Atmospheric CO_2 level affects carbon use efficiency of sunflower stands

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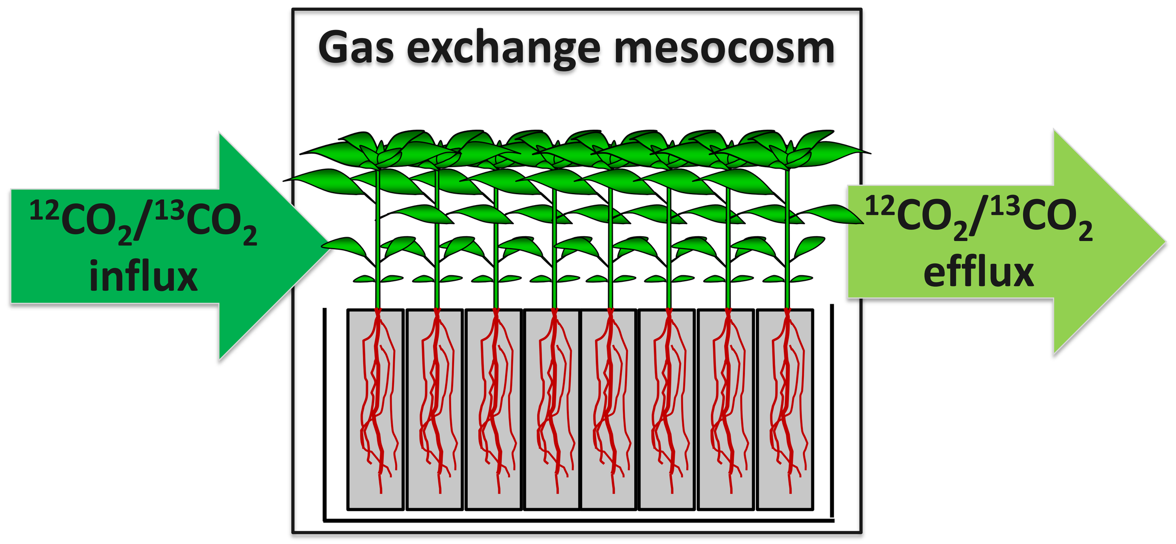
1 Introduction

- Plant carbon use efficiency, CUE = NPP/GPP = $(\sum A - \sum R_D)/(\sum A + \sum R_L)$, with A the net assimilation rate, and R_L and R_D the dark respiration in light and in dark
- A major uncertainty on CUE: R_L at stand-scale.
- We measured stand-scale R_L, using a dynamic labeling technique, and determined the response of CUE to $[CO_2]$ level.

2 Methods

- Sunflowers were grown in gas exchange mesocosms with $[CO_2]$ levels of 200 ppm and 1000 ppm.
- A and R_D were monitored.
- R_L was quantified by the ^{13}C dynamic labeling approach of Schnyder et al. (2003).
- Respiratory substrate supply system was characterized by compartment modeling of tracer kinetics in dark respiration.



3 Results

▪ Morphological responses

Elevated $[CO_2]$ increased biomass per plant and root mass ratio, and decreased leaf mass ratio.

▪ CO_2 fluxes and carbon balance

Elevated $[CO_2]$ increased all CO_2 fluxes: P was increased by 91%, R_D by 97%, R_L by 142%.

