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Comparison of the lethal water potential of nine temperate tree species submitted to a prolonged water stress

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Introduction

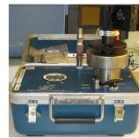
The threshold of water-stress induced mortality is known to vary with tree species and reflect their ability to withstand an acute drought spell. We exposed potted juvenile trees to a range of water stresses, triggering plant death to evaluate their drying-limits of viability. We carry out a census of predawn (Ψ_p), midday xylem water potential (Ψ_m), and of the evapotranspiration of the potted trees of nine species to assess the lethal water potential (Ψ_{let}) i.e. the water potential when the $\Psi_p - \Psi_m \leq 0.4$ MPa (Ducrey, 1988).

Material and methods

We relied on 3 hygrophytes (*Alnus glutinosa* (Ag), *Populus tremula* x *Populus alba* (Pta) and *Salix alba* (Sa)), 3 mesophytes (*Fagus sylvatica* (Fs), *Quercus petraea* (Qp) and *Pseudotsuga menziesii* (Pm)) and 3 xerophytes (*Quercus ilex* (Qi), *Pinus halepensis* (Ph) and *Cedrus atlantica* (Ca)).



Young potted trees on automatic scale



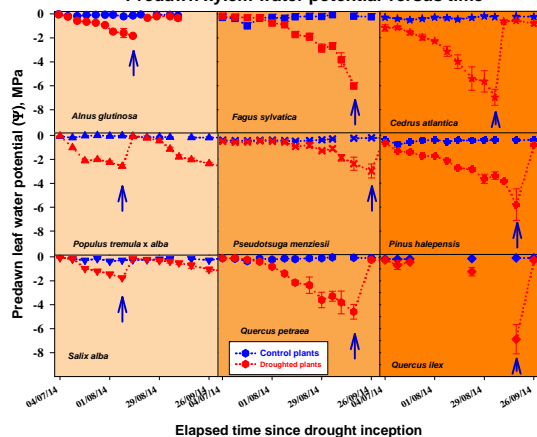
Pressure chamber



Cavitron

Results and conclusions

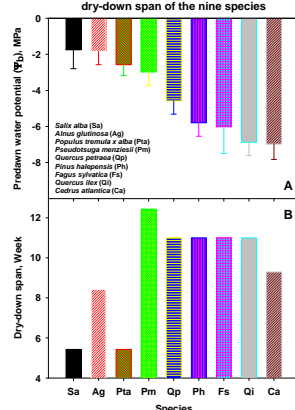
Predawn xylem water potential versus time



Elapsed time since drought inception

The Ψ_p of the control trees ranged from -1 MPa and 0 MPa. In contrast, the Ψ_p of the droughted trees varied largely (-6.97 MPa $\leq \Psi_p \leq -1.75$ MPa) regarding the dry-down span and the reputed habitat of the species. Based on their minimal Ψ_p , we gathered the tree species in 3 groups : Ag, Sa, Pta, Pm ($\Psi_p \geq -3$ MPa); Ca, Qi ($\Psi_p \leq -6$ MPa) and Qp, Ph, Fs (-6 MPa $\leq \Psi_p \leq -3$ MPa). The arrows stand for the re-watering dates.

Critical predawn xylem water potential and the dry-down span of the nine species



The lethal water potential (Ψ_{let}) of the study species ranged from 5 to 12 weeks: 5 weeks for Sa and Pta; 8 for Ag; 9 for Ca; 11 for Qp, Ph, Fs and Qi; more than 12 weeks for Pm. The observed differences in Ψ_{let} probably relied on their ability to control their stomata.

The Ψ_{let} ranged from -1.75 ± 1.05 MPa (*Salix alba*) to -6.97 ± 0.85 MPa (*Cedrus atlantica*). The results revealed that the threshold of water-stress induced mortality ranged from 5 weeks (*Populus tremula* x *P. alba*; *Salix alba*) to more than 12 weeks (*Pseudotsuga menziesii*). Besides, the observed predicted native percent loss conductance are in line with previous reports (Brodrribb and Cochard, 2009; Barigah et al., 2013).

Reference

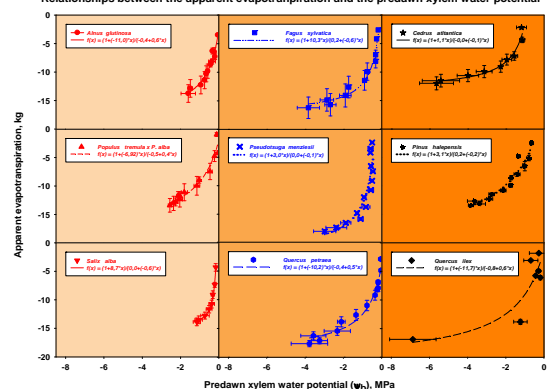
- Barigah, T. S., Charrier, O., Douris, M., Bonhomme, M., Herbette, S., Ameglio, T., Fichot, R., Brignolas, F., Cochard, H., 2013. Water stress-induced xylem hydraulic failure is a causal factor of tree mortality in beech and poplar. *Annals of Botany* 112: 1431-1437. DOI : 10.1093/aob/mct204 <http://prodnra.inra.fr/record/214060>.
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Species	Xylem water potential inducing 50% PLC (Ψ_{50} , MPa)	Xylem water potential (Ψ_m , MPa)	Predicted native Percent Loss Conductance (PLCp, %)
<i>Alnus glutinosa</i> (Ag)	-2.09 ± 0.02	-2.57	> 99.5
<i>Populus tremula</i> x <i>P. alba</i> (Pta)	-2.79 ± 0.05	-3.17	> 95.0
<i>Salix alba</i> (Sa)	-2.18 ± 0.06	-2.80	87.0
<i>Fagus sylvatica</i> (Fs)	-3.60 ± 0.13	-7.50	> 95.0
<i>Pseudotsuga menziesii</i> (Pm)	-3.40 ± 0.04	-3.71	72.5
<i>Quercus petraea</i> (Qp)	-	-5.41	-
<i>Cedrus atlantica</i> (Ca)	-5.80 ± 0.09	-7.82	87.6
<i>Pinus halepensis</i> (Ph)	-6.02 ± 0.16	6.53	67.0
<i>Quercus ilex</i> (Qi)	-	-7.61	-

Xylem water potential inducing 50% percent loss of hydraulic conductance (PLC) of the study species using the Cavitron technique. Predicted native (PLC_p) drawn from the vulnerability curve of current year old shoots of the control trees relying on the mean midday xylem water potential measured on 3 to 5 droughted trees of each species.

No vulnerability curve was built for the *Ilex* vessel oak species.

Relationships between the apparent evapotranspiration and the predawn xylem water potential



A non linear relationship between the Ψ_p and the apparent evapotranspiration of the potted trees following a species specific fitting equation.