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Plant hydraulics

Recent advances and some perspectives in the grapevine

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Switzerland

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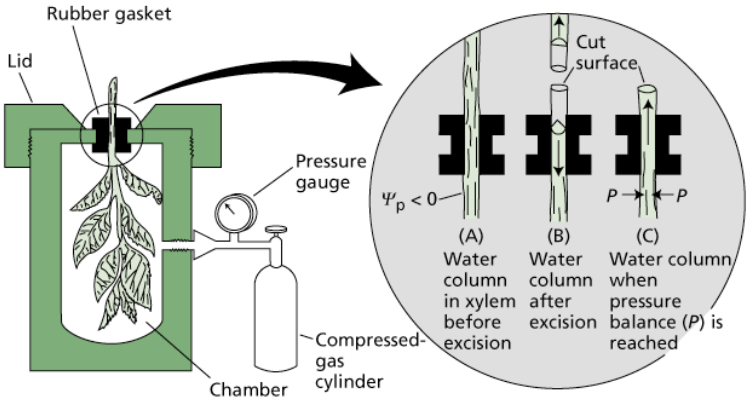
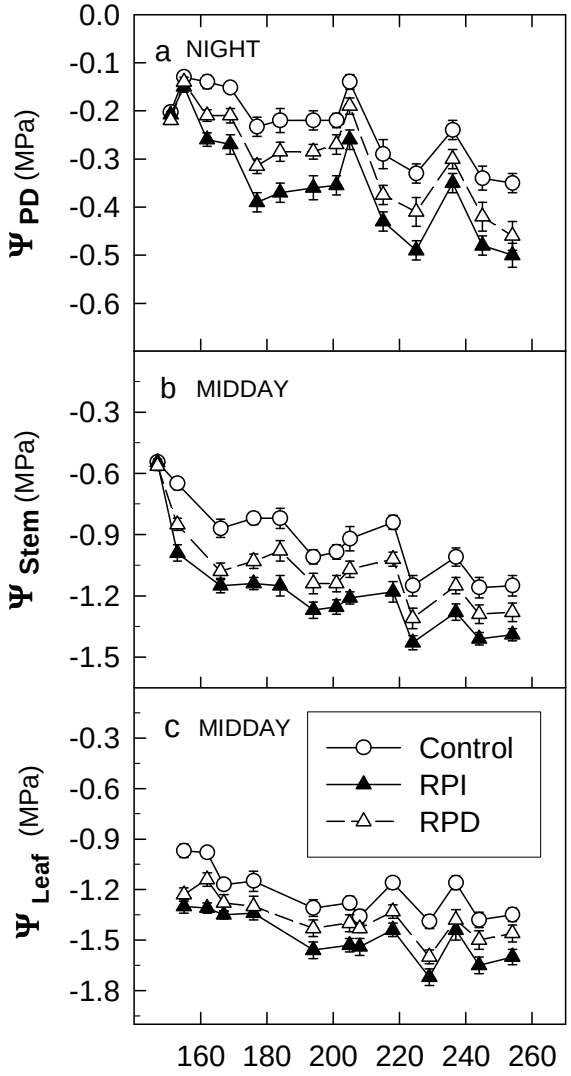
Indicators/measurements of Plant Water Status

Shoot growth rate, vigor (pruning weight), leaf wilting…

Relative Water Content (RWC)
Leaf-Stem Water Potential (Ψ)
Stomatal Conductance (gs)
Leaf-canopy temperature
Xylem Sapflow
Isotopic signatures (^{13}C, ^{18}O, ^{2}H)
Dendrometry
Water balance models, FTSW
Hydraulic Conductivity (HPFM, XYL'EM)
Acoustic emissions
Hormonal indicators
…

Leaf-Stem Water Potential (Ψ)





Syrah, Davis CA
Zufferey and Smart (2007)

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Comparison of the meaning of values of 4 measurements of plant water status

Table 1 - Water potential and $\delta^{13}C$ values with respect to vine water deficit thresholds

