Secrets of succulents' water-wise ways revealed

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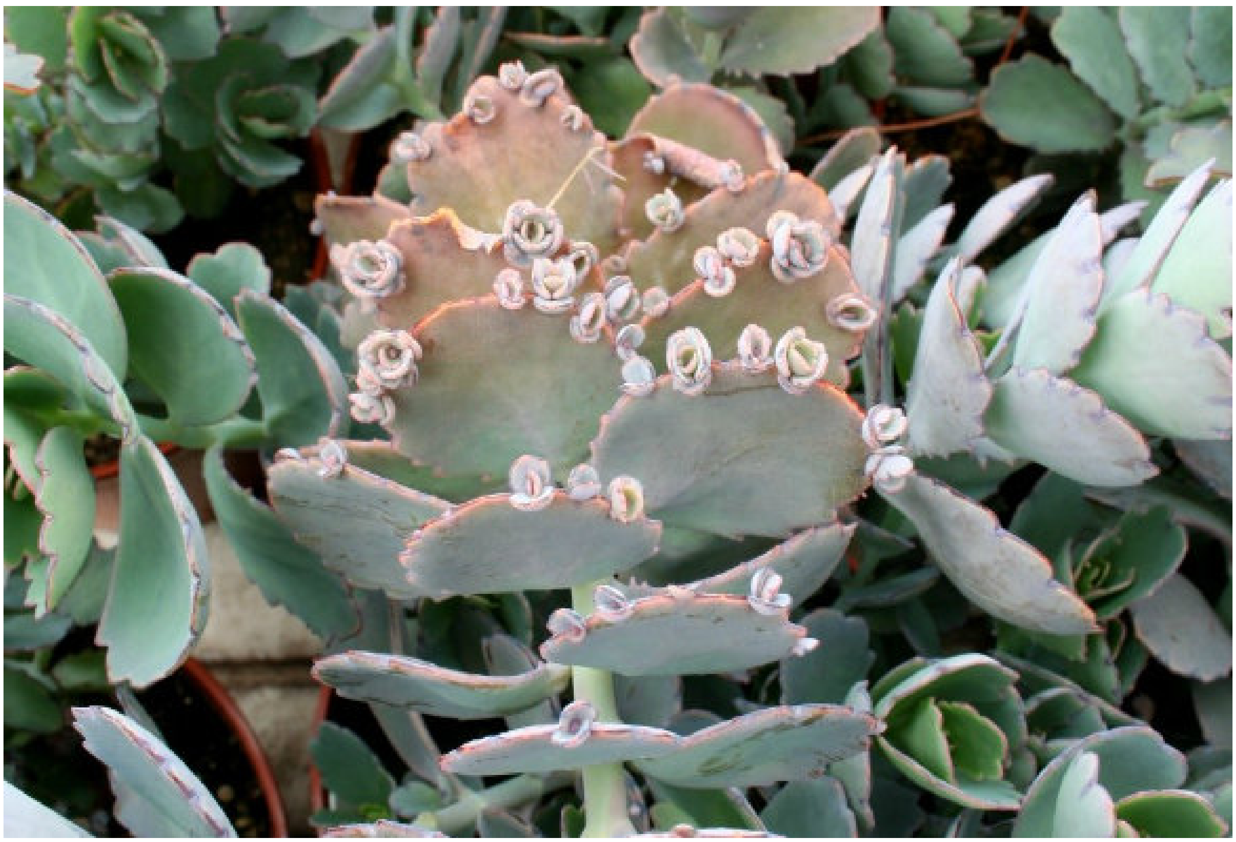

Kalanchoë fedtschenkoi. Credit: Dr James Hartwell

Plant Scientists at the University of Liverpool have revealed new insights into the mechanisms that allow certain plants to conserve water and tolerate drought.

The research, which is published in *The Plant Cell*, could be used to help produce new crops that can thrive in previously inhospitable, hot and dry regions across the world.

Drought resistant plants, such as cacti, agaves and succulents, make use of an enhanced form of photosynthesis known as crassulacean acid metabolism, or CAM, to minimise water loss.

Photosynthesis involves taking carbon dioxide from the atmosphere to convert into sugars using sunlight. Unlike other plants, CAM plants are able to take up CO2 during the cooler night, which reduces water loss, and store captured CO2 as malic acid inside the cell, allowing its use for photosynthesis without water loss during the next day.

CAM photosynthesis is regulated by the plant's internal circadian clock, which allows plants to differentiate and pre-empt day and night and adjust their metabolism accordingly. However, relatively little is known about the exact molecular processes that underpin the optimal timing of CO2 being stored and released in this unique way.

A team of researchers at the University's Institute of Integrative Biology looked at an enzyme of interest called PPCK that is involved in controlling the conversion of CO2 to its overnight stored form (malic acid; the fruit acid that makes apples taste sharp) and back again. They wanted to know whether PPCK is a necessary component for engineering CAM photosynthesis and tested this by switching the PPCK gene off in the succulent CAM plant Kalanchoë fedtschenkoi.

They found that, for CAM to work properly, the cells must switch on PPCK each night driven by their internal circadian clock. When they prevented Kalanchoë from making PPCK at night, the plants could only capture a third of the CO2 captured by the normal plants.

In addition, they found that the plants that were unable to make PPCK each night had alterations in their circadian clock, a surprising finding that suggests metabolites associated with CAM communicate time-of-day information into the plant's central timekeeper.

Dr James Hartwell commented: "Drought is a key cause of global crop losses, so understanding the mechanisms that some desert-adapted plants have evolved to survive water stress is vital for engineering improved drought tolerance in crop species.

"Our work demonstrates that ongoing efforts to engineer CAM photosynthesis into other plants will need to include PPCK. The unexpected complexity we revealed in the relationship between PPCK, CAM and the circadian clock also highlights the need for continued research into CAM processes before we can fully understand and exploit their ways."

More information: Susanna F. Boxall et al. Phosphorylation of Phosphoenolpyruvate Carboxylase Is Essential for Maximal and Sustained Dark CO2Fixation and Core Circadian Clock Operation in the Obligate Crassulacean Acid Metabolism SpeciesKalanchoë fedtschenkoi, *The Plant Cell* (2017). DOI: 10.1105/tpc.17.00301

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