Environmental influences on carbon isotope ratios of dark-respired CO_2 and respiratory compounds in potato

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Introduction

The isotopic composition of leaf dark-respired CO_2 ($\delta^{13}C_{res}$) contains information about plant physiology and biochemical processes. Environmental factors such as higher temperatures and drought can influence the diel cycle of $\delta^{13}C_{res}$ and $\delta^{13}C$ of respiratory compounds ($\delta^{13}C_{rc}$) such as sugars, transitory starch and organic acids. Under drought, more positive $\delta^{13}C_{res}$ and $\delta^{13}C_{rc}$ values were found. However, less is known about the influence of higher temperatures or combined environmental factors, i.e., temperature and water availability.

Objectives

1) Determine if environmental factors such as higher temperatures and drought can alter diel isotopic cycles of $\delta^{13}C_{res}$ and $\delta^{13}C_{rc}$
2) Determine the relationship between $\delta^{13}C_{res}$ and $\delta^{13}C_{rc}$
3) Establish methods for compound specific isotope analysis (CSIA)

Fig.1 Potato plants (*Solanum tuberosum* L. cv. Annabell) were grown in (a) greenhouses and transfered to (b) climate chambers for acclimatisation and experiments

Conclusions

1) Higher temperatures drive lower assimilation (A) and higher intercellular CO_2 (C_i), causing diel cycles with more negative $\delta^{13}C_{res}$ and $\delta^{13}C_{rc}$ values
2) Drought drives lower stomatal conductance (g_s) and causes diel cycles with more positive isotopic values
3) Higher temperatures in combination with drought result in diel cycles with intermediate $\delta^{13}C_{res}$ and $\delta^{13}C_{rc}$ values
4) Strong correlation between diurnal $\delta^{13}C$ values of malic acid and $\delta^{13}C_{res}$ ($R^2 = 0.69$)