	Midday Stem Water Potential (MPa)	Midday Leaf Water Potential (MPa)	Pre-dawn Leaf Water Potential (MPa)	$\delta^{13}C$
No water deficit	> -0.6	> -0.9	> -0.2	< -26
Weak water deficit	-0.6 to -0.9	-0.9 to -1.1	-0.2 to -0.3	-24.5 to -26
Moderate to weak water deficit	-0.9 to -1.1	-1.1 to -1.3	-0.3 to -0.5	-23 to -24.5
Moderate to severe water deficit	-1.1 to -1.4	-1.3 to -1.4	-0.5 to -0.8	-21.5 to -23
Severe water deficit	< -1.4	< -1.4	< -0.8	> -21.5

From K. Van Leeuwen

J. Int. Sci. Vigne Vin, 2009, **43**, n°3, 121-134

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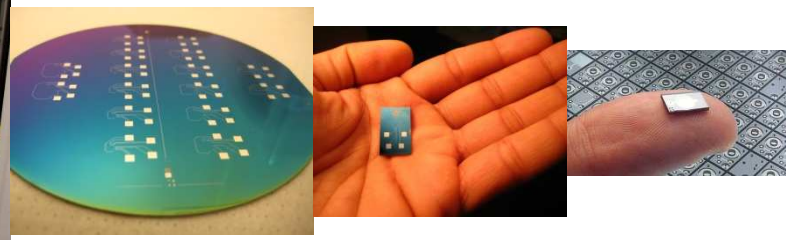
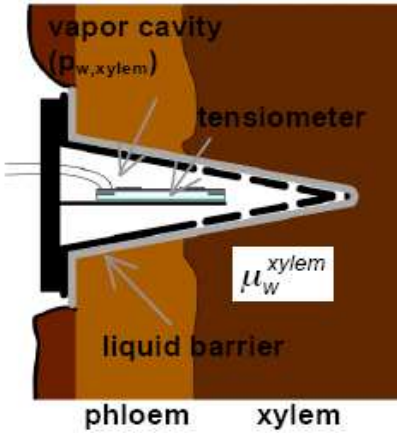
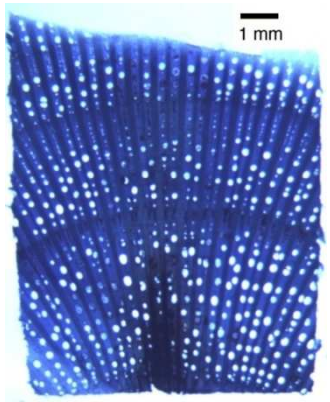
Development of an Embedded Microsensor for Tree and Vine Trunks to Continuously Monitor Stem Water Potentials

Lakso A., Pagay V., Stroock A. 2012
(Cornell University, NY)

