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Global perspectives on molecular breeding: Bridging innovation and food security.

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Introduction

Global food security demands coordinated policy and research efforts. Initiatives like the CGIAR Genebank Platform and the FAO's Global Plan of Action for Plant Genetic Resources promote data sharing, capacity-building, and equitable access. As the global population surges toward 10 billion by 2050, the pressure on agriculture to deliver more food with fewer resources intensifies. Climate change, soil degradation, water scarcity, and emerging pests threaten crop productivity and sustainability. In response, molecular breeding has emerged as a transformative approach to crop improvement one that leverages genetic insights and biotechnological tools to enhance yield, resilience, and nutritional quality. Across continents, molecular breeding is bridging innovation and food security, offering tailored solutions to diverse agricultural challenges [1, 2].

Public-private partnerships are essential to scale innovations and ensure that molecular breeding benefits all stakeholders from biotech firms to smallholder farmers. Molecular breeding integrates molecular biology techniques with traditional plant breeding to accelerate and refine the development of improved crop varieties. It includes: Transcriptomics, proteomics, and metabolomics for understanding complex traits. These tools enable breeders to target traits such as drought tolerance, disease resistance, and nutrient efficiency with unprecedented precision [3, 4].

In Asia, where rice and wheat dominate diets, molecular breeding has focused on yield stability and nutritional enhancement. Golden Rice, engineered to produce beta-carotene, addresses vitamin A deficiency in Southeast Asia. In India and China, MAS and CRISPR have been used to develop drought-tolerant and disease-resistant rice varieties, improving productivity under climate stress [5, 6].

Africa faces unique challenges low-input farming, erratic rainfall, and nutrient-poor soils. Molecular breeding has enabled the development of drought-tolerant maize and biofortified cassava with higher iron and zinc content. The African Orphan Crops Consortium is applying genomic tools to underutilized crops like millet and sorghum, enhancing food diversity and resilience [7, 8].

European molecular breeding emphasizes sustainability and environmental stewardship. Genomic selection is widely used in wheat and barley to reduce fertilizer dependence and improve disease resistance. However, strict GMO regulations have slowed the adoption of gene-edited crops, prompting debates on policy reform to embrace non-transgenic innovations. In North and South America, molecular breeding is driving large-scale agricultural innovation. In Brazil, soybean and maize varieties have been improved using transgenic and CRISPR technologies to resist pests and tolerate drought. In the U.S., molecular breeding supports precision agriculture, integrating AI and big data to optimize crop performance [9, 10].

Conclusion

Molecular breeding is more than a scientific breakthrough—it's a strategic imperative for global food security. By bridging innovation with practical solutions, it empowers agriculture to meet the demands of a changing world. As nations embrace molecular tools and collaborate across borders, the future of farming becomes smarter,

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more resilient, and more equitable. The seeds of tomorrow's harvest are being sown today—in labs, fields, and policies around the globe.

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