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The Water-Water Cycle Is Essential for Chloroplast Protection in the Absence of Stress

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Abstract

Maintaining electron flow through the photosynthetic apparatus, even in the absence of a sufficient amount of NADP+ as an electron acceptor, is essential for chloroplast protection from photooxidative stress. At least two different pathways are thought to participate in this process, i.e. cyclic electron flow and the water-water cycle. Although the function of the water-water cycle was inferred from a number of biochemical and physiological studies, genetic evidence for the function of this cycle is very limited. Here we show that knockdown Arabidopsis plants with suppressed expression of the key water-water cycle enzyme, thylakoid-attached copper/zinc superoxide dismutase (KD-SOD), are suppressed in their growth and development. Chloroplast size, chlorophyll content, and photosynthetic activity were also reduced in KD-SOD plants. Microarray analysis of KD-SOD plants, grown under controlled conditions, revealed changes in transcript expression consistent with an acclimation response to light stress. Although a number of transcripts involved in the defense of plants from oxidative stress were induced in KD-SOD plants, and seedlings of KD-SOD plants were more tolerant to oxidative stress, these mechanisms were unable to compensate for the suppression of the water-water cycle in mature leaves. Thus, the localization of copper/zinc superoxide dismutase at the vicinity of photosystem I may be essential for its function. Our studies provide genetic evidence for the importance of the water-water cycle in protecting the photosynthetic apparatus of higher plants from photooxidative damage.

Keywords: water-water cycle, copper-zinc superoxide dismutase, chloroplast protection, photooxidative stress,

Full text

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