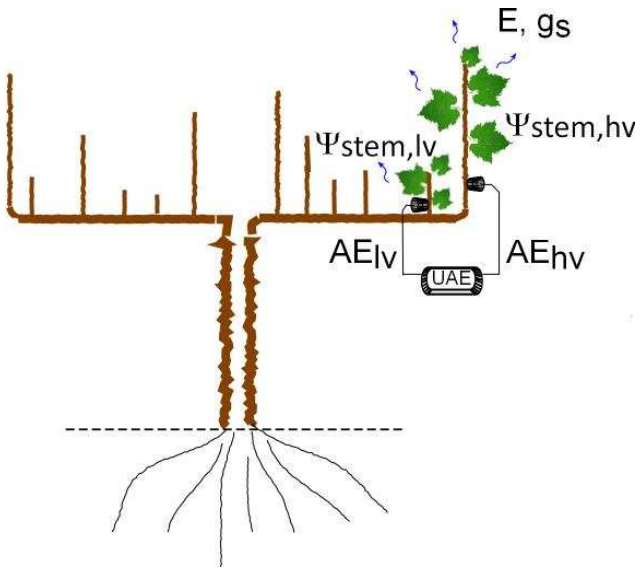


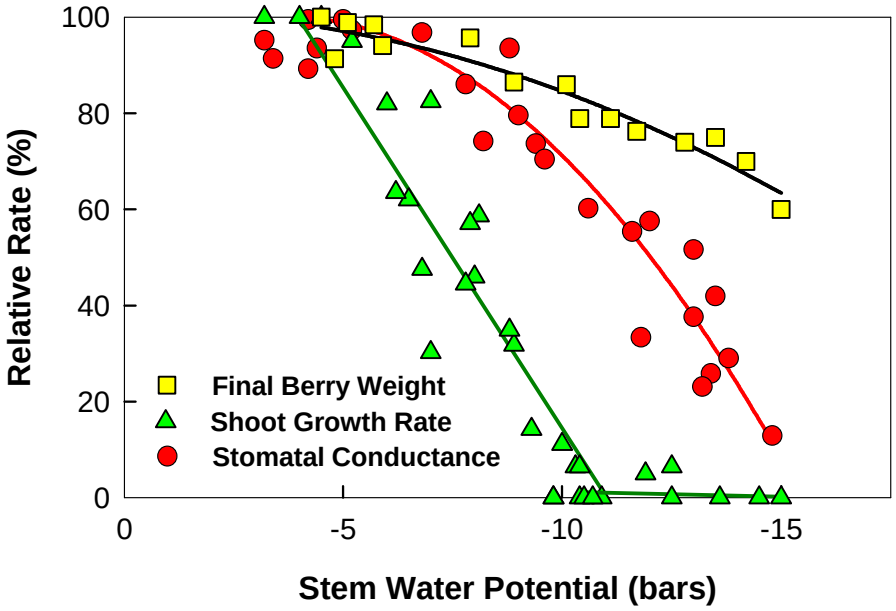




Water relations in the vineyard

(Riesling, Geneva NY 2011)