Results

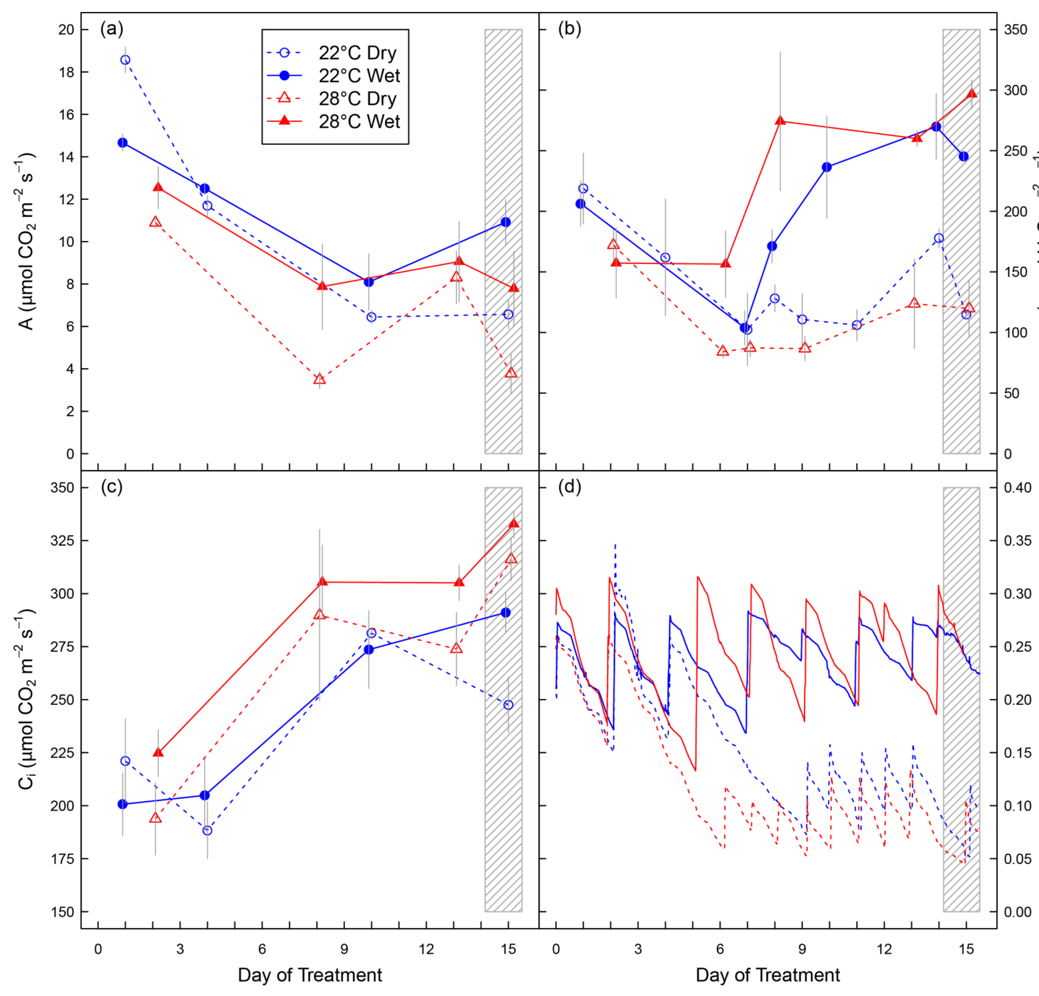
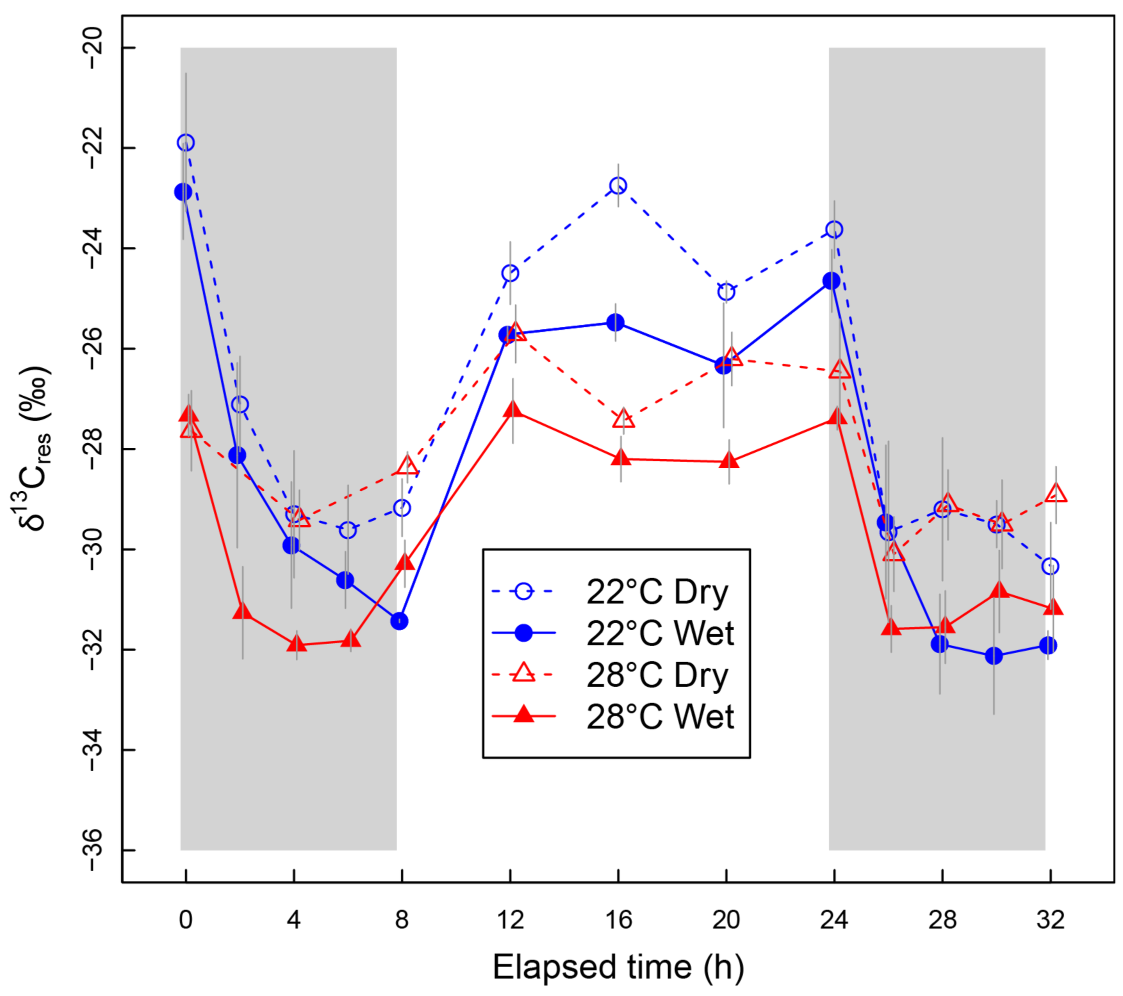


Fig.2 Treatment period over 15 days. (a) net assimilation rate (*A*), (b) stomatal conductance (g_s), (c) intercellular CO_2 concentration (C_i), (d) volumetric water content (*VWC*). 22°C Day/17°C Night (blue lines), 28°C/23°C (red lines), Wet (closed symbols), Dry (open symbols). Data are means of three biological units measured at 1-9 individuals (n = 3) ± SE. Grey area indicates sampling period of 32 h.



