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How low can you go? Assessing minimum concentrations of NSC in carbon limited tree saplings

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Tissue concentrations of non-structural carbohydrates (NSC) are frequently used to determine the carbon balance of plants. Over the last years, an increasing number of studies have inferred carbon starvation in trees under environmental stress like drought from low tissue NSC concentrations. However, such inferences are limited by the fact that minimum concentrations of NSC required for survival are not known. So far, it was hypothesized that even under lethal carbon starvation, starch and low molecular sugar concentrations cannot be completely depleted and that minimum NSC concentrations at death vary across tissues and species.

Here we present results of an experiment that aimed to determine minimum NSC concentrations in different tissues of saplings of two broad-leaved tree species (Acer pseudoplatanus and Quercus petratea) exposed to lethal carbon starvation via continuous darkening. In addition, we investigated recovery rates of NSC concentrations in saplings that had been darkened for different periods of time and were then re-exposed to light. Both species survived continuous darkening for about 12 weeks (confirmed by testing the ability to re-sprout after darkness). In all investigated tissues, starch concentrations declined close to zero within three to six weeks of darkness. Low molecular sugars also decreased strongly within the first weeks of darkness, but seemed to stabilize at low concentrations of 0.5 to 2 % dry matter (depending on tissue and species) almost until death. NSC concentrations recovered surprisingly fast in saplings that were re-exposed to light. After 3 weeks of continuous darkness, tissue NSC concentrations recovered within 6 weeks to levels of unshaded control saplings in all tissues and in both species.

To our knowledge, this study represents the first experimental attempt to quantify minimum tissue NSC concentrations at lethal carbon starvation. Most importantly, our results suggest that carbon-starved tree saplings are able to survive several weeks without starch reserves and with extremely low sugar concentrations in all organs. Although it remains to be tested whether our findings are also valid for mature trees, these results show that NSC pools in trees are very sensitive to carbon limitation and that lethal carbon starvation is preceded by a significant (almost complete) depletion of starch and sugars in all tree organs.