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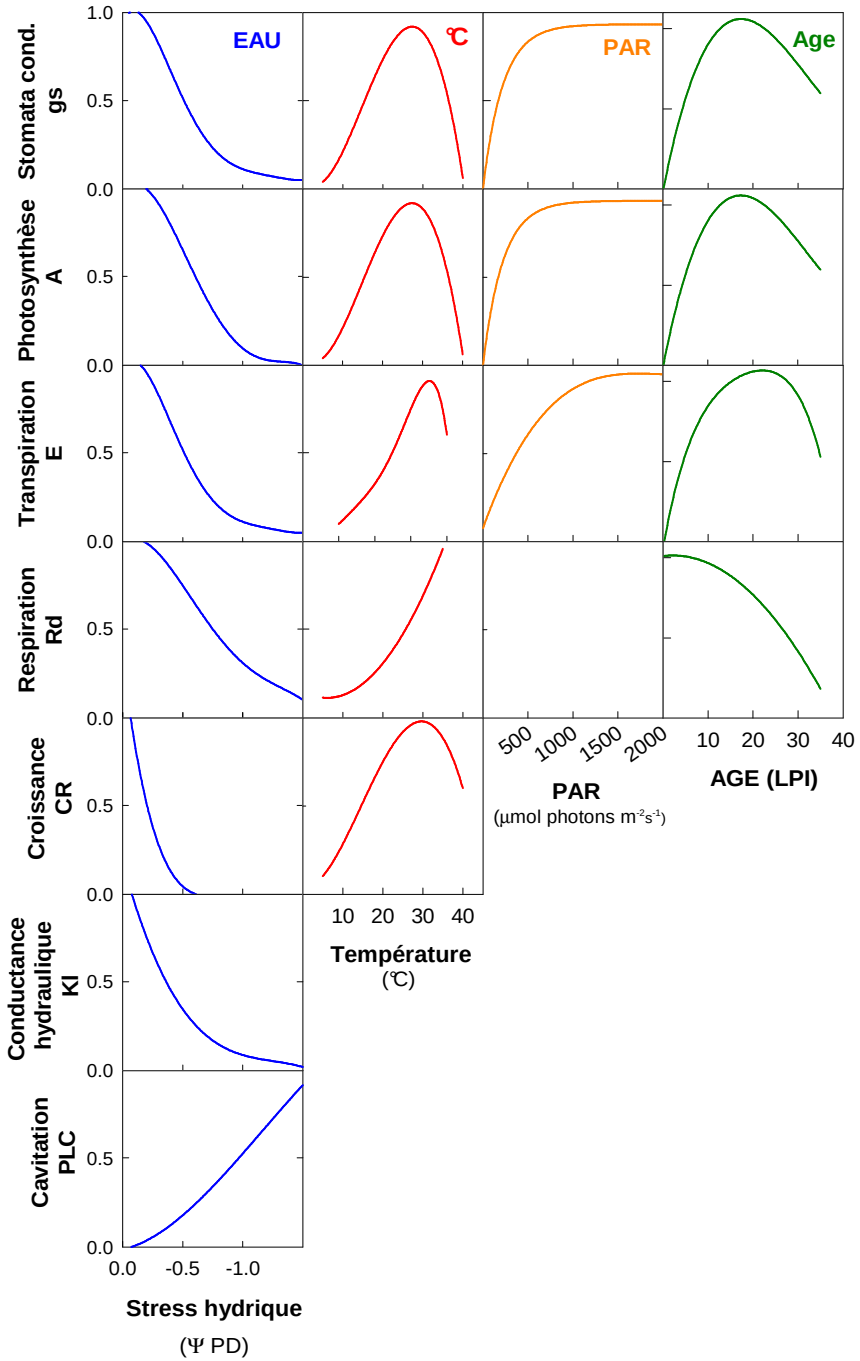
Empirical model using response functions (gas exchanges, growth…)

