Plant hydraulic: new insights brought by HRCT?

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Introduction

- Recent advances in plant hydraulics have shed light on artifacts generated by destructive hydraulic measurements.
- A major issue relates to the presence of open xylem vessels in tissue used for hydraulic measurements with the centrifuge system.
- These artifacts are thought to overestimate plant drought vulnerability, influencing our understanding of the whole plant water balance.
- High resolution computed tomography (HRCT) allows the detection of air and sap-filled xylem conducing elements in the wood of intact plants and can provide non-biased assessment of plants adaptation to drought.

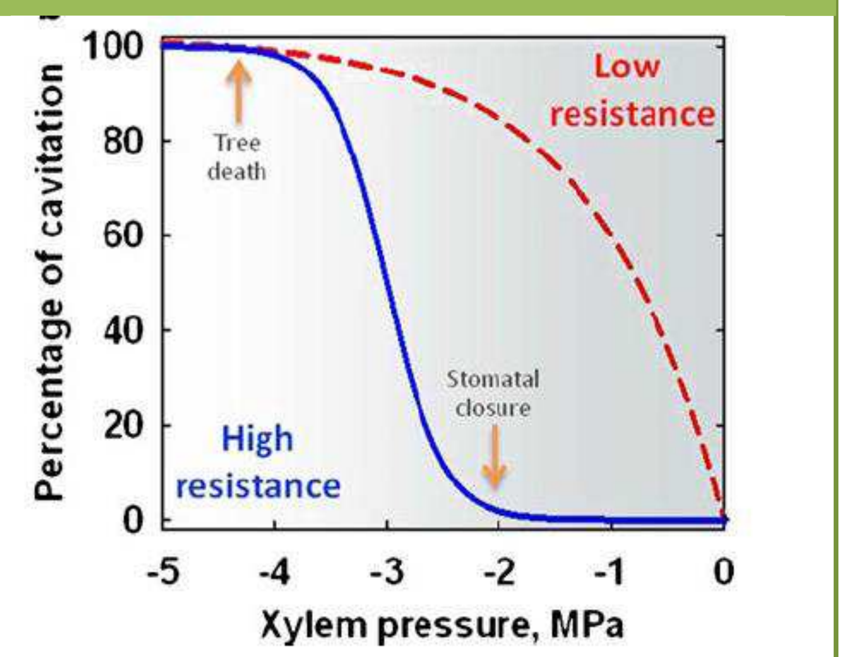


Figure 1: taken from [1]. The red VC shows a very low resistance if compared to the point of stomata closure. This curve is often obtained with classical laboratory methods in long-vesseled species. The blue curve is consistent with the idea that plant are resistant to cavitation and that stomata regulate water loss to avoid cavitation.

OBJECTIVE : Assessing plant hydraulic responses to drought across 3 HRCT experiments

Material & Methods

Figure 2: Bench drying and centrifugre were used as standard techniques to assess VC in ring porous, diffuse porous and conifers

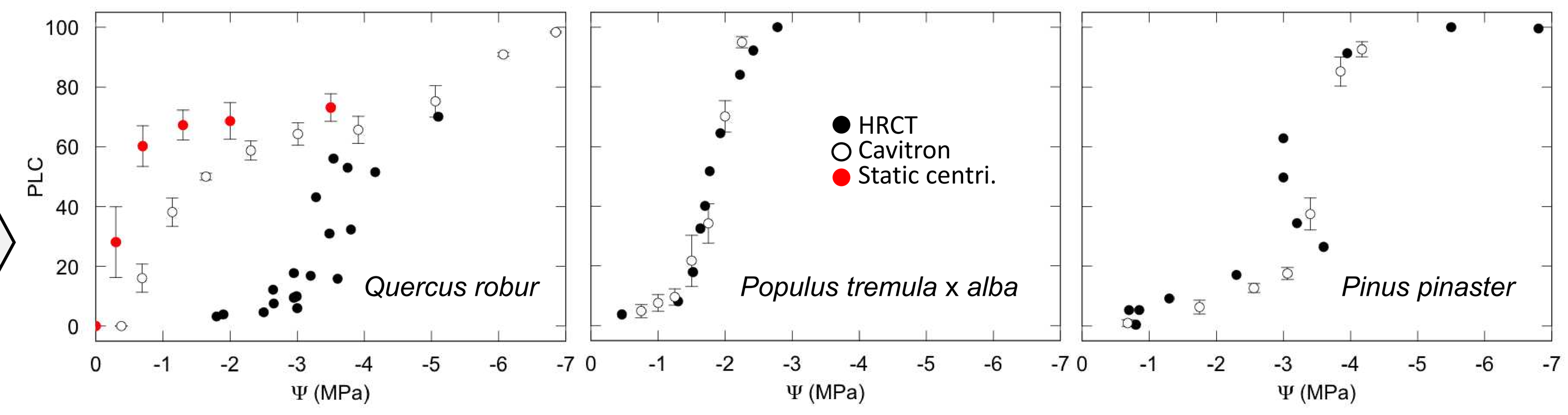
(1) We compared Vulnerability Curves to cavitation (VC) assessed with classical hydraulic methods (Bench dehydration, Static centrifuge, Cavitron) and HRCT for species with different wood anatomies (*i.e.* ring-porous, diffuse porous, and tracheids).

