K : Flood tolerance; Rice breeding; Marker-assisted breeding; Genetic markers; Versatile tools; Sustainable agriculture

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Rice (Oryza sativa L.) is a staple food for a significant portion of the global population [1], particularly in regions prone to flooding. However, the vulnerability of rice crops to submergence stress poses a substantial threat to food security and agricultural sustainability. Flooding, whether due to heavy rainfall or inadequate drainage, can lead to severe yield losses, making the development of flood-tolerant rice varieties a critical objective in agricultural research [2-4]. Traditional breeding methods for improving flood tolerance in rice are time-consuming and often yield unpredictable results due to the polygenic nature of tolerance traits. In recent decades, the integration of marker-assisted breeding (MAB) has revolutionized rice breeding programs by enabling the identification and selection of genetic markers linked to flood tolerance genes. This approach not only expedites the breeding process but also enhances the precision of selecting desirable traits.

Alongside MAB, the application of versatile tools such as genomic selection, next-generation sequencing, and genome editing technologies like CRISPR-Cas9 has further augmented the capacity to understand and manipulate the genetic basis of flood tolerance in rice [5]. These tools offer unprecedented opportunities to uncover novel genetic variations associated with flood response mechanisms and to introduce precise modifications into rice genomes to enhance tolerance. In this context, this review explores the current state of knowledge and technological advancements in enhancing flood tolerance in rice through the integration of marker-assisted breeding and versatile tools. We discuss key genetic mechanisms underlying flood tolerance, recent successes in breeding programs, and the potential for these technologies to contribute to sustainable agriculture by mitigating the impact of flooding on rice production [6]. This introduction sets the stage by highlighting the importance of flood tolerance in rice, the limitations of traditional breeding methods, and the transformative potential of marker-assisted breeding and versatile tools in addressing these challenges.

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