to environmental variables

Chasselas, Switzerland



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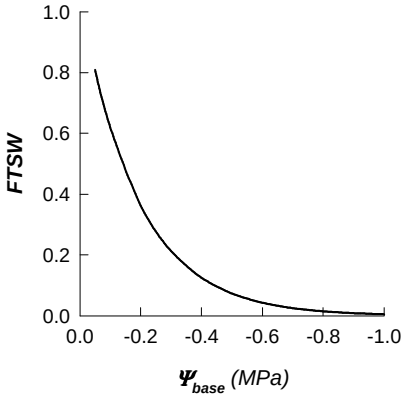
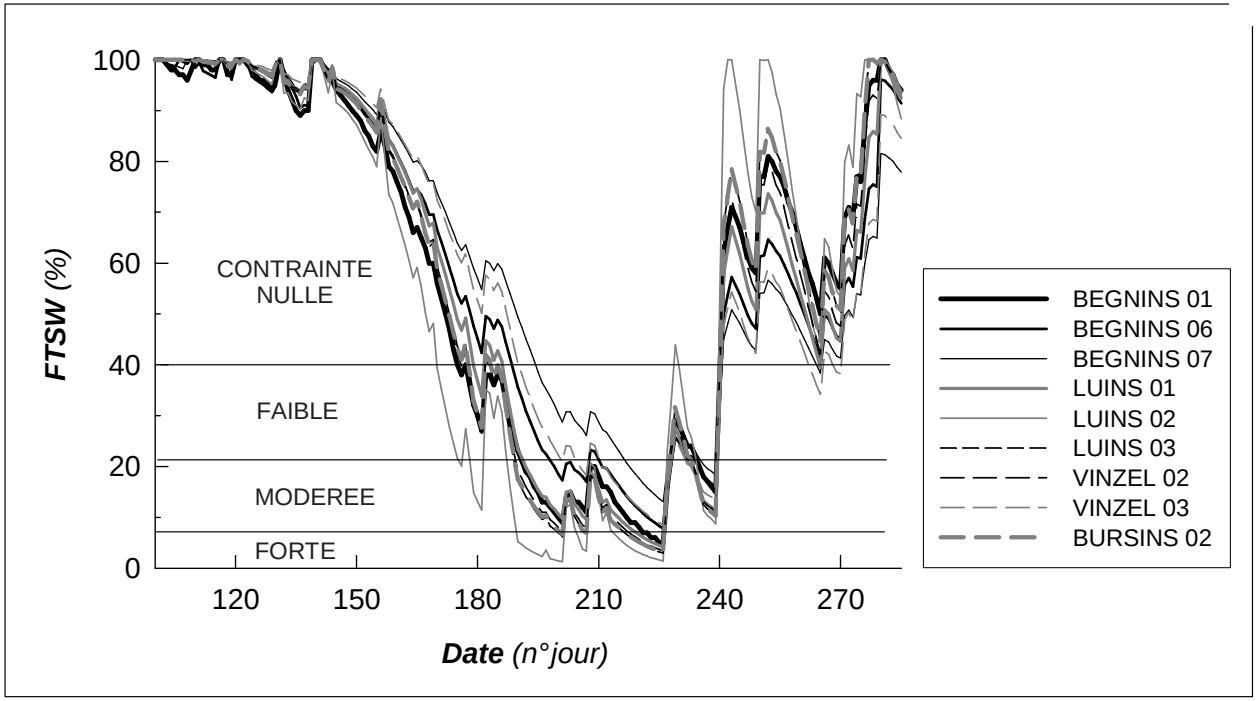
Changes in FTSW (fraction of transpirable soil water) using a water balance model (Lebon *et al*. 2003)

