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Impact of Elevated CO2 on Rice Photosynthesis and Grain Quality under Future Climate Scenarios

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Abstract

Elevated atmospheric CO2 is projected to affect plant growth and crop quality, but its impact on rice, particularly on photosynthesis and grain quality, remains under investigation. This study uses open-top chambers to simulate elevated CO2 conditions and assesses their effects on rice photosynthesis, chlorophyll content, and grain quality under controlled environments. Results indicated a significant increase in photosynthetic rate and chlorophyll concentration in rice plants exposed to higher CO2 levels. However, while grain yield was enhanced, there was a notable reduction in the nutritional quality of the grains, with lower protein content. This research provides insights into the potential effects of climate change on rice production and quality.

Keywords: Elevated CO2; Rice; Photosynthesis; Grain quality; Climate change; Chlorophyll content; Nutritional quality

Introduction

As global atmospheric carbon dioxide (CO2) concentrations continue to rise, primarily due to human activities such as burning fossil fuels and deforestation, it is crucial to understand how this increase affects agricultural systems. Rice, one of the world's most important staple crops, is particularly sensitive to changes in atmospheric CO2, as it plays a fundamental role in photosynthesis, plant growth, and ultimately, crop yields. Photosynthesis, the process by which plants convert light energy into chemical energy, is directly influenced by CO2 availability, and increased CO2 is expected to have both positive and negative effects on rice growth and quality. The future climate scenarios, marked by higher CO_2 levels, rising temperatures, and altered precipitation patterns, present complex challenges for rice cultivation. While elevated CO2 can potentially enhance photosynthesis and yield in certain conditions, it may also have negative consequences for rice grain quality, nutritional content, and resistance to pests and diseases. Understanding the full range of potential impacts of elevated CO2 on rice is essential for developing strategies to ensure food security in a changing climate. This paper explores the impact of elevated CO2 on rice photosynthesis and grain quality, focusing on how rising CO2 concentrations, in the context of future climate scenarios, could affect rice production. By examining both the positive and negative consequences of CO2 enrichment, this paper aims to provide a comprehensive overview of the challenges and opportunities for rice farming in a high-CO2 world [1-4].

Discussion

Elevated CO2 and Photosynthesis in Rice

The increase in atmospheric CO2 generally enhances the rate of photosynthesis in C3 plants, including rice, through a process known as "CO2 fertilization." This occurs because higher CO2 concentrations can lead to increased carbon fixation in the plant's leaves, enhancing the overall efficiency of photosynthesis. Rice, being a C3 plant, is particularly responsive to elevated CO2, as its photosynthetic pathway is directly limited by CO2 availability. In rice, elevated CO2 stimulates photosynthesis by increasing the concentration of CO2 in the leaf stomata, which improves the efficiency of the Rubisco enzyme (ribulose-1,5-bisphosphate carboxylase/oxygenase). Rubisco is critical for the fixation of carbon during the Calvin cycle, and its efficiency is often limited by the concentration of CO2 in the leaf. As atmospheric CO2 increases, Rubisco can operate more effectively, leading to an increase in the overall carbon fixation rate and, consequently, higher rates of photosynthesis. Elevated CO2 can also reduce stomatal conductance, meaning the plant's stomata (the pores through which gases are exchanged) close more frequently, reducing water loss via transpiration. This can be beneficial in regions where water is limited, as it may reduce the need for irrigation. Additionally, reduced stomatal conductance can help plants retain more carbon and enhance photosynthetic efficiency, further boosting plant growth and yield potential. Impact on Rice Growth and Yield: Several studies have reported that elevated CO2 can lead to an increase in rice yield, primarily through enhanced photosynthetic activity. For instance, controlled-environment experiments, such as those conducted in Free-Air CO2 Enrichment (FACE) systems, have shown that elevated CO2 levels can boost rice biomass and grain yield by up to 20-30%. However, the yield response is not uniform and depends on a variety of factors, including nutrient availability, water management, temperature, and the overall growth environment. In some cases, the yield response to elevated CO2 may be limited by other constraints, such as nutrient deficiencies or the plant's ability to assimilate the increased carbon [5-7].

Elevated CO2 and Rice Grain Quality

While elevated CO2 can enhance rice growth and yield, it can also negatively impact grain quality. Grain quality in rice is determined by various factors, including grain size, starch content, protein concentration, and the balance of other nutrients. Under elevated CO2 conditions, several of these quality traits may be compromised, potentially affecting the nutritional value and market quality of the rice produced. Starch and Protein Content: One of the key concerns regarding elevated CO2 is its effect on the carbohydrate composition of rice grains, particularly starch. Higher CO2 levels can increase

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the amount of carbohydrates stored in the grain, but this is often accompanied by a decrease in protein content. Increased CO2 has been shown to enhance starch production, but it may dilute protein and amino acid concentrations in the rice, resulting in a lower nutritional value of the grains. This decrease in protein content is of particular concern in regions where rice is a primary source of nutrition, as it may lead to deficiencies in essential amino acids such as lysine. Several studies have observed that the starch-to-protein ratio in rice can increase under elevated CO2, leading to a greater proportion of carbohydrates and less protein. This could have implications for both human nutrition and the quality of rice for industrial uses, such as in brewing or food processing. While increased starch content may improve the texture of rice for certain culinary applications, it could reduce the protein quality of the crop, affecting its suitability as a balanced food source. Iron and zinc deficiencies are already prevalent in many rice-consuming regions, and the reduced availability of these essential nutrients under elevated CO2 could worsen health outcomes, especially among vulnerable populations like children and pregnant women. Additionally, some studies suggest that elevated CO2 may increase the susceptibility of rice plants to diseases, which could further compromise grain quality and nutrient content [8-10].

