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Stem hydraulic capacitance of Quercus ilex trees subjected to long term throughfall exclusion

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Tree plasticity in hydraulic traits is a key factor to cope with drought stress under changing climate. Changes in hydraulic allometry by reductions in leaf area (LA) and in the LA to sapwood area (SA) ratio are commonly observed as a strategy to reduce water loss while maintaining xylem hydraulic functionality. These allometric changes may also influence stem hydraulic capacitance (CS) that buffers peaks in xylem tension by releasing water from stem reservoirs. We compared CS of four Quercus ilex trees subjected to 14 years of continuous throughfall exclusion (TE) with that of four control (C) trees, with CS being estimated as the amount of stem water released for a given reduction in water potential. To this end, stem volumetric water content (VWC) was continuously monitored using frequency domain reflectometry and leaf water potential was discretely measured across seven measurement campaigns during 2017, which occurred to be an exceptionally dry year in Mediterranean regions, including the study area.

Stem hydraulic capacitance varied through the year, more in TE than C trees. On a seasonal basis, CS was higher in TE trees at the beginning of the growing season (P = 0.05; 124 and 218 kg MPa-1 m-3 for C and TE trees, respectively), when largest reductions in stem VWC (50-70 kg m-3) were observed at relatively high predawn water potential (ΨPD > -1MPa). Along summer drought, CS was largely reduced to mean values below 10 kg MPa-1 m-3 and did not differ between treatments (P > 0.1). During this time, large reductions in ΨPD, reaching mean values below – 5 MPa at the end of summer drought, resulted in a relatively small water release (ΔVWC = 30-40 kg m-3). First rains after summer drought led to rapid refill of stem water reservoirs (ΔVWC = 30-50 kg m-3) and great relaxation of xylem tension (ΨPD > -1.5 MPa). Consistently, water release on a sub-daily basis was marginally higher in the TE treatment (P = 0.06) uniquely at the beginning of the growing period, when trees were not drought-stressed yet, while sub-daily water fluctuations along summer drought remained homeostatic between treatments.

These preliminary results suggest an exponential shape of the stem water desorption curve, with a steep decrease in stem VWC under well-watered conditions (likely resulting from capillary and elastic water), which flattens as drought-stress exacerbates (when capillary water is mostly depleted). Given that stem water storage capacity and CS are relatively plastic traits directly related to the sapwood volume, increased SA:LA ratio in response to sustained throughfall exclusion may explain CS increases at the onset of the stem water desorption curve. More research in SA responsiveness to water deficit would help to strengthen this conclusion and to better discriminate capacitive water sources.