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Woody tissue photosynthesis: an alternative carbon source in the stem to alleviate drought stress

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Leaf photosynthesis is widely assumed to be the only source of carbon (C) assimilation in plants. However, recent evidence challenges this paradigm. Woody tissue photosynthesis (WTP) is found to be an alternative and significant C source, which contributes to maintain xylem hydraulic functioning when phloem sugar transport from leaves is limited during drought. To advance knowledge on the importance of WTP in tree hydraulic functioning and the overall C budget, European aspen (*Populus tremula* L.) trees were exposed to three treatments: (i) control (no stress), (ii) drought-stress (irrigation reduction) and (iii) drought-stress combined with light-exclusion of woody tissues (by means of loosely wrapping stem and branches with aluminum foil). Trees were equipped with plant sensors to monitor their ecophysiological behavior across the drought-stress gradient. Hydraulic-related measurements included stem diameter variations of bark and xylem, sap flow, soil water potential, and midday and predawn xylem water potential. Carbon-related measurements included leaf photosynthesis, xylem CO_2 concentration and temperature, stem CO_2 efflux and non-structural carbon content of xylem and bark.

Before drought, a more negative xylem water potential was observed in the light-excluded trees compared to the control ones. In addition, light-excluded trees showed higher transpiration and leaf photosynthesis rates, which could point to a compensation mechanism for the lost carbon influx due to light-exclusion of the stem. Following drought application, the water potential of light-excluded trees directly dropped, while drought-stressed trees only showed stress after a week. WTP thus seems to be an important mechanism to alleviate drought stress. Stem CO_2 efflux in light-excluded trees was higher across the entire duration of the experiment and resulted in a less negative normalized efflux depression, demonstrating that WTP influences the local carbon balance in the stem. Also, a lower starch content in the stem tissues of the light-excluded trees was observed.

Our results highlight the importance of WTP in maintaining xylem hydraulic functioning and in the local carbon balance. Our findings also reveal valuable information on the processes that take place in the stem and help improving our understanding on how trees respond to a drier climate.