

FUNDING PROGRAM FOR NEXT GENERATION WORLD-LEADING RESEARCHERS

Project Title: Elucidation of molecular mechanism of C₄ evolution aim at engineering C₄ crop

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1. Background of research

C₄ crop such as maize, sorghum and sugarcane possess CO₂ concentration mechanisms to fix CO₂, which is called C₄ photosynthesis. Therefore, in C₄ crop, water use efficiency, nutrient use efficiency and productivity is higher than C₃ crop. Despite the massive investigation and many trials of introduction of C₄ enzyme into C₃ crop, engineering of C₄ photosynthesis in C₃ crop has not been succeeded yet. C₄ photosynthesis appears to be a recent evolutionary innovation of land plants, possibly driven by survival advantage in the hot, often dry or nutrient-poor soils of the tropics and subtropics. There are 8,000 to 10,000 species of C₄ plants classified into 18 families including monocots and dicots. In a recent study, C₄ plants was reported to be arisen 62 times independently from different C₃ ancestors. C₄ photosynthesis is suggested to be achieved via C₃-C₄ intermediate stage by alteration of several master genes or its regulatory sequences for expression.

2. Research objectives

Research object is to identify the master genes and its regulatory sequences for expression inducing alteration of C₃ photosynthesis into C₄ photosynthesis. For this study, we perform comparative analysis of gene expression and genome sequence in several genera which contain C₃, C₃-C₄ intermediate and C₄ species.

3. Research characteristics (incl. originality and creativity)

For engineering of C₄ photosynthesis in C₃ crop, we propose to introduce master genes inducing C₄ photosynthesis that might be modified in the C₄ evolution. In previous studies, transgenic C₃ plants over-expressing C₄ cycle enzymes were produced; however, those plants often showed growth inhibition due to unbalanced metabolism or unbalanced energy sink-source. Introduction of genes based on information of evolutionary process is considered to solve these problems because master genes are expected to change expression of many genes secondly and thirdly.

4. Anticipated effects and future applications of research

Our study will contribute to identify the master genes inducing C₄ photosynthesis that will be enable us to produce GM C₄ crop such as C₄ rice which is expected to make a second green revolution.