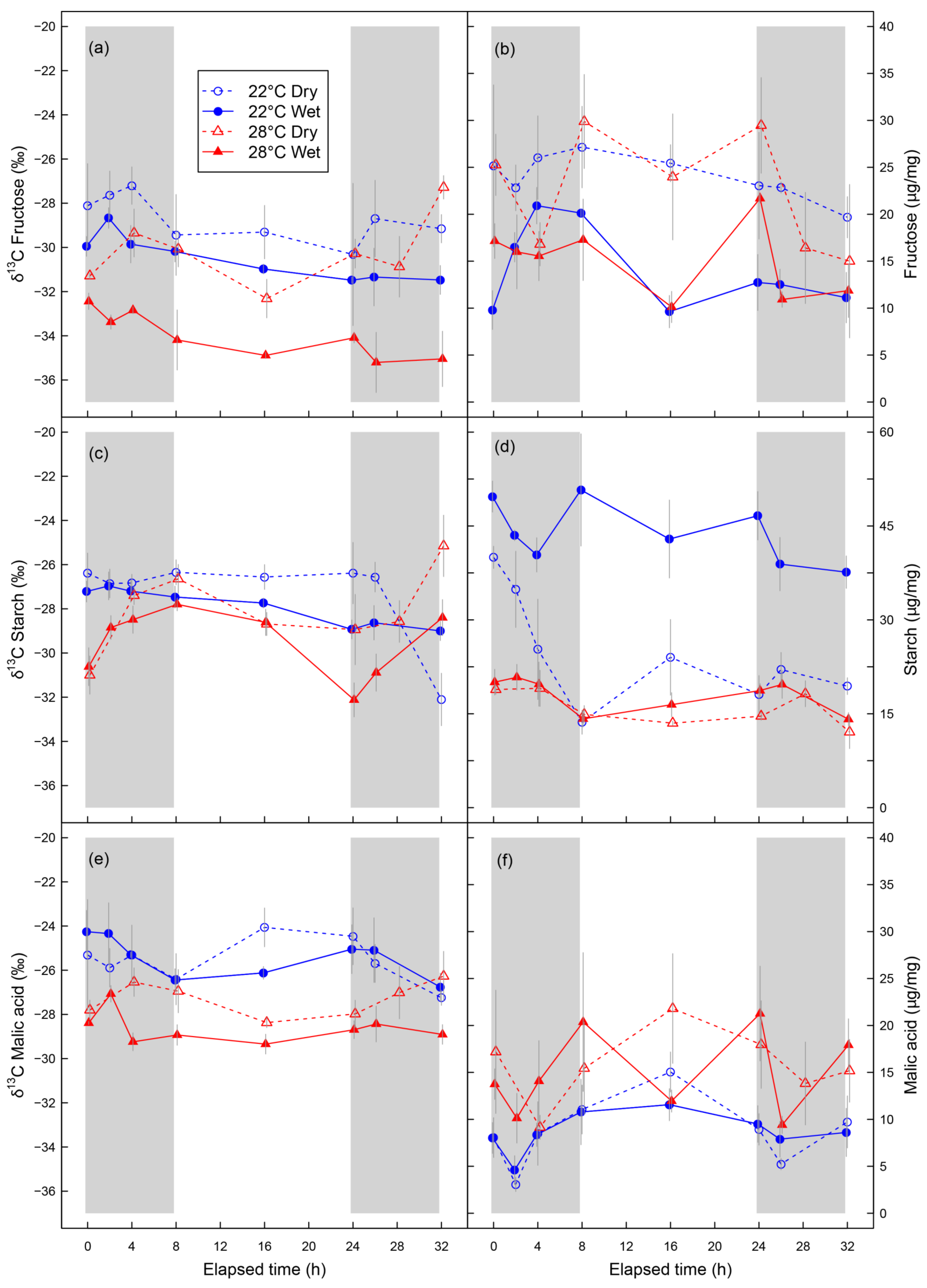


Fig.3 Diel isotopic cycles (32 h) of leaf dark-respired CO_2 ($\delta^{13}C_{res}$).
Fig.4 Diel isotopic cycles (32 h) of respiratory compounds and their concentrations. $\delta^{13}C$ of (a) fructose, (c) transitory starch, (e) malic acid. Concentrations of (b) fructose, (d) transitory starch, (f) malic acid. 22°C Day/17°C Night (blue lines), 28°C/23°C (red lines), Wet (closed symbols), Dry (open symbols). In general, data represent means of three biological units (n = 3) ± SE.

Material & Methods

Potato plants were held under two different temperature and two water regimes in a nested design under controlled conditions. The diel cycle of $\delta^{13}C_{res}$ was measured with the in-tube incubation technique. In parallel, $\delta^{13}C$ and concentrations of several carbohydrates (soluble mono- and disaccharides; transitory starch) as well as organic acids (malic and citric acid) were measured by EA- and LC-IRMS over 32h. Sugar and organic acids samples were separated by ion exchange chromatography, whereas transitory starch were enzymatically analyzed. Plant physiological data were measured with an infared gas analyzer Li-6400, a handheld leaf porometer (Decagon), and soil moisture sensors (Decagon).

Swiss National Science Foundation