2]Department of Soil Science and Agricultural Chemistry, Vikram University, Ujjain, Madhya Pradesh, India
*Corresponding Author's email: masoom_23134325007@hnbgu.edu.in

Finger millet (*Eleusine coracana*), a resilient cereal crop from the Poaceae family within the monocot group, plays a crucial role in enhancing food availability and reducing malnutrition. This grain is especially valued for its rich levels of calcium, iron, and dietary fiber, making it a vital energy and protein source for populations in arid regions. According to Thapliyal and Singh (2015), it offers multiple health-related and nutritional benefits. Due to its high calcium (0.38%), fiber (18%), and phenolic content (0.03%–3%), finger millet holds strong potential in addressing nutrient deficiencies. In recent times, progress in breeding methods and nutritional enhancement has contributed to both better crop yield and improved nutritional standards, which are essential in meeting the global demand for sustainable and healthy food options.

Primarily cultivated for personal consumption, finger millet is commonly grown in dry tropical areas, particularly across Africa and Asia. Originally native to Ethiopia (Chandra *et al.*, 2016), the crop has now spread globally as a key and nourishing grain. Beyond its use for food, it is also grown for animal feed, fresh forage, and preservation as fodder (Bellundagi *et al.*, 2018). Dida *et al.* (2008) estimated that finger millet accounts for around 10% of the total 30 million tons of millet produced globally. India remains the top producer, covering 26.6% of the global cultivation area and 83% of the millet area in Asia (Warisa *et al.*, 2025). The grain is extensively grown in states such as Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Kerala, Uttarakhand, Odisha, Jharkhand, Maharashtra, Assam, Meghalaya, Arunachal Pradesh, Tripura, and Nagaland.

Fig: Distribution of Finger millet (Elusine corocana L.) (Warisa et al, 2025)

## Nutritional Importance of Finger Millet

Finger millet is a rich source of essential micronutrients and bioactive compounds. It is notably high in calcium, iron, zinc, and dietary fiber, which are critical for addressing widespread nutritional deficiencies in developing regions. Studies have shown that finger millet contains approximately 344 mg of calcium per 100 g, which is significantly higher than that found in other major cereals (Gaikwad *et al*, 2023). Moreover, its high fiber content contributes to better digestive health and glycemic control, making it beneficial for individuals with diabetes and metabolic disorders (Sharma & Arora, 2019). Despite its nutritional benefits, the full potential of finger millet remains underutilized due to limitations in production systems and the crop's relatively low commercial profile.

## Constraints in Finger Millet Production Systems

Although finger millet is a hardy crop that can grow in drought-prone and nutrient-poor soils, several challenges continue to limit its yield and widespread adoption. These include inadequate genetic diversity, susceptibility to pests and diseases, and insufficient research investments into modern farming practices. While traditional farming methods have sustained local production, these approaches often fail to fully capitalize on the crop's potential. Researchers agree that global climate change can impact crop yields and is a critical issue for achieving food security (Wang *et al*, 2018).

## Enhancing Yield and Resilience by enhancing breeding in Finger millet

The development of high-yielding, resilient varieties of finger millet is key to improving its adoption and productivity. Traditional breeding techniques, such as selection for drought tolerance and disease resistance, have made notable contributions, but recent advances in molecular breeding are beginning to offer more precise and efficient solutions. Marker-assisted selection (MAS) and genomic selection (GS) are two such techniques that allow for the identification of beneficial traits at the genetic level, thus accelerating the development of improved varieties (Nelson *et al.,* 2018). For example, researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have developed finger millet varieties with enhanced resistance to common pests and diseases, such as the finger millet blast fungus (*Pyricularia grisea*), and improved tolerance to drought stress. These varieties offer a more stable yield under adverse conditions, which is crucial for regions prone to climate variability. Additionally, the use of hybridization has been explored to shorten the maturation period of finger millet, enabling farmers to harvest multiple crops in a single year, thus increasing overall productivity and food security (Dinesh *et al*., 2021).

## Biofortification of Finger Millet

Biofortification, the process of enhancing the micronutrient content of crops, is a critical strategy for addressing widespread deficiencies in essential nutrients like iron, zinc, and vitamin A. Finger millet's biofortification potential is particularly promising, given its ability to accumulate high levels of calcium and its capacity for bioavailability enhancement (Sreenivasulu *et al*., 2021). Biofortification of this crop has the potential to directly alleviate iron and zinc deficiencies, which affect millions of people, particularly in rural and impoverished regions where diverse diets are not easily accessible.

Several breeding programs have focused on developing biofortified varieties of finger millet by selecting for higher levels of bioavailable iron and zinc. Research by the Food and Agriculture Organization (FAO) has demonstrated that biofortified finger millet can significantly improve dietary iron and zinc intake, helping to combat the global burden of micronutrient deficiencies (FAO, 2022). Biofortification has also been achieved through improved agronomic practices, such as optimizing soil health and nutrient management, which can further enhance the crop's micronutrient content (Fu *et al*., 2019).

## Genetic Engineering and CRISPR-Cas9 in Finger Millet Biofortification

Recent breakthroughs in genetic engineering, particularly the advent of CRISPR-Cas9 gene-editing technology, offer an exciting frontier for improving the nutritional quality of finger millet. CRISPR-Cas9 allows for precise modification of the plant's genome to enhance the expression of key genes involved in micronutrient biosynthesis or improve nutrient uptake efficiency. Researchers have already begun exploring CRISPR-Cas9 to increase the bioavailability of iron and zinc in biofortified crops, a process that could be applied to finger millet. Additionally, gene editing could allow for the development of varieties that are not only more nutritious but also better suited to withstand the stresses of climate change, such as temperature extremes and drought. The combination of genetic engineering and traditional breeding methods holds the potential to create a new generation of finger millet varieties that are both nutritionally superior and more resilient to environmental challenges.

## Policy and Socio-economic Considerations for adopting Finger millet

For the potential benefits of improved finger millet varieties to be realized, widespread adoption must be encouraged through both policy support and public awareness initiatives. Policies that promote research and development in the agricultural sector, provide incentives for the cultivation of biofortified crops, and support market access for smallholder farmers are essential for scaling up the cultivation of finger millet. Furthermore, increasing consumer awareness of the health benefits of finger millet can boost its demand, especially in urban markets where its consumption is less common.

Integrating finger millet into national food security programs, school feeding initiatives, and government nutrition schemes could also enhance its uptake, particularly in countries with high levels of malnutrition. By promoting finger millet not only as a staple crop but also as a dietary supplement, policymakers can help reduce the reliance on less nutritious grains like rice and maize.

## Conclusion

The future of finger millet lies in leveraging cutting-edge technologies such as molecular breeding, biofortification, genetic engineering etc. to enhance its yield, nutritional profile, and climate resilience. By addressing both production constraints and nutritional deficiencies, finger millet has the potential to contribute significantly to food security and health in vulnerable regions. However, for these innovations to be fully realized, collaborative efforts between scientists, policymakers, and farmers are essential. With sustained investment and strategic support, finger millet could become a key player in the global fight against malnutrition and food insecurity.

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