Chasselas, Switzerland





Direct Calibration of Sap Flow with Gas Exchange chamber

From A. Lakso (Geneva, NY)

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Diurnal Canopy NCER, Transpiration WCT and Water Use Efficiency

Poni *et al.1997*

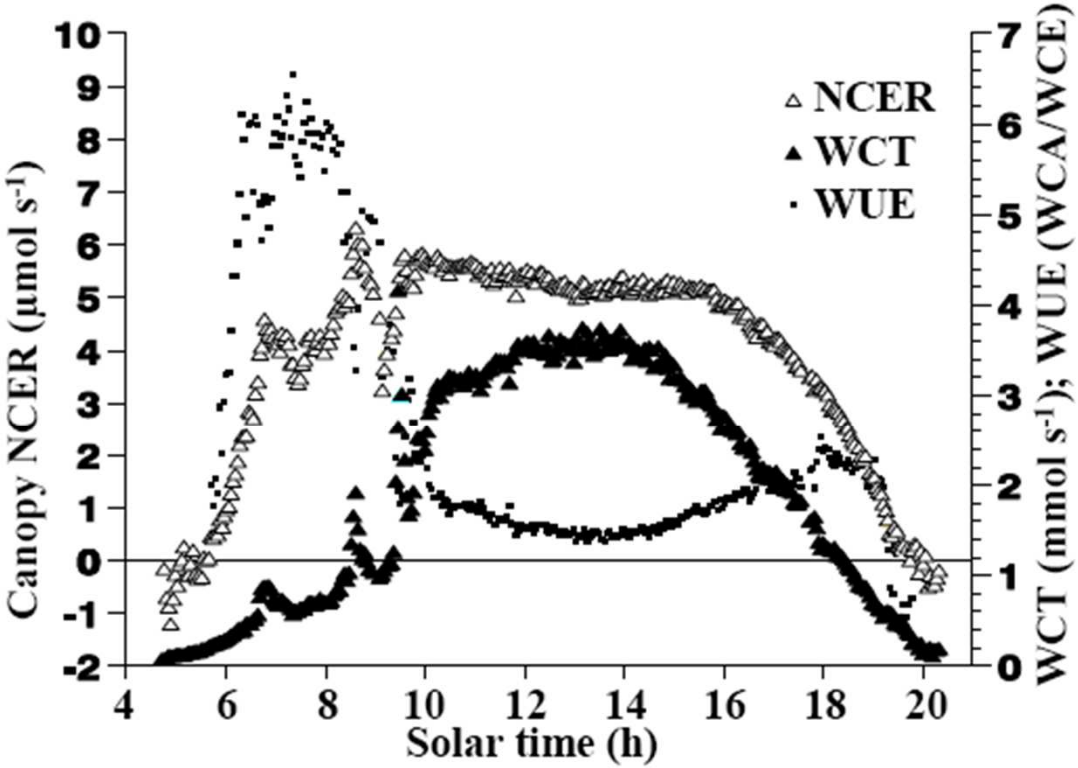

Fig. 6. Diurnal trends of canopy NCER, transpiration (WCT) and water use efficiency plotted for head-trained potted vines over a clear day. Source: Poni et al., 1997.

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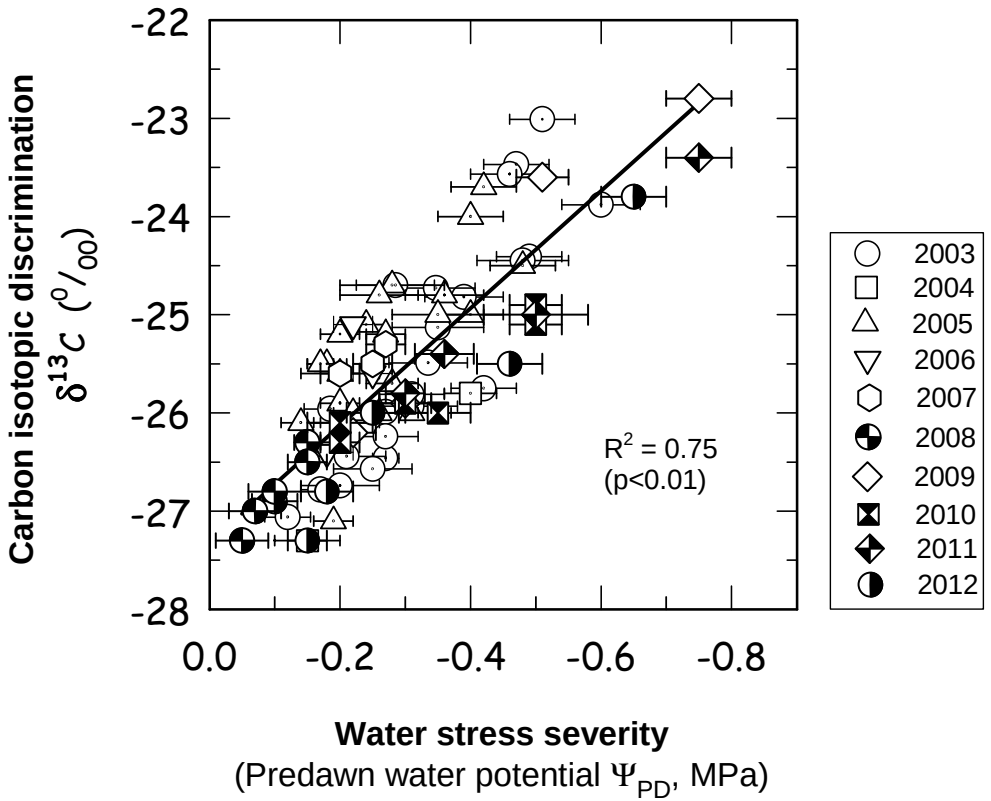
Relationship between water stress severity and carbon isotopic discrimination in berries

(Chasselas, Switzerland)



