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Unraveling carbohydrate transport mechanisms in young beech trees (Fagus sylvatica f. purpurea) by $13CO_2$ efflux measurements from stem and soil

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Transport mechanisms of soluble carbohydrates and diurnal CO_2 efflux from tree stems and surrounding soil are well studied. However, the effect of transport carbohydrates on respiration and their interaction with storage processes is largely unknown. Therefore, we performed a set of $13CO_2$ pulse labeling experiments on young trees of European beech (Fagus sylvatica f. purpurea). We labeled the whole tree crowns in a closed transparent plastic chamber with 99% $13CO_2$ for 30 min. In one experiment, only a single branch was labeled and removed 36 hours after labeling. In all experiments, we continuously measured the $13CO_2$ efflux from stem, branch and soil and sampled leaf and stem material every 3 h for 2 days, followed by a daily sampling of leaves in the successive 5 days. The compound specific δ 13C value of extracted soluble carbohydrates from leaf and stem material was measured by high-performance liquid chromatography linked with an isotope ratio mass spectrometer (HPLC-IRMS). The $13CO_2$ signal from soil respiration occurred only few hours after labeling indicating a very high transport rate of carbohydrates from leaf to roots and to the rhizosphere. The label was continuously depleted within the next 5 days. In contrast, we observed a remarkable oscillating pattern of $13CO_2$ efflux from the stem with maximum $13CO_2$ enrichment at noon and minima at night time. This oscillation suggests that enriched carbohydrates are respired during the day, whereas in the night the enriched sugars are not respired. The observed oscillation in stem $13CO_2$ enrichment remained unchanged even when only single branches were labelled and cut right afterwards. Thus, storage and conversion of carbohydrates only occurred within the stem. The δ13C patterns of extracted soluble carbohydrates showed, that a transformation of transitory starch to carbohydrates and vice versa was no driver of the oscillating $13CO_2$ efflux from the stem. Carbohydrates might have been transported in the phloem to the location of biosynthesis further to a storage pool from which they are respired during the day.
Keywords: $13CO_2$ efflux, oscillating pattern, carbohydrates, transitory starch