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The Lhcb8 antenna protein reshapes the functional architecture of the photosystem II supercomplex in Arabidopsis thaliana

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The photosystem II (PSII) supercomplex (SC) of higher plants is a (multi)protein-pigment assembly performing the initial steps of photosynthetic electron transport consisting of water oxidation and photochemical plastoquinone reduction. In angiosperms, the PSII SC is equipped with three LHCB4-6 monomeric pigment-binding proteins which connect the dimeric core complex with the peripheral antennae composed of trimeric LHCB1-3 complexes. In Arabidopsis thaliana, LHCB4 is encoded by three gene isoforms: Lhcb4.1, Lhcb4.2, and Lhcb4.3. While LHCB4.1 and LHCB4.2 share high sequence similarity and are constitutively expressed, the latter is divergent both in terms of sequence similarity and for being exclusively expressed under persistent abiotic stress. Therefore, it has been renamed as LHCB8.
In this work, we constructed an Arabidopsis thaliana genotype depleted of the products of both Lhcb4.1 and 4.2 genes and exclusively accumulates the LHCB8 protein. The results demonstrate that LHCB8 replaces LHCB4.1 and LHCB4.2 in the CP29-binding site of the PSII SC, preventing the association of the LHCB6 subunit and leading to a reduction of LHCB3 levels. Upon biochemical investigation, the LHCB8-expressing plants displayed a smaller PSII SC compared to the wild type, which possibly results in a lower photon-harvesting capacity. Moreover, cryo-EM analysis revealed a loose arrangement of peripheral antenna complexes in the Lhcb8-containing PSII SC, potentially reducing the antenna-core energy transfer rate. The structural alterations are caused by a shorter C-terminal domain of LHCB8 compared with LHCB4.1/4.2 and the absence of two chlorophyll ligands. LHCB8-expressing plants displayed a smaller PSII functional antenna and lower non-photochemical quenching (NPQ) capacity than wild-type plants. Altogether, our results suggest that the induction of LHCB8 expression reduces photon harvesting in response to excess light. Therefore, the Lhcb8 gene may be considered a viable Lhcb target in plant biotechnology to optimize the balance between light-harvesting and photoprotection in crops.

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