Engineering of a CO_2-fixing gene from desert plant *Agave* improves both plant growth and stress tolerance

U.S. DEPARTMENT OF ENERGY | Office of Science

Background

- It has been challenging to simultaneously improve growth and stress tolerance in plants.
- Desert plant *Agave americana* uses crassulacean acid metabolism (CAM) for CO_2 fixation during the night, which is mediated by an enzyme called phosphoenolpyruvate carboxylase 1 (AaPEPC1).

Approach

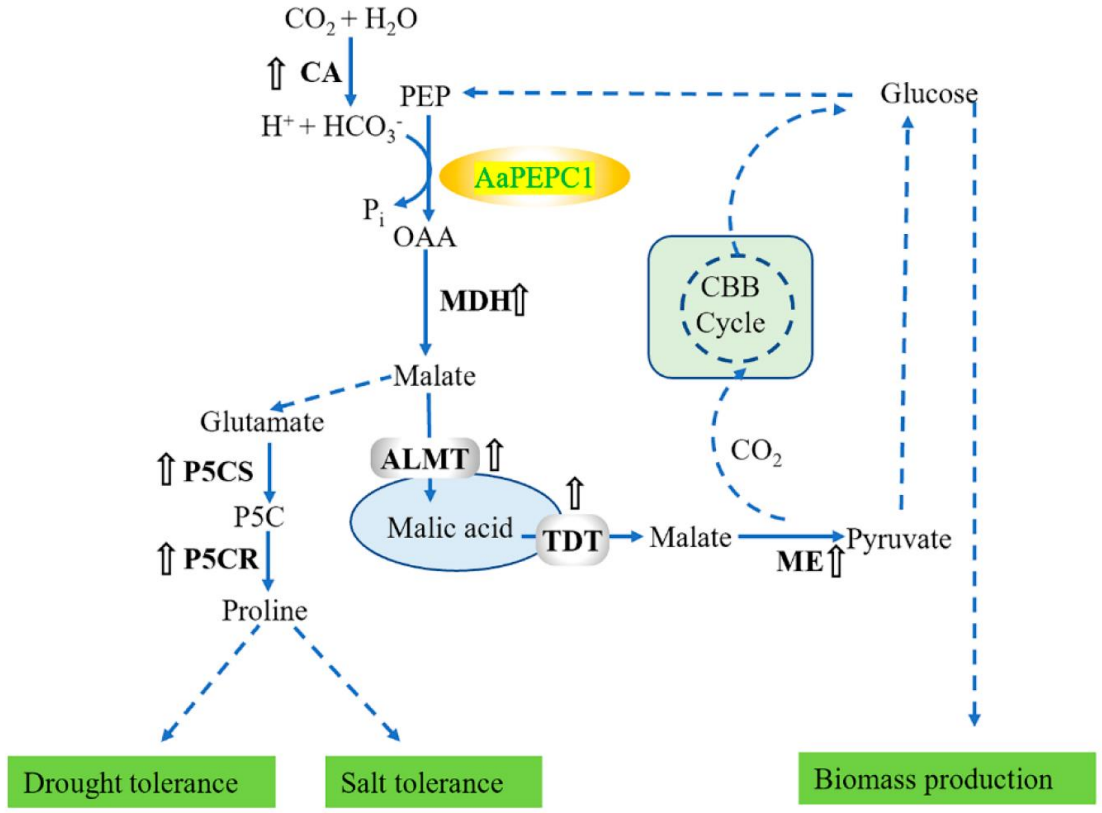
- The gene encoding AaPEPC1 was cloned from *Agave* and engineered into tobacco using *Agrobacterium*-mediated transformation.
- The transgenic tobacco plants were characterized to determine the impact of AaPEPC1 overexpression on gene expression, metabolite accumulation, and plant growth under normal and stress conditions.

Outcome

- In comparison with wild-type controls, transgenic tobacco plants expressing AaPEPC1 showed a higher photosynthetic rate and biomass production under normal condition.
- AaPEPC1 overexpression enhanced proline biosynthesis, and improved salt and drought tolerance in the transgenic plants.
- The metabolic changes which were caused by AaPEPC1 overexpression up-regulated the expression of multiple CAM pathway genes.

Significance

- Our findings open a new door to the simultaneous improvement of growth and stress tolerance in plants, including target biofeedstocks.



Molecular mechanism underlying the beneficial pleiotropic effects of AaPEPC1: Overexpression of AaPEPC1 upregulated the expression of two genes (P5CS and P5CR) involved in proline biosynthesis, resulting in enhanced tolerance to drought and salt stresses. In transgenic plants expressing AaPEPC1, the expression of multiple CAM pathway genes (CA, MDH, ALMT, TDT and ME) was up-regulated, leading to improved photosynthesis and biomass production.

Liu D., Hu R., Zhang J., Guo H.-B., Cheng H., Li L., Borland A.M., Qin H., Chen J.-G., Muchero W., Tuskan G.A., Yang X. 2021. "Overexpression of an *Agave* phosphoenolpyruvate carboxylase improves plant growth and stress tolerance." *Cells* 10: 582. doi.org/10.3390/cells10030582

THE CENTER FOR BIOENERGY INNOVATION