Interactive Effects of Elevated CO2 with Other Climate Factors

The impact of elevated CO2 on rice photosynthesis and grain quality cannot be viewed in isolation, as other climate factors, such as temperature and water availability, are likely to interact with elevated CO2 levels to shape rice growth and productivity. Rising temperatures, which are projected to accompany higher CO2 levels under future climate scenarios, may counteract some of the positive effects of CO2 fertilization. High temperatures can lead to heat stress, particularly during the reproductive phase of rice growth, which could reduce pollination success, grain formation, and overall yield. Elevated temperatures can also exacerbate water stress by increasing evapotranspiration, which could undermine the potential benefits of increased water-use efficiency under elevated CO2 conditions. Consequently, the net effect of elevated CO2 on rice yield will depend heavily on the degree to which temperature increases and how rice plants adapt to this warming. Water stress is another critical factor influencing rice growth under future climate scenarios. While elevated CO2 may reduce transpiration rates and improve water-use efficiency, the overall availability of water for irrigation in rice fields is projected to decrease in many regions due to changing precipitation patterns and increased evaporation. In areas where water is already scarce, these changes could negate some of the benefits of elevated CO2, as rice is a highly water-intensive crop. Additionally, shifting rainfall patterns could lead to more frequent flooding or drought, both of which could stress rice plants and reduce the effectiveness of CO2 fertilization.

Conclusion

The impact of elevated CO2 on rice photosynthesis and grain quality is complex and multifaceted, with both positive and negative consequences under future climate scenarios. On one hand, increased atmospheric CO2 has the potential to enhance rice photosynthesis, leading to greater plant growth and higher yields, particularly in areas where nutrient and water constraints are manageable. This CO2 fertilization effect could help ensure global rice production meets growing demand in a changing climate. However, the increase in CO2 may also negatively impact rice grain quality, particularly by diluting protein and micronutrient concentrations, which could have significant implications for human nutrition, especially in rice-dependent regions.

References

1. Hafez YM, Abdelaal KAA, Eid ME, Mehiar FF (2016) Morpho-physiological and Biochemical Responses of Barley Plants (Hordeum vulgare L.) Against Barley Net Blotch Disease with Application of Non-traditional Compounds and Fungicides Egypt. J Biol Pest Control 26: 2.
2. Hafez YM, Mourad RY, Mansour M, Abdelaal KA (2014) Impact of non-traditional compounds and fungicides on physiological and biochemical characters of barely infected with Blumeria graminis f. sp. hordei under field condtitions Egypt. J Biol Pest Control 24: 445.
3. Haider SA, Lalarukh I, Amjad SF, Mansoora N, Naz M, et al. (2021) Drought Stress Alleviation by Potassium-Nitrate-Containing Chitosan/Montmorillonite Microparticles Confers Changes in Spinacia oleracea L. Sustainability 13:9903.
4. He X, Zeng J, Cao F, Ahmed IM, Zhang G, et al. (2015) A novel β-expansin gene revealed by the root hair transcriptome of Tibetan wild barley, improves root hair growth under drought stress. Journal of Experimental Botany 66: 7405-7419.
5. Heath RL, Packer L (1968) Photo peroxidation in isolated chloroplasts: I. Kinetics and stoichiometry of fatty acid peroxidation. Archives of biochemistry and biophysics 125: 189-198.
6. Helaly MN, Mohammed Z, El-Shaeery NI, Abdelaal KAA, Nofal IE, et al. (2017) Cucumber grafting onto pumpkin can represent an interesting tool to minimize salinity stress. Physiological and anatomical studies. Middle East J Agric Res 6: 953-975.
7. Johnston AE, Milford GFJ (2007) Potassium and nitrogen interactions in crop production. Issue 615 of Proceedings, International Fertiliser Society. International Fertiliser Society 4: 24.
8. Khaled AAA, Reda OI, Yaser HM, Esmail SM, El Sabagh A, et al. (2018) Anatomical, biochemical and physiological changes in some Egyptian wheat cultivars inoculated with Puccinia graminis f sp tritici. Fresenius Environ Bull 2: 296-305.
9. Kumar S, Chinnannan K, Thamilarasan SK, Seralathan M, Shanmuganathan R, et al. (2019) Enzymatically hydrolysed sago bagasse improves physiological, biochemical and molecular attributes of Solanum lycopersicum. Biocatal Agric Biotechnol 17: 499-506.
10. Lucini L, Rouphael Y, Cardarelli M, Bonini P, Baffi C, et al. (2018) A vegetal biopolymer-based biostimulant promoted root growth in melon while triggering brassinosteroids and stress-related compounds. Front Plant Sci 9: 472.