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A Review

Performance assessment of photosynthetic efficiency, adaptation and yield potential in wheat, rice and maize for building resilience under climate change

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Abstract : This review paper provides a comprehensive comparative analysis of photosynthetic efficiency and yield potential in three major cereal crops—wheat (*Triticum aestivum*), rice (*Oryza sativa*), and maize (*Zea mays*). Focusing on the distinct C3 and C4 photosynthetic pathways, the paper explores the anatomical, biochemical, and physiological differences that underlie their varying productivity under current and future climate scenarios. Key findings highlight maize's superior radiation use efficiency (RUE) and water-use efficiency (WUE) due to its C4 pathway, while wheat and rice exhibit adaptive strengths in cooler and high-humidity environments, respectively. The review also examines innovative bioengineering strategies, canopy optimization techniques, and climate-resilient traits aimed at enhancing photosynthetic performance. Despite plateauing yield gains, advancements in genetic modification, such as Rubisco engineering and synthetic photorespiratory bypasses, offer promising avenues for sustainable yield improvement. The paper concludes with a discussion of challenges, including physiological trade-offs and technological limitations, and emphasizes the need for integrated approaches to meet global food security demands.

Key Words : Photosynthetic efficiency, C3 and C4 pathways, Wheat, Rice, Maize, Yield potential, Climate resilience, Bioengineering, Radiation use efficiency, Water-use efficiency, Rubisco, Photorespiration, Crop improvement

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Introduction

Global food security imperative :

The twenty-first century presents a formidable challenge: feeding a global population projected to exceed 9.7 billion by 2050. To meet this demand, food production must increase by at least 60%, yet the expansion of arable land is constrained by environmental, political, and logistical limits (Fischer and Edmeades, 2010). Today, agriculture occupies nearly 38% of the Earth's terrestrial surface, contributing around 25% of global greenhouse gas emissions (Furbank *et al.*, 2015). Therefore, intensifying crop productivity on existing land—rather

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