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Oxygen isotope enrichment of organic matter in *Ricinus communis* during the diel course and as affected by assimilate transport

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Summary

- The oxygen isotope composition in leaf water and organic compounds in different plant tissues is useful for assessing the physiological performance of plants in their environment, but more information is needed on $\Delta^{18}O$ variation during a diel course.
- Here, we assessed $\Delta^{18}O$ of the organic matter in leaves, phloem and xylem in stem segments, and fine roots of *Ricinus communis* during a full diel cycle. Enrichment of newly assimilated organic matter in equilibrium with leaf water was calculated by applying a nonsteady-state evaporative enrichment model.
- During the light period, $\Delta^{18}O$ of the water soluble organic matter pool in leaves and phloem could be explained by a 27‰ enrichment compared with leaf water enrichment. Leaf water enrichment influenced $\Delta^{18}O$ of phloem organic matter during the night via daytime starch synthesis and night-time starch remobilization. Phloem transport did not affect $\Delta^{18}O$ of phloem organic matter.
- Diel variation in $\Delta^{18}O$ in organic matter pools can be modeled, and oxygen isotopic information is not biased during transport through the plant. These findings will aid field studies that characterize environmental influences on plant water balance using $\Delta^{18}O$ in phloem organic matter or tree rings.

Key words: evaporative enrichment, oxygen isotopes, phloem-to-xylem exchange, phloem transport, transitory starch, xylem transport.

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Introduction

The determination of the oxygen isotope composition in leaf water and organic compounds is a promising tool for assessing the physiological performance of plants in their environment (Wang & Yakir, 1995; Barbour *et al.*, 2001, 2002; Cernusak *et al.*, 2005). In particular, the isotopic information in organic matter pools with different turn-over times (e.g. short-lived phloem sugars representing recent assimilates; long-lived structural compounds such as tree ring cellulose) is now widely used – often together with $\delta^{13}C$ signatures – to integrate the influence of a range of environmental factors on the water balance of plants (Saurer *et al.*, 1997; Scheidegger *et al.*, 2000; Keitel *et al.*, 2003; Brandes *et al.*, 2006). The oxygen isotope composition of organic matter is mainly influenced by two factors: the $\delta^{18}O$ signature of source water and the evaporative enrichment of mean lamina leaf water, which is the reaction water for the newly produced assimilates (Fehri & Letolle, 1977; Cernusak *et al.*, 2003b). Mean lamina leaf water enrichment depends in turn on the diffusion of ^{18}O enriched water from the sites of evaporation back into the mesophyll cells and the convection of unenriched xylem water via the transpiration stream in the opposite direction (Farquhar & Lloyd, 1993; Barbour *et al.*, 2000a). As evaporative enrichment