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Are large carbon-reserve pools beneficial for trees under drought?

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All plants store parts of the assimilated carbon (C) as non-structural C reserves (mainly starch, sugars and lipids) that can be re-allocated to growth or metabolism during times when the demand of C-sinks exceeds the current C-assimilation. It is generally assumed that the size of the C-reserve pool of a plant is indicative of its net C-balance. In contrast, it has been recently hypothesized that the often observed increase of C-reserve concentrations in trees exposed to climatic stress like drought or cold, are not caused by the overabundance of photoassimilates following the stress-induced cessation of growth, but might be intrinsic reactions to anticipate potential C-limitation under stressful situations (Wiley and Helliker 2012, New Phytologist 195).
Within two experiments, we (1) tested the responsiveness of non-structural carbohydrates (NSC) in seedlings of three deciduous tree species (Carpinus, Fagus, Quercus) to C-shortage and -surplus, and (2) assessed the significance of the size of C-reserve stores to survive drought stress. We quantified the changes of NSC concentrations in seedlings that were exposed to different C-supplies for the first three month of the growing season (April to June), by exposing them to either different light regimes (100 %, 30 %, 3 % of full sunlight) or different atmospheric CO_2 concentrations (200 ppm, 400 ppm, 600 ppm CO_2). In all species, the concentrations of NSC reacted very strongly to the different treatments, with seedlings growing under low C-supply showing a significant depletion (especially starch), thereby corroborating the principal responsiveness of C-reserve pools to C-source-sink imbalances. Following this preconditioning, half of the seedlings from each light and CO_2 treatment were exposed to moderate drought situations that led to the death of most of the seedlings by the end of the growing season (October). Differences in the drying-out rates between the light and CO_2 treatments were compensated by selective watering throughout the drought experiment. Most interestingly, the tissue NSC concentrations at the beginning of the drought stress had no significant effect on the seedling's survival rate in the shading experiment, indicating that under the applied experimental conditions, higher initial NSC pools were not advantage for survival. In contrast, drought stressed seedlings that were exposed to very low CO_2 concentrations tended to die a few days earlier than those exposed to mid or high CO_2 concentrations. Forthcoming analyses of NSC in seedlings harvested by the end of the experiment will show, if the four months drought period depleted the C-reserve pools in dead seedlings, and if the initial C-reserve pool size were determinant for C-limitation under drought.