From Salinity to Nutrient-Rich Vegetables in Protected Cultivation

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Salinity, a significant abiotic stressor, imperils vegetable growth, yield, and quality. According to the FAO, approximately 1.5 million hectares of farmland are rendered unproductive each year due to soil salinization. Projections suggest that by 2050, nearly half of the world's cultivable land will be impacted by escalating salinity levels as a direct consequence of climate change. Moreover, elevated salinity levels jeopardize vegetable nutritional quality. In particular, protected cultivation systems, responsible for 60% of the global vegetable industry's economic value, encounter notable challenges in managing salinity due to limitations in water runoff and drainage mechanisms. Therefore, it is crucial to understand the intricate mechanisms that control salinity and use this knowledge to improve plant tolerance to these conditions. In this study, we explore strategies to effectively mitigate the detrimental impacts of salinity on vegetable crops cultivated within protected environments. Several approaches have been proposed to effectively reduce the harmful effects of salinity stress, including salinity tolerance and plant breeding, grafting, soilless culture, regulation of environmental conditions, external chemical interventions, utilization of plant growth-promoting microorganisms, and a paradigm shift in reevaluating our crop management methods. Additionally, we investigate the benefits of controlled moderate salinity adjustments in protected cultivation to enhance their nutritional content. As a result of metabolic reprogramming, vegetables fortify themselves by synthesizing phytonutrients, health-promoting compounds, in their produce. Thus, moderate salinity or nutrient solution increases typically raise total soluble solids, sugar, vitamin C, phenols, lycopene, and antioxidants in most fruit vegetables. Though generally applicable to leafy vegetables, exceptions like lettuce and wild rocket may show inconsistencies, potentially reducing some quality traits. Given the impracticality of desalinating all areas, soilless greenhouses in saline, arid regions can be utilized to optimize limited land resources. Blending brackish local water with rainwater creates a balanced, nutrient-rich solution that enables the growth of high-quality, nutrient-dense vegetables. The slight salinity stress can enhance crop taste and nutrition, increasing beneficial compounds such as minerals, vitamins, and secondary metabolites in vegetables. This innovative model showcases how renewable energy and sustainable farming can be harmonized, providing a resilient approach to food production in challenging environments. Interdisciplinary approaches are essential to develop sustainable solutions for managing salinity in protected cultivation systems. This will ensure the resilience of vegetable production in the face of changing environmental conditions.

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