ABSTRACT

DISSECTING THE ROLE OF PEROXISOMES IN MODULATING ENVIRONMENTAL STRESS RESPONSE AND PHOTOSYNTHESIS

By

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Peroxisomes are essential organelles that house a wide array of metabolic reactions important for plant growth and development. These organelles also interact with other organelles to support cellular functions. However, our knowledge regarding the role of peroxisomal proteins in various biological processes, including plant stress response and photosynthesis, is still incomplete. To address this question at the systems level, I exploited in silico analysis, mutant screens and in-depth physiological and biochemical characterizations. First, I used microarray data to generate a comprehensive view of transcript level changes for Arabidopsis peroxisomal genes during development and under abiotic and biotic stress conditions. Second, mutants of LON2 protease and the photorespiratory enzyme hydroxypyruvate reductase 1 (HPR1) were identified to have enhanced susceptibility to drought, suggesting the involvement of peroxisomal quality control and photorespiration in drought resistance. Third, I conducted a comprehensive peroxisomal mutant screen, in which 147 mutants of 104 Arabidopsis genes encoding peroxisomal proteins were subjected to an automated screening system, the Dynamic Environment Phenotype Imager (DEPI). This screen identified multiple peroxisomal proteins required for robust photosynthesis efficiency under dynamically changing light, including peroxisomal biogenesis and division proteins, photorespiratory proteins, and a NAD+ transporter protein PXN, which was found to be an additional player in photorespiration. Fourth, further characterization of the photorespiratory mutants provided insights into the molecular mechanisms regarding how the blocking of photorespiration alters photosynthetic efficiency. My data supported an integrated model for the events that occur in the photorespiration mutants, where metabolites and molecules resulting from the block of photorespiration inhibit triose phosphate isomerase

(TPI) activity, compromise photosystem integrity, reduce photosystem subunit abundance, decrease proton efflux and diminish ATP synthase conductivity, induce cyclic electron flow (CEF) and activate energy dissipation. In summary, my work has provided significant insights into the connection between peroxisomal function and drought stress response and the links between photorespiration and photosynthesis. Knowledge gained from my dissertation research opens up new avenues to further investigate environmental stress response, photosynthesis, photorespiration and interorganellar communication.