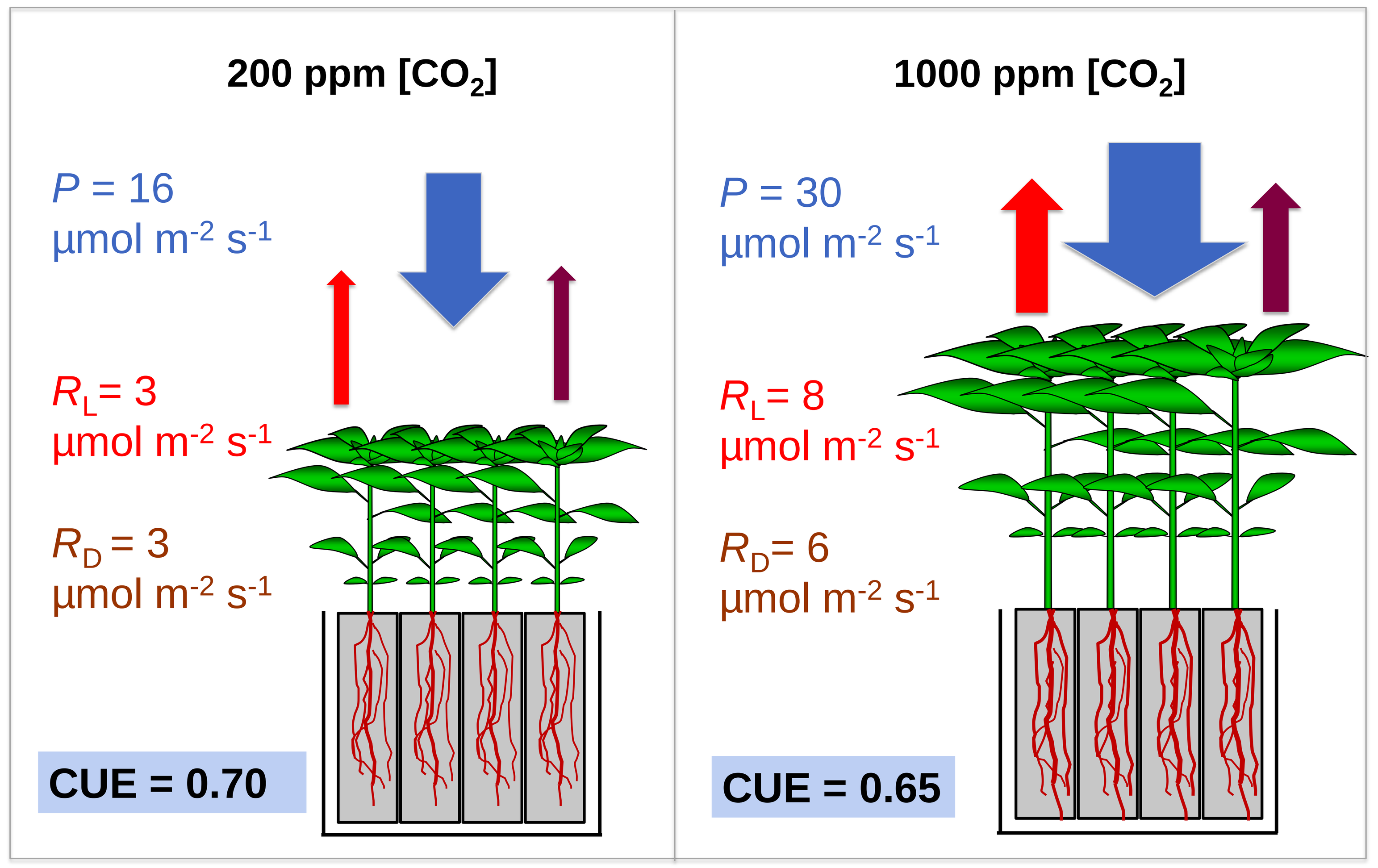
The extent of temperature adjusted inhibition of dark respiration in light ($1 - R_L/R_{D\ adj}$) was lower at elevated $[CO_2]$ (6%) than at subambient $[CO_2]$ (25%)

CUE was higher at the subambient $[CO_2]$.

Table 1 The responses of morphological parameters to $[CO_2]$ level. Results are means ± standard error of means.

	200 ppm $[CO_2]$	1000 ppm $[CO_2]$	Elevated/ subambient
Biomass (g plant^{-1})	5.7 ± 0.5	8.7 ± 0.5	1.5
Leaf mass ratio	0.37 ± 0.02	0.25 ± 0.01	0.7
Stem mass ratio	0.36 ± 0.02	0.36 ± 0.02	1.0
Root mass ratio	0.28 ± 0.03	0.39 ± 0.03	1.4

Fig. 1 CO_2 exchange rates and CUE of sunflower stands: net photosynthesis rate (P), rate of dark respiration in light (R_L), and rate of dark respiration in dark (R_D)



4 Conclusions and discussion

- Elevated $[CO_2]$ increased R_L/R_D, decreased CUE
- The $[CO_2]$ effect on CUE discourages the use of a constant CUE in carbon cycling models (as reviewed by Gifford 2003).
- CUE was related to:

1) leaf mass ratio, i.e. the ratio of autotrophic biomass to total biomass;

2) the inhibition of dark respiration in light;

3) the contribution of stores to respiration (data not shown).

- Our study provided the first assessment on CUE using measured R_L.
- The quantification on CUE will contribute to more precise predictions of the responses of terrestrial ecosystems to climate change.

References

Gifford, R.M., 2003. Plant respiration in productivity models: conceptualisation, representation and issues for global terrestrial carbon-cycle research. Funct. Plant Biol. 30, 171-186.
Schnyder, H., Schäufele, R., Lötscher, M., Gebbing, T., 2003. Disentangling CO_2 fluxes: direct measurements of mesocosm-scale natural abundance $^{13}CO_2/^{12}CO_2$ gas exchange, ^{13}C discrimination, and labelling of CO_2 exchange flux components in controlled environments. Plant, Cell and Environ. 26, 1863-1874.

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