Regulation of chloroplast biogenesis by a novel chloroplast thioredoxin NTRC

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Thioredoxins are small regulatory proteins, which catalyze disulphide-dithiol interchange in their target proteins, thus being crucial for the regulatory redox networks in cellular compartments. Thioredoxin reductases (NTR) mediate the internal and external signals to thioredoxins. Thioredoxin systems in chloroplast are remarkable complex with several thioredoxins and thioredoxin-like proteins and two thioredoxin reductases, ferredoxin-thioredoxin reductase and the NADPH-thioredoxin reductase (NTRC). Chloroplast thioredoxins are demonstrated to control several metabolic processes in chloroplast and to protect plastids from oxidative stress. Here we provide evidence that a thioredoxin system is also involved in the regulation of chloroplast biogenesis in mesophyll cells.

Recently-discovered chloroplast NADPH-thioredoxin reductase (NTRC) is a unique multidomain NTR enzyme comprising both the NTR and thioredoxin sequences within the protein. We have dissected the impact of NTRC in chloroplasts. Knockout of *NTRC* severely reduced the growth of *Arabidopsis thaliana* (1). Transcript and metabolite profiling revealed severe developmental and metabolic defects in *ntrc* plants, especially, if plants were grown under short 8-hour light period. The number of chloroplasts per cell and the level of chlorophyll in leaves were significantly reduced in the knockout *ntrc* plants. Transmission electron microscopy illustrated a distorted biogenesis of chloroplasts in *ntrc* plants. A series from the regular to severely distorted chloroplasts with abnormally distributed thylakoid membranes is found from a single *ntrc* mesophyll cell. Genes encoding critical regulatory enzymes in chlorophyll biosynthesis were differentially expressed in *ntrc* plants. We propose that NTRC contributes the redox regulation of chlorophyll biosynthesis and/or to the control of thylakoid membrane formation. The distorted chloroplast biogenesis probably is the primary cause for the retarded *ntrc* growth, whereas the involvement of NTRC in the redox control of starch metabolism may further deteriorate the fitness of *ntrc* plants.

1) Lepistö et al (2009) Plant Physiol 149, 1261-1276