Figure 3: SOLEIL synchrtron where most of the HRCT data shows in these studies were measured.

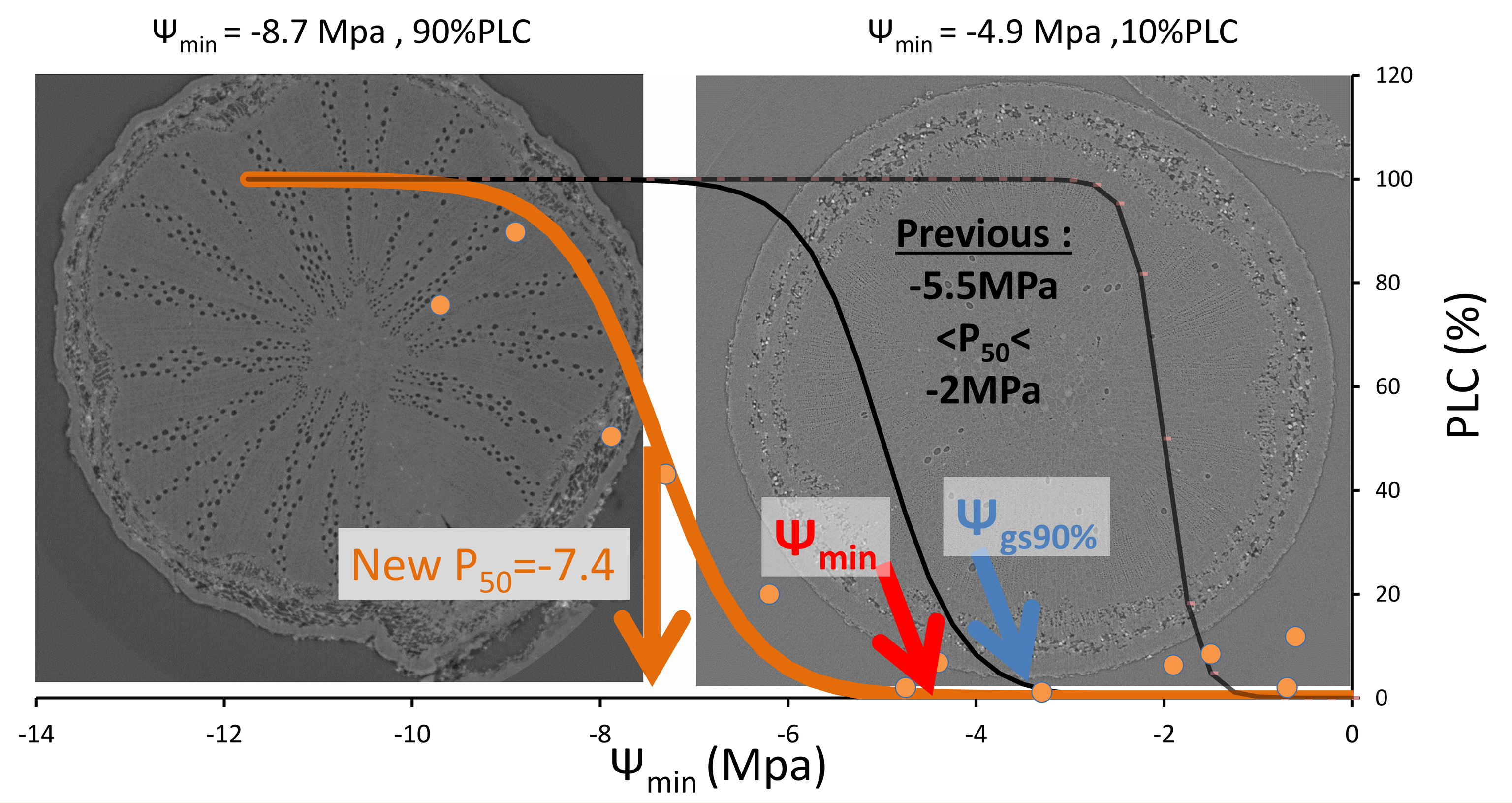
(2) We compared safety margins for stomatal conductance and minimum water potential, based on HRCT VC (3 years-old intact seedlings), with previous safety margins for the well documented Mediterranean oak *Q.ilex*

(3) We computed HRCT-based VC in two grapevine species (*Vitis vinifera* cv Cabernet-Sauvignon and *Vitis riparia* cv 'Gloire de Montpellier'), and two organs (stems and petioles).

