

Emerging model systems for functional genomics analysis of crassulacean acid metabolism

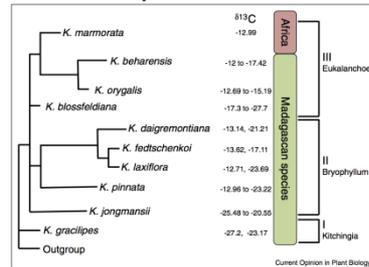
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Background: The water-conserving mode of photosynthesis known as crassulacean acid metabolism (CAM) is a strategic target for synthetic biology to engineer more productive C_3 crops for a warmer and drier world. Optimal operation of CAM requires a series of metabolic enzymes, membrane-localised metabolite transporters and their cognate regulatory proteins, but little is known about the minimal gene set that is indispensable for efficient CAM. Here, we reviewed candidate model CAM species that will underpin rapid advances in understanding of the functional genomics of CAM. Particular emphasis was placed on species in the genus *Kalanchoë* that are readily transformed, and for which our project has generated genomic resources.

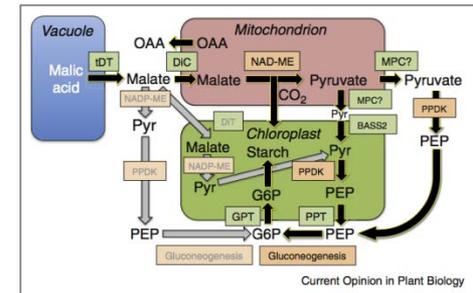
Approach:

- An overview was presented of the importance and value of achieving a comprehensive understanding of the functional genomics of CAM to underpin forward engineering and biodesign of CAM.
- The power of applying amenable model CAM species for resolving the components of the CAM genetic blueprint was argued.
- A particular emphasis was placed on the genus *Kalanchoë* due to their ease of stable transformation and the availability of draft genome sequences for several species.

Both molecular phylogenetic and physiological approaches provide evidence for the rapid divergence for the CAM trait across the genus *Kalanchoë*



Transgenic loss-of-function studies in *Kalanchoë* have revealed the most likely route for malate decarboxylation in the light during CAM (black arrows); thereby refining understanding of the minimal parts-list required for CAM biodesign



Significance:

- This review highlighted the power of using transgenic approaches to test the operational significance of candidate CAM genes through the adoption of *Kalanchoë* species as functional genomics models.
- A framework of candidate model *Kalanchoë* species was proposed, ranging from basal species that perform C_3 photosynthesis with inducible CAM, through to more derived species that perform strong CAM.
- Coverage was also provided for a range of other potential model CAM species that will provide unique insights into CAM convergent evolution through the application of comparative genomics approaches.

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