Unraveling the Mechanisms of Duckweed Tolerance to UV-B Radiation Stress: Insights Into Adaptive Plant Responses

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Environmental changes, including rising atmospheric carbon dioxide levels and increasing ozone pollution, continue to alter Earth's atmosphere. Ozone layer depletion leads to increased levels of UV-B radiation reaching Earth's surface. This risks human health, and challenges plant growth and agricultural productivity. UV-B radiation can disrupt photosynthesis, damage DNA, increase the production of harmful reactive oxygen species, and reduce crop yields. Therefore, developing UV-B-tolerant plants is crucial for sustaining agricultural productivity and ensuring global food security. In this study, duckweed (Spirodela polyrhiza) plantlets were exposed to varying durations of UV-B radiation. After exposure, the plantlets recovered under normal growth conditions and were sampled at 0, 12, and 24 hours for lipidomics and RNA-Seq analysis. Changes in membrane lipids were analyzed using mass spectrometry, and two upregulated genes in response to UV-B stress were functionally characterized in Arabidopsis thaliana. Our results indicate that UV-B stress in duckweed led to the degradation of chloroplast lipids and increased accumulation of triacylglycerols enriched in 18:3 unsaturated fatty acids via active membrane lipid modification. RNA-Seq analysis revealed the upregulation of the suppressor of gamma response 1 (SOG1) and retinoblastoma-related protein (RBR1) genes in UV-B-treated duckweed. The ectopic expression of SOG1 and RBR1 from duckweed in Arabidopsis enhanced tolerance to UV-B stress. Furthermore, these plants exhibited UV-B stress tolerance and normal photosynthesis. These findings provide the foundation for developing UV-B-resistant crops to enhance agricultural resilience and productivity in the face of increasing environmental stressors.

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