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Seasonal dynamics of mobile carbohydrates and stem growth in Scots pine (Pinus sylvestris) exposed to drought

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Tree growth requires a continuous supply of carbon as structural material and as a source for metabolic energy. To detect whether intra-annual stem growth is related to changes in carbon allocation, we monitored seasonal dynamics of shoot and radial growth and concentrations of mobile carbohydrates (NSC) in above- and belowground organs of Scots pine (Pinus sylvestris L.). The study area is situated within an inner Alpine dry environment (750 m asl, Tyrol, Austria), which is characterized by recurring drought periods at the start of the growing season in spring and limited water holding capacity of nutrient deficient, shallow stony soils. Shoot elongation was monitored on lateral branches in the canopy and stem radius changes were continuously followed by electronic band dendrometers. Daily radial stem growth and tree water deficit (ΔW) were extracted from dendrometer records. ΔW is regarded a reliable measure of drought stress in trees and develops when transpirational water loss from leaves exceeds water uptake by the root system. Daily radial stem growth and ΔW were related to environmental variables and determination of NSC was performed using specific enzymatic assays. Results revealed quite early culmination of aboveground growth rates in late April (shoot growth) and late May (radial growth), and increasing accumulation of NSC in coarse roots in June. NSC content in roots peaked at the end of July and thereafter decreased again, indicating a shift in carbon allocation after an early cessation of aboveground stem growth. ΔW was found to peak in late summer, when high temperatures prevailed. That maximum growth rates of aboveground organs peaked quite before precipitation increased during summer is related to the finding that ΔW and radial stem growth were more strongly controlled by the atmospheric environment, than by soil water content. We conclude that as a response to the seasonal development of ΔW a shift in carbon allocation from aboveground growth to the mycorrhiza-associated root system occurs to ensure adequate resource acquisition on the drought-prone substrate.