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Current and Future of Plant Breeding Strategies to Cope with Climate Change: A Review

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Abstract

Climate change poses significant challenges to global food security and agricultural productivity, necessitating the development of climate-resilient crop varieties. This review explores current and future plant breeding strategies aimed at coping with climate change. Various approaches, including traditional and cutting-edge techniques, wild relatives, and climate-informed strategies, have been employed to develop climate-resilient crop varieties. Traits such as heat and drought tolerance, early flowering, and maturation have been bred into varieties to mitigate the impact of changing climate conditions. Genetic mapping has identified genomic regions and candidate genes associated with stress tolerance, enabling the incorporation of stress tolerance alleles into high-yielding genetic backgrounds. Furthermore, advanced techniques such as gene editing, genomic selection, high-throughput phenotyping, and omics technologies have revolutionized plant breeding for climate adaptation, offering precise and efficient means of introducing desired traits. The integration of these cutting-edge techniques holds immense potential for developing climate-resilient crop varieties. However, challenges related to regulatory frameworks, intellectual property rights, and public acceptance must be addressed for responsible and sustainable adoption. A holistic, multidisciplinary approach that links breeding and climate science is crucial to strengthen adaptation and ensure food security in the face of accelerated climate change. Continued advancements in gene editing, genomic selection, high-throughput phenotyping, and omics technologies will further enhance breeding efficiency and precision. The future of plant breeding lies in the development of "climate-smart" varieties and cultivation systems resilient to future conditions with a focus on addressing farmer needs and global food security.

Keywords: Crop; Climate Change; Plant Breeding; Agriculture

Introduction

Climate change is now a fact, according to the overwhelming scientific consensus. Climate change poses significant challenges to global food security and agricultural productivity through rising temperatures, shifting precipitation patterns, and more frequent extreme weather events [1]. While many countries find it challenging to effectively address climate change through their existing measures, turning to favorable agricultural practices remains a promising avenue for mitigating the impact of climate change. Using advanced scientific achievements in the field of plant genetic is seen a potent tool for developing plant varieties that are resilient to climate challenges. This paper reviews current approaches in plant breeding to develop climate-resilient traits and discusses future opportunities

and challenges for coping with climate change.

Current Approaches in Plant Breeding for Climate Change

Efforts in plant breeding for climate change adaptation are diverse, incorporating traditional and cutting-edge techniques, wild relatives, and climate-informed strategies. These approaches collectively contribute to the development of climate- resilient crop varieties, which are essential for ensuring food security in the face of a changing climate. Crops bred to tolerate heat, drought, flooding, and salinity will become increasingly important under climate change [2-4]. Traits like early flowering and maturation have been bred into varieties to avoid heat and drought stress during critical reproductive periods [5]. Genetic mapping has identified genomic regions and candidate genes associated with stress tolerance, advancing our understanding of the genetic and molecular bases of these traits [6].

Breeding efforts utilize these genomic tools and resources, along with high-throughput phenotyping, to introgression stress tolerance alleles into high-yielding genetic backgrounds [7]. Multiplication testing evaluates performance of candidate varieties across a range of climate conditions to identify broadly adapted genotypes [8].

Cutting-edge techniques such as gene editing, genomic selection, high-throughput phenotyping, and omics technologies are revolutionizing plant breeding for climate adaptation [9]. These techniques offer precise and efficient means of introducing desired traits and accelerating breeding efforts. By harnessing the potential of these techniques, plant breeders can develop climate-resilient crop varieties that contribute to global food security in the face of climate change.

Future Directions

The integration of cutting-edge techniques in plant breeding holds immense potential for developing climate-resilient crop varieties. Continued advancements in gene editing, genomic selection, high-throughput phenotyping, and omics technologies will further enhance breeding efficiency and precision. However, challenges such as regulatory frameworks, intellectual property rights, and public acceptance need to be addressed to ensure responsible and sustainable adoption of these techniques.

Plant breeding is a major component of efforts to develop climate-resilient agriculture. Significant advancement has been achieved in breeding stress tolerance traits, thanks to genomic tools, high-throughput techniques and public-private partnerships. However, accelerated climate change requires an intensified focus on "climate-smart" varieties and cultivation systems resilient to future conditions. A holistic, multidisciplinary approach linking breeding, climate science and stakeholder needs shows promise to strengthen adaptation and food security worldwide in the decades ahead.

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