Drought shifts internal carbon partitioning of recent photosynthates in black spruce trees: From bud to mature shoot

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Springtime bud-break and shoot development induces substantial carbon (C) costs in trees, altering the internal canopy source-sink relationships. Drought stress impedes C translocation delaying shoot development and potentially increasing the total C cost associated with foliar development. We studied effects of drought and re-hydration on shoot development and C use, in 10-year old Picea mariana [black spruce] trees to identify and quantify key morphological/physiological processes. Trees were subjected to one of two treatments in a growth chamber; well-watered control (Cont.) or drought and re-hydration (D). We monitored changes in morphological, biochemical (osmolality, [chlorophyll], [nitrogen], [C] and [non-structural carbohydrates (NSC)]) and physiological (rates of respiration (Rd) and light-saturated photosynthesis (Asat)) processes during shoot development. Further, to study functional compartmentalization and use of new assimilates; we 13C-pulse labeled shoots at multiple development stages (at individual branch level), and measured isotopic signatures of leaf respiration, NSC pool and structural biomass. Overall shoot development was delayed by drought. Water deficit during shoot expansion resulted in more compact shoots with on average greater (63%) needle osmolality compared to the shoots on the control-trees. The positive non-linear relationship through time between shoot xylem water pressure potential and needle osmolality suggests osmoregulation occurs in all developmental stages. Development of the photosynthetic apparatus was delayed, as shoots on Cont.-trees broke-even (Asat > 0) 14 days prior to D-shoots. Average values of Rd decreased with shoot maturation, ranging from 224.8 to 12.8 and from 96.8 to 12.5 nmol g-1 s-1, in treatment Cont. and D, respectively. 12C:13C isotopic patterns, indicated that internal C partitioning and use were dependent on foliar developmental stage and treatment. Shoots on Cont.-trees respired a greater proportion of recently fixed C; this was especially true during early stages of shoot development. Mean residence time of C was dependent on rates of respiration more so than C uptake (as Asat). In conclusion, temporary periods of water deficit inhibit C translocation from older organs delaying new shoot development (increasing C input) in black spruce. This entails shifts in internal C partitioning and use to maintain substrate availability for respiration.