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A ABA-induced triacylglycerol accumulation and lipid remodeling in Lemna minor toward metabolic engineering of duckweed

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Duckweeds are among the fastest-growing flowering plants and represent promising aquatic biomass resources for food, feed, bioenergy, and other value-added compounds. However, the endogenous mechanisms controlling carbon allocation and lipid accumulation in duckweeds remain poorly understood. Here, we investigated abscisic acid (ABA)-induced lipid remodeling in *Lemna minor*. Treatment with 1 μM ABA caused a pronounced and sustained increase in triacylglycerol (TAG), reaching approximately 2.9-fold higher levels than in untreated plants. Time-course analysis showed that TAG continued to accumulate over seven days. Lipidomic profiling revealed extensive remodeling of plastidial and extraplastidial membrane lipids. In particular, reduced monogalactosyldiacylglycerol suggested that membrane-derived fatty acids may contribute to TAG synthesis. ABA strongly induced diacylglycerol acyltransferase genes involved in the terminal step of TAG assembly, while repressing fatty acid desaturase genes, resulting in lower polyunsaturated fatty acid levels and increased proportions of oleic and linoleic acids. Confocal microscopy further demonstrated substantial lipid droplet accumulation in both fronds and chloroplast-containing roots. Notably, sustained ABA-induced TAG accumulation was particularly prominent in *L. minor* and was not observed to a comparable extent in other duckweed species or in Arabidopsis thaliana under identical conditions. These findings reveal a species-specific link between ABA signaling, membrane lipid turnover, and carbon storage in duckweed. Building on these findings, we are establishing a Korean duckweed collection to explore natural variation in lipid metabolic traits. We are also developing transformation-based approaches to modify carotenoid and lipid composition. Together, these efforts integrate duckweed biodiversity, stress physiology, and metabolic engineering toward sustainable biotechnological applications.

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References

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