Carbon assimilation in plants under stressful and changing environments

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Aim

To characterise variation in the CO_2-assimilation pattern in different varieties of *Kalanchoe blossfeldiana*, under well watered and drought conditions.

Introduction

K. blossfeldiana varieties are known to have the capacity to be induced to crassulacean acid metabolism (CAM), a photosynthetic adaptation to arid environments. It is however not known if all varieties of this species have this capacity or some varieties are impaired in the expression of CAM. Our hypothesis was that finding natural variants of CAM induction/expression among *K. blossfeldiana* would facilitate the isolation of key regulatory genes of the pathway and help in the effort of transferring this sophisticated adaptation to drought in key crops. In addition CAM expression was monitored in leaves of different ages to check the impact of carbohydrates on CAM expression. Understanding and manipulation of plant genomics in order to produce more efficient crops for food, feed and biofuels is becoming a pressing issue in the modern world. An ideal solution to prevent a food crisis in the future would be to use marginal land to grow crops and CAM plants are particularly adapted to these environments.

Objectives

- **Map carbon assimilation** in different varieties of *K. blossfeldiana*, using a BINOS gas exchange analyser, over the 24-hour day/night course.
- **Measure organic acid levels in leaves at dawn and dusk** to assess CAM expression.
- **Measure internal sugar and starch levels** to check availability of carbon substrate for CAM expression.

Figure 1. A mature *Kalanchoe blossfeldiana* plant used in the study. Leaves have been removed from the upper half of the plant for carbohydrate and organic acid analysis. Lower leaves were used in gas exchange analysis to monitor carbon assimilation.

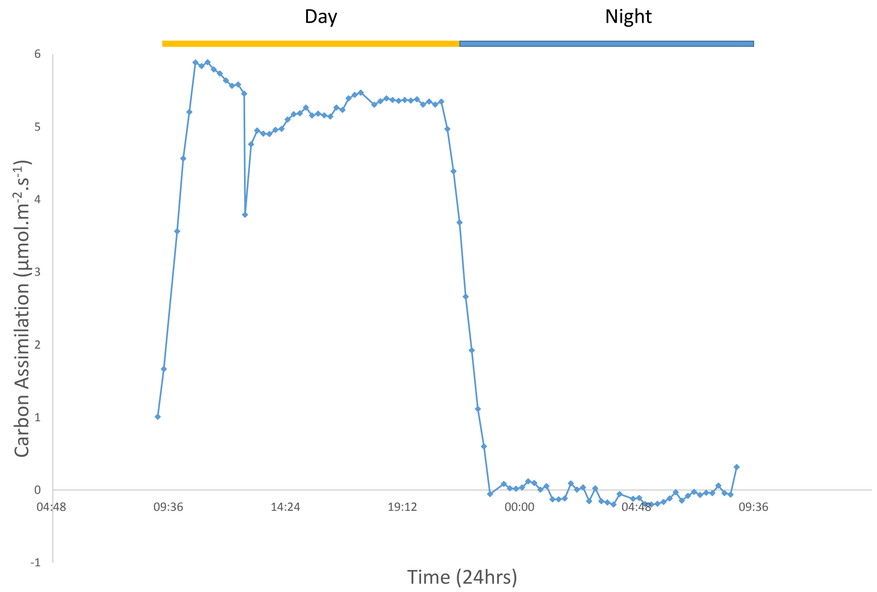

Figure 2. Pattern of carbon assimilation over a 24 hour day/night cycle in unstressed *Kalanchoe blossfeldiana*, kerenzai plant showing a typical C3 mode of photosynthesis. The yellow bar represents the period of light and the blue bar represents the period of darkness.

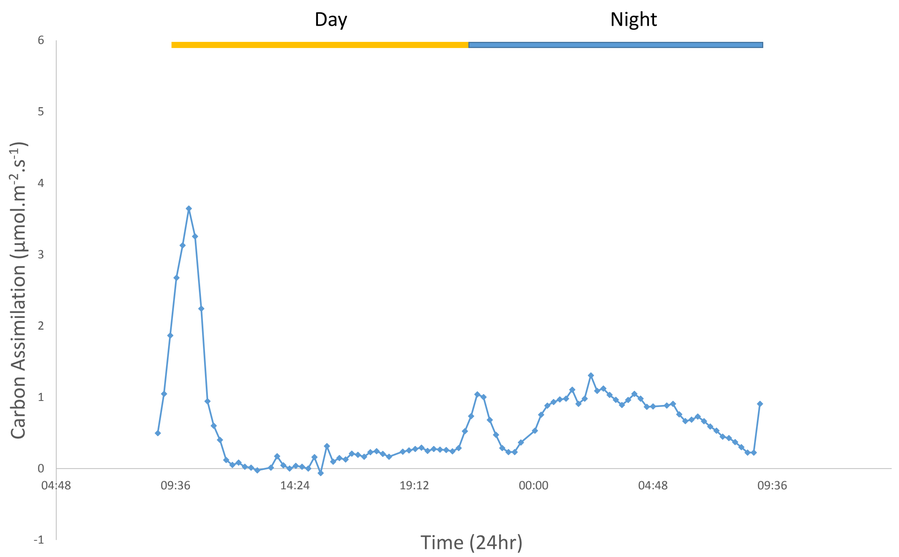

Figure 3. Pattern of carbon assimilation over a 24 hour day/night cycle in *Kalanchoe blossfeldiana, Kerenzai* plant subjected to drought, showing a typical CAM mode of photosynthesis. The yellow bar represents the period of light and the blue bar represents the period of darkness.

Conclusions and Discussion

- The Kerenzai variety of *K. blossfeldiana*,, expressed C3 photosynthesis, under well-watered conditions and shifted to CAM under drought conditions (see figures 2 and 3)
- The levels of CAM expressed under drought was low in comparison to other *K. blossfeldiana varieties*.
- This could be due to the plant being very young and having thin layers of mesophyll cells, as the calculations of carbon assimilation were based on leaf area and not chlorophyll density.
- Different varieties might have different patterns of CO_2 uptake under stress conditions.
- Both stressed and unstressed plants showed reduced levels of starch during the night, while soluble sugar levels increased.
- Stressed plants showed a larger decrease in starch as well as a larger increase in sugar levels, than the unstressed plants. This was expected, as the plant needs a supply of CO_2 otherwise it breaks down starch.
- There were negligible changes in malate levels between dusk and dawn which means that CAM was expressed, but not at a high enough level to result in significant changes in the organic acid levels.
- Finally it was found that age of the leaf impacted on CAM expression. Very young and very old leaves had shown no CAM expression due to carbohydrate limitations.

References

Winter K and Holtum J. (2014) Facultative crassulacean acid metabolism (CAM plants: powerful tools for unravelling the functional elements of CAM photosynthesis. Journal of Experimental Botany. http://dx.doi.org/10.1093/jxb/eru063