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Transport of soluble carbohydrates in temperate deciduous trees: beech (Fagus sylvatica) and ash (Fraxinus excelsior) in comparison

Ronny Thoms (1), Michael Köhler (2), Arthur Gessler (3), and Gerd Gleixner (1)

(1) MPI-BGC, Jena, Germany (rthoms@bgc-jena.mpg.de), (2) Nordwestdeutsche Forstliche Versuchsanstalt, Göttingen, Germany (mikoe1@gmx.de), (3) Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, Birmsdorf, Germany (gessler@zalf.de)

Abstract

The structure of phloem cells and the physiology of the transport of soluble carbohydrates in plants are well studied. However, the influence of different phloem un- and uploading strategies on the translocation of carbohydrates in different tree species is largely unknown. Therefore, we conducted a pulse labeling on 20 young trees of European beech (Fagus sylvatica) and European ash (Fraxinus excelsior) respectively, using the stable isotope 13C in a temperate deciduous forest in Central Germany. In one growing season each tree species was labeled in a closed transparent plastic chamber with 99% $13CO_2$ for 5 h. The compound specific δ 13C from carbohydrates in the different compartments leaf, branch, stem and root was measured by high-performance liquid chromatography linked with an isotope ratio mass spectrometer (HPLC-IRMS). We found that both tree species used sucrose as a transport sugar, but carbohydrates of the raffinose group (RFO) served as main transport sugar in ash trees. This indicate that beech used only the apoplastic loading strategy into the phloem cells while ash trees relied on both, apoplastic and symplastic loading, preferring the latter at the end of the growing season. Furthermore, we observed different transport velocities of labeled sugars in the two species. Here, sucrose in beech and carbohydrates of the RFO in ash were transported fastest, whereas sucrose was constantly slowest in ash trees. The label of carbohydrates was found over 60 day in the roots of both tree species, with the highest δ 13C enrichment in carbohydrates of RFO than in the other sugars. Accordingly, the mean residence time (MRT) and half life time (HLT) of 13C in different compartments were longest for carbohydrates of RFO in roots (25.6 days) and sucrose in stems (14.9 days), while the shortest MRT and HLT for sucrose appeared in beech in all compartments. Our results give evidence that RFO are preferentially transported to the root tissue as an agent against frost damage. This could have a great impact on the transport and storage behavior of sucrose in ash trees in the end of growing season. We conclude that transport mechanisms of carbohydrates in roots and stems differ. Intermediate storage of sucrose in line with different unloading strategies might be the limiting factor.