Geophysical Research Abstracts
Vol. 13, EGU2011-130, 2011
EGU General Assembly 2011

Hydraulic adaptations underlying drought resistance of Pinus halepensis

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Drought-induced tree mortality is becoming a major challenge for forests worldwide. Elucidating physiological mechanisms which underlie drought resistance in trees is imperative for understanding forest function. Our objective was to investigate the hydraulic adaptations underlying the ability of Pinus halepensis, a key forest tree species in the Mediterranean, to survive the seasonal, routine droughts prevailing in the dry timberline. One hundred 18 months old trees were exposed to 10 different drought treatments, simulating a variety of drought intensities and durations, from full weekly irrigation to only 25% irrigation once in 3 weeks.

• At Ψl = -2.8 MPa stomata closed, suggesting isohydric stomatal regulation, yet xylem conductivity loss was ∼45%, indicating high sensitivity of the xylem to embolism and narrow hydraulic safety margins (merely 0.3 MPa between stomatal closure and PLC50) in comparison to other coniferous species.

• The narrow hydraulic safety margins meant that stomata maximized CO2 uptake by using the full hydraulic capacity of the xylem.

• However in trees under extreme drought treatments, stomatal closure reduced CO2 uptake to -1 μmol m-2 s-1, presumably leading to carbon starvation.

• A differential effect of drought intensity and duration was mediated by a strong dependency of the T/ET partitioning ratio on the patterns of water supply, where the larger irrigation doses allowed higher partitioning to transpiration.

• Under intense or prolonged drought the root system became the main target for biomass accumulation, taking up to 100% of the added biomass, while the stem tissue biomass decreased, also reflected by up to 60% reduction in xylem volume.