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The use of internal water storage-a key parameter for tree survival under drought

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Current climatic forecasts predict that drought severity will intensify in the next decades with potentially unprecedented impacts on organisms and ecosystems. Already in the past 10 years, there has been an alarming rise in reports of drought-related, large-scale tree mortality in various biomes..........()...(.)(.)(.)... A potentially critical mechanism that helps trees sustain drought stress is the use of the internal water storage. It protects from water loss by soil evaporation and from competition with neighboring trees, and help the tree to buffer against increasing transpiration demands on both the diurnal and seasonal time-scales.

Here, we examined the importance of trees' internal water storage in a semi-arid Aleppo pine forest exposed to long seasonal drought (Yatir forest; 280 mm mean annual precipitation, over 300 dry days). We measured continuously during a full annual cycle, transpiration (***E***) with automatic branch chambers (16 chambers), soil moisture (***SWC***; 9 probes) sap flow (***SF***; 40 trees) and stem growth and shrinkage by electronic dendrometers (20 trees) accompanied with periodical measurements of water potential (Ψg)gnd needles relative water content (***RWC)***. A tree hydraulics model was used in order to study the role of the trees' internal water storage in its water balance dynamics, and to identify the key processes involved in water transport in the soil-plant-atmosphere system under different climatic conditions and tree characteristics.

The results showed a time-lag of 5-8 hours between ***E*** and ***SF*** during the dry season, with ***E*** peaking in the early morning when the evaporative demand is relatively low, and stem ***SF*** only gradually increase to a peak during midday. This time-lag diminishes in the wet season to less than 1 hour. These findings indicate that the the early morning ***E*** under low water availability critically depends on internal water storage. We quantified the dynamics of water storage in the xylem, bark and phloem, branches and needles, combining measurements and modelling. The results indicated diurnal and seasonal dynamics of water storage in the xylem, bark and needles, with larger diurnal amplitude in the dry season. The model results showed the best fit to all observations when the use of the internal water storage component was included in the simulations. Most significantly, Ψ_{leaf}without internal storage reaches unreasonable values for the study species, which leads to hydraulic failure already in the early morning. When including internal water storage, Ψ_{leaf}remains within reasonable values of around -2.6MPa at midday. It seems that the lack of internal storage, would lead to runaway cavitation, hydraulic failure and mortality under drought.

We conclude, that the use of internal water storage results in the observed ***E*** vs. ***SF*** time-lag in the dry season and that under dry climate, early morning peak in ***E*** prevents severe decrease in water potential, which can lead to tree mortality. The importance and relevance of water storage in dryland forests is important to implement in management and modelling of biomes that are likely to experience increasing frequency in drought events in the future.