

Hydraulic efficiency and safety of conifer needles

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Leaves, representing the distal section of the soil-plant-atmosphere-continuum, are exposed to lowest water potentials within the plant. In contrast to angiosperm leaves, insight into the hydraulic architecture of conifer needles is poor. We investigated the hydraulic efficiency and safety of *Pinus pinaster* needles.

The conductivity and vulnerability to drought induced embolism of the needle xylem was analysed in Cavitron measurements and compared with axes hydraulics. The conductance and vulnerability of entire needles was measured via rehydration kinetics, and Cryo-SEM and x-ray microtomography were used for structural analysis.

Needle xylem showed 50% loss of conductivity at a water potential (P_{50}) of -1.5 MPa, while axes P_{50} ranged between -3.6 to -3.2 MPa. Specific hydraulic conductivity of the needle and axes xylem was $2.0 \cdot 10^{-4}$ and $7.7 \cdot 10^{-4} \text{ m}^2 \text{ s}^{-1} \text{ MPa}^{-1}$. P_{50} of entire needles was -0.5 MPa. During dehydration to -3.5 MPa, collapse and embolism in xylem tracheids as well as gap formation in surrounding tissues were observed.

Results indicated that the needle xylem has lower hydraulic safety than axes xylem while hydraulic efficiencies were similar. Within needles, non-vascular tissues were more vulnerable than the xylem. These tissues may limit water transport but also help to buffer water deficits and avoid xylem embolism.