A Role for Differential Rca Isoform Expression in C4 Bioenergy Grass Thermotolerance?

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Project Goal: Enhancement of crop production of C4 bioenergy grass by modifying posttranslational modification of Rubisco activase.

Rubisco activase (Rca) uses energy from ATP hydrolysis to remodel the conformation of Rubisco protein (ribulose-1,5-bisphosphate carboxylase/oxygenase), allowing dissociation of inhibitory sugar phosphates from Rubisco active sites, thereby facilitating CO_2 fixation. In Arabidopsis and rice, a single Rca gene generates two protein isoforms (Rca-α and Rca-β) by alternative splicing. The C-terminal extension (CTE) found in the α-isoform contains the two redox-sensitive Cys residues that are known to regulate activity. In addition, Arabidopsis Rca is phosphorylated at Thr-78 (T78) in the dark, which appears to serve a regulatory role in growth and photosynthesis. Despite the knowledge of Rca in C3 plants, little is known about the role of Rca in C4 plants where Rubisco is confined to bundle sheath chloroplasts. Our studies focus on determining the impact of these posttranslational modifications (PTMs) of Rca on C4 plant performance with the rationale that regulation of Rca activity at low light may restrict the ability of photosynthesis to respond to rapid changes in irradiance and as a result, constrain the light use efficiency of photosynthesis. We found that three C4 plants (sorghum, setaria and maize) contain separate genes for the Rca isoforms and Rca-α contains T78 phosphosite and Cys residues in CTE. Interestingly, the Rca-α isoforms were expressed only at high temperature (>40ºC) and the Rca-α proteins were slowly degraded at 25ºC. Gas exchange data suggest the Rca-α expressing sorghum and setaria performed photosynthesis less effectively than the control. Collectively, the results suggest that Rca-α of C4 may play a role at high-temperature tolerance via a redox-sensing mechanism.

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