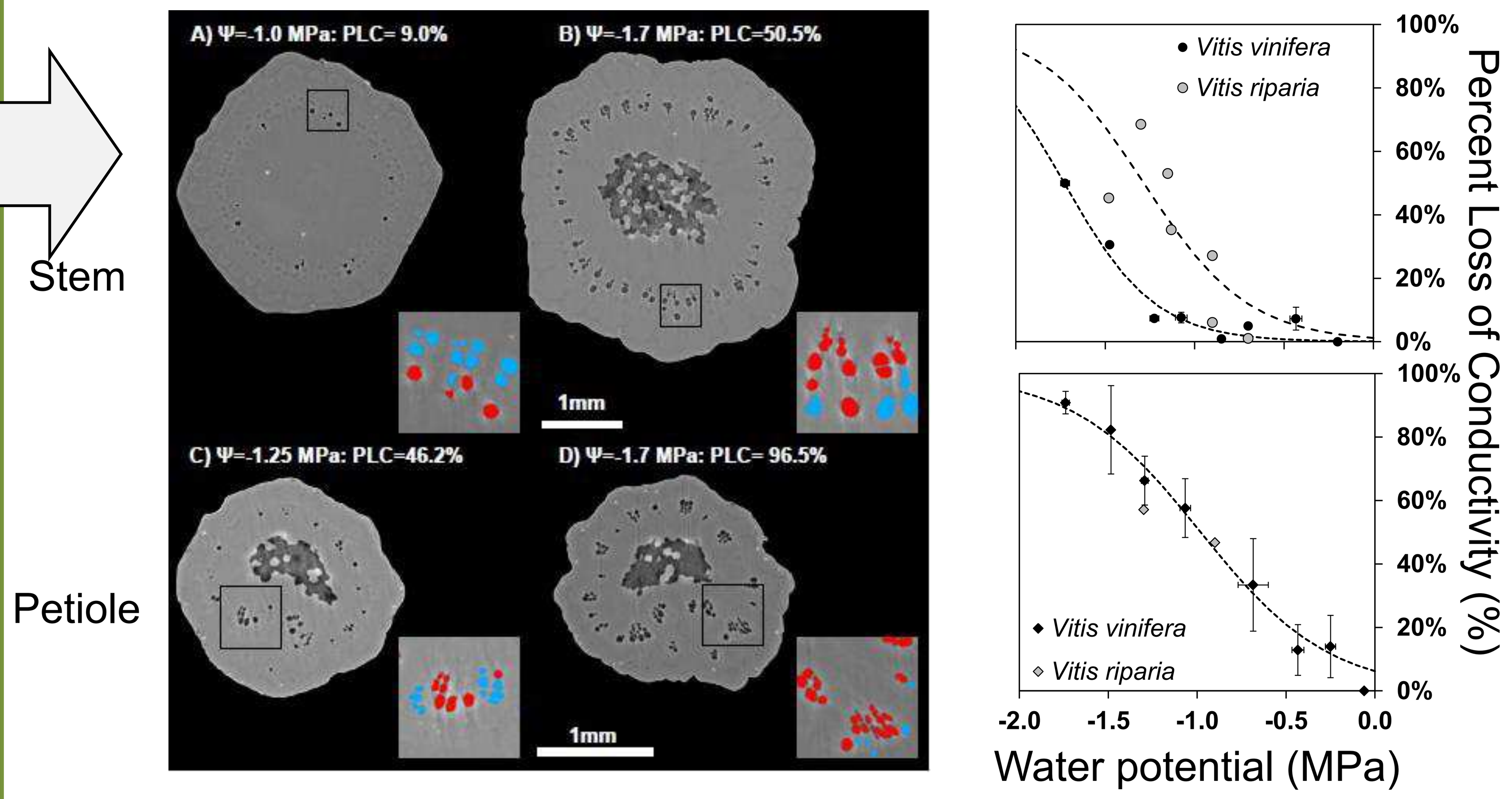
Results & Discussion



Result 1: Vulnerability curves produced with common methods (cavitron, static centrifuge) yielded consistent results only in tracheid-based (*Pinus*) and relatively short-vesseled species (*Populus*). HRCT confirmed the open-vessel artifact with common methods in long vessels species (*Quercus*).



Result 2: Previously published P_{50} for this species with ranged between -2 to -5.5MPa with very low safety margins. HRCT demonstrates that *Q. ilex* has P50 of about -7.4 MPa with safety margins 2 to 5 MPa higher than previously described [2].



Result 3: *Vitis vinifera* exhibits no embolism in stem above -1.0MPa (Ψ_{50}= -1.73MPa), whereas *Vitis riparia* is more drought-sensitive (Ψ_{50}= -1.28MPa). Also, petioles are more sensitive than stems (Ψ_{50}= -0.98MPa).

Conclusion

- HRCT allows us to work **on intact plants** and evaluate the xylem hydraulic functioning by direct observation
- HRCT is a relevant method to study plant hydraulics, especially in species that are prone to artefacts with usual hydraulic methods.

References: [1] Cochard H, Delzon S. Hydraulic failure and repair are not routine in trees. *Ann For Sci*. 2013. doi:10.1007/s13595-013-0317-5.
[2] Martin-StPaul NK, Longepierre D, Huc R, et al. How reliable are methods to assess xylem vulnerability to cavitation? The issue of "open vessel" artifact in oaks. *Tree Physiol*. 2014;34(8):894-905. doi:10.1093/treephys/tpu059.