Variation in the isotopic composition of organic matter allocated from the leaves to the roots of trees – effects of photosynthetic and post-photosynthetic carbon isotope fractionation

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Introduction

Whilst C isotope discrimination during photosynthesis is well described, there is a lack of information on fractionation steps of subsequent metabolic pathways and transport processes, collectively referred to as post-photosynthetic fractionation.

However, intra-plant gradients and diel variations in $\delta^{13}C$ of organic matter as a consequence of post-photosynthetic isotope discrimination, as well as potential variations in isotope fractionation during respiration, may be relevant for a) approaches that aim to differentiate assimilatory and respiratory CO_2 fluxes and b) the interpretation of $\delta^{13}C$ in different plant tissues as a time-integrating proxy for environmental effects on c_i/c_a.

Diel variations in $\delta^{13}C$ of organic matter – *Eucalyptus delegatensis*

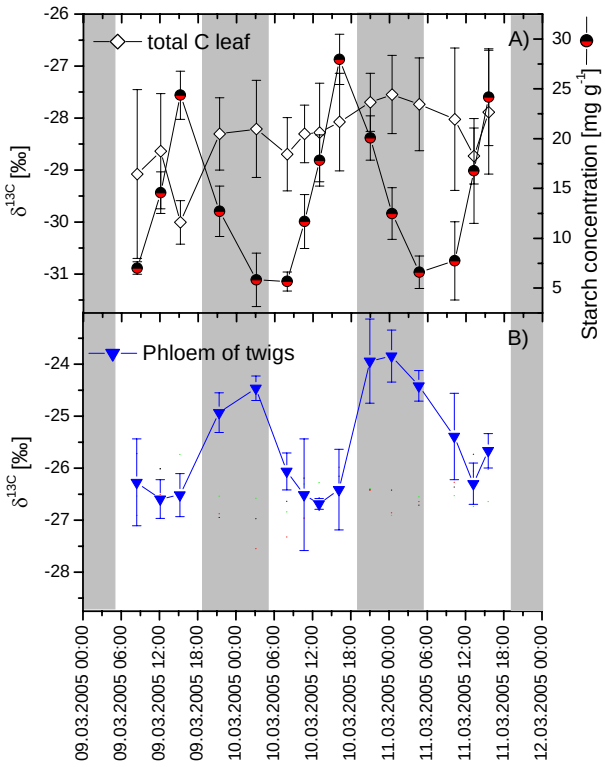

Fig. 1 Carbon isotopic composition of foliage total organic matter, starch concentration in the leaves (A) and carbon isotopic composition of phloem organic matter of twigs (B) from the upper canopy of *Eucalyptus delegatensis* (c. 34 m height; site: Tumbaruma, NSW, Australia). Data shown are mean values ± SD from 3 different trees. The shaded fields denote the night period.

There was a strong diel variation in the twig phloem with highest relative ^{13}C enrichment during night and greatest relative depletion during day. This pattern was corresponding to the diel rhythm of decrease and increase in starch concentrations observed in leaves..

We assume patterns of transitory starch accumulation and remobilisation to strongly govern the diel rhythm of $\delta^{13}C$ in phloem transported organic matter.

Conclusions

When using carbon isotope signature for partitioning CO_2 fluxes on the ecosystem level or for assessing environmental effects like water availability on c_i/c_a, it must be considered that photosynthetic carbon isotope fractionation is superimposed by post-photosynthetic discrimination.

Intra-plant gradients – *Pinus sylvestris*

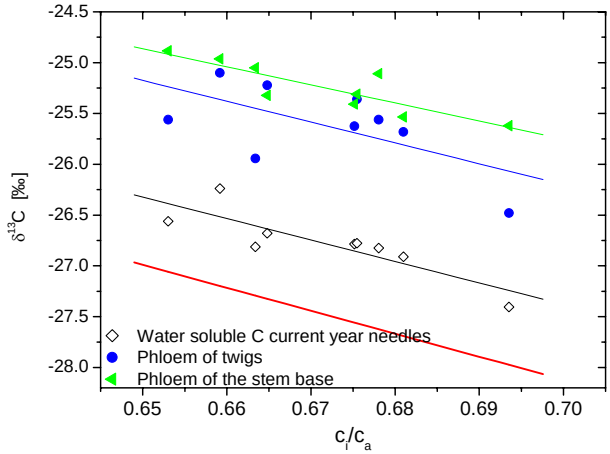

Fig. 2 Regression between daily means of c_i/c_a and $\delta^{13}C$ of the water soluble organic matter of current year needles and from phloem of twigs (in c. 12 m) and of the stem base of. *P. sylvestris* over a 9 day period in July 2004 (site: Hartheim, Germany). c_i/c_a was weighted for assimilation. The red line is $\delta^{13}C$ calculated from $\Delta_i=a+(b-a)\ c_i/c_a$ assuming $\delta^{13}C$ of atmospheric CO_2 amounting to constantly -7.9 ‰. For correlating $\delta^{13}C$ from the stem base with c_i/c_a a time lag of one day was applied as it could be shown that this is the time it takes for assimilates to be transported from the leaves to the stem base.

There is on the one hand ^{13}C enrichment from primary assimilates to soluble leaf carbon and on the other hand between this exportable carbon fraction and phloem organic matter. Also during phloem transport further enrichment was detected.

Continuous ^{13}C enrichment from the leaves to the stem base indicates fractionation, associated with metabolic processes in source and sink tissues

Potential C-isotope fractionation during respiration – *P. sylvestris*

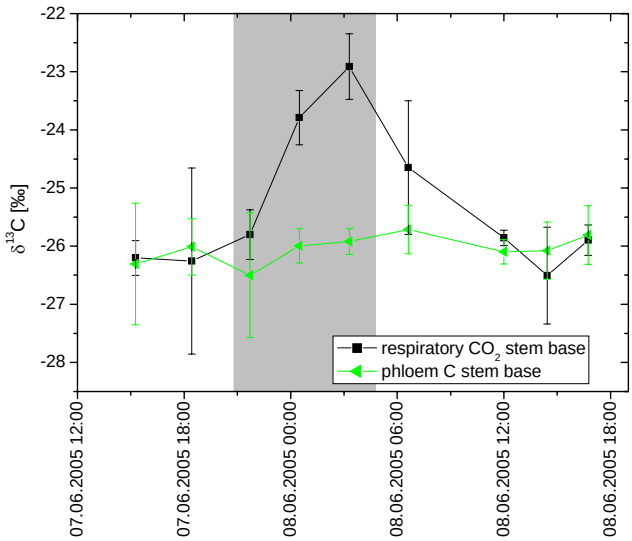

Fig. 3 Carbon isotopic composition of phloem organic matter from the stem base and of CO_2 respired at the same position during a diel course. Data shown are mean values ± SD from 3 different *P. sylvestris* trees. The shaded field denotes the night period.

There was only slight diel variation in $\delta^{13}C$ of phloem organic matter at the stem base. Compared to twigs the diel signal originating from starch accumulation/remobilisation is buffered at the stem base. However we observe a strong diel pattern of $\delta^{13}C$ in emitted CO_2 that cannot be explained by phloem carbon isotope signatures.

We assume this observation potentially to be a result of varying importance of fragmentation fractionation during respiration *

*for further information see the poster of Kodama et al.