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Drought-ready plant resilience: Harnessing nano-biotechnology techniques for swift screening and selection of organic crop varieties

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ABSTRACT

Drought, an ever-looming threat to agriculture, is of paramount concern in organic crop production. The traditional methodologies employed for screening and selecting drought-resistant crops are characterized by their laborious and time-intensive nature. However, the integration of molecular techniques has wrought a revolutionary transformation, expediting the identification and precise selection of crop varieties resilient to drought stress. This review explores the intricate relationship between molecular technologies and the imperative to streamline the screening and selection process for drought-resistant crops in organic agriculture. The advantages of these molecular methodologies are delved into, revealing the potential to accelerate the breeding of crops capable of withstanding the challenges posed by water scarcity. However, this exploration is full of challenges. From scalability issues to cost-effectiveness, ethical implications, and environmental impact, a comprehensive examination is crucial for a nuanced understanding of integrating these technologies into the organic crop production landscape. Moreover, this review extends beyond the present, casting a discerning eye toward the prospects of molecular techniques in pursuing sustainable agriculture. The potential for refinement, overcoming challenges, and synergies with other emerging technologies is crucially considered as a resilient and environmentally conscious agricultural future is envisioned. In essence, this exploration serves as a comprehensive guide, shedding light on the transformative power of molecular techniques in navigating the intricate path towards drought-resistant crop varieties, thereby fostering sustainable practices in the face of an increasingly unpredictable climate.

1. Introduction

Drought stress poses a formidable challenge in organic crop production, necessitating the development of resilient varieties capable of thriving in unpredictable climates shaped by climate change (Koohafkan and Altieri, 2016). Traditional methods for identifying drought-resistant crops involve subjecting plants to water stress conditions, but their limitations in time and resources impede prompt variety release for organic agriculture (Ali et al., 2014; Gupta et al., 2023; Gammatantrawet et al., 2023). The integration of molecular techniques in recent years has ushered in a revolutionary era for drought-resistant crop development. Genomic and biotechnological advancements offer a precise and efficient means of screening and selecting plants with heightened resilience to drought conditions (Bapela et al., 2022). This review critically explores the transformative role of molecular technologies, emphasizing their manifold advantages, including reduced time and resource requirements and early identification of molecular markers indicative of drought resistance. Notably, the review delves into the challenges of these modern approaches, such as the cost implications of molecular techniques, and underscores the necessity for rigorous field validation. The urgency of this review lies in bridging the gap between traditional and modern approaches, elucidating the potential of molecular technologies to revolutionize organic crop production amid escalating climate uncertainties. By emphasizing promises and challenges, the review aims to guide future research and facilitate informed

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