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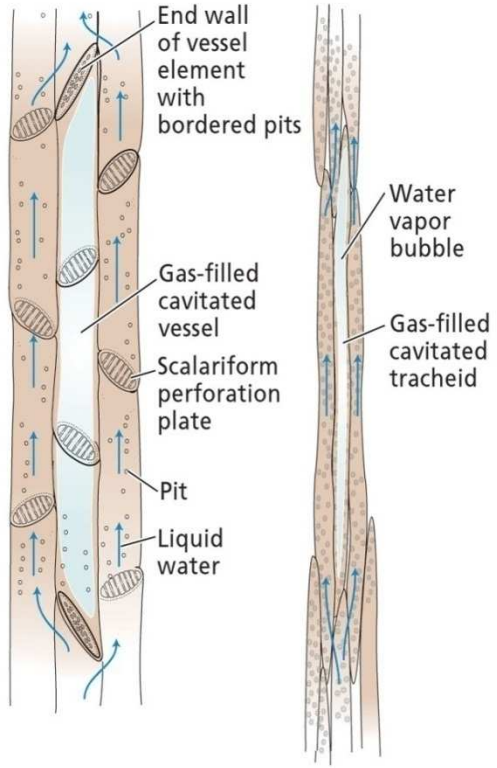
Cavitation events and embolism

(air bubles in vessels and tracheids)



Cavitation events induce:

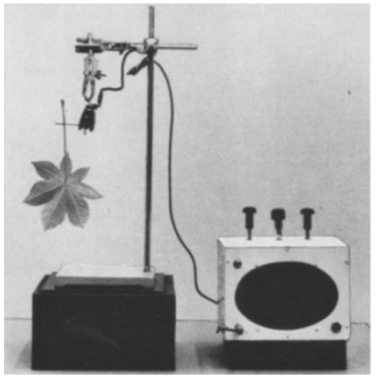
- **a decrease of hydraulic conductivity**
- **a progressive stomatal closure**
- **a decrease in transpiration/assimilation rates**
- **physiological disorders (apoplexia, leaf shrivelling…)**
- **leaf or vine death in extreme situations**

Embolism events seem to be reversible (day-night) by the grapevine

Cavitation events measurements

Acoustic emissions

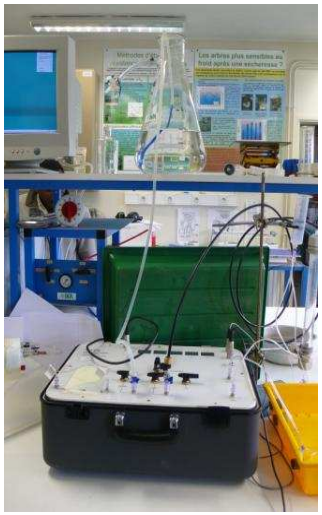
Milburn and Johnson, 1966



Geneva, 2011

Loss of water conductivity

Xylem, Cochard *et al*. 2002



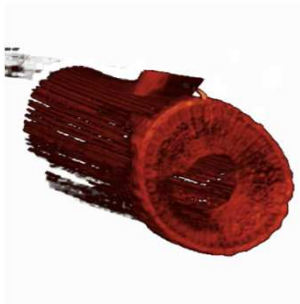
Cavitron

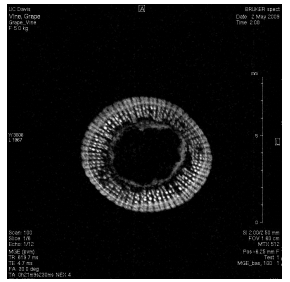
Cochard *et al*. 2005

MRI
magnetic resonance Imagery

Choat, 2009

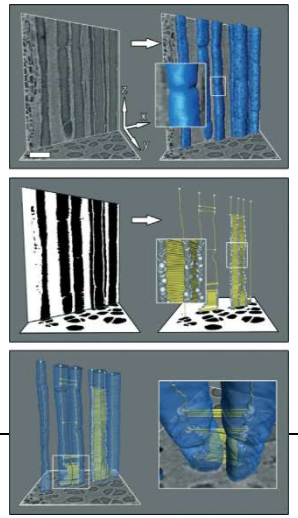
UC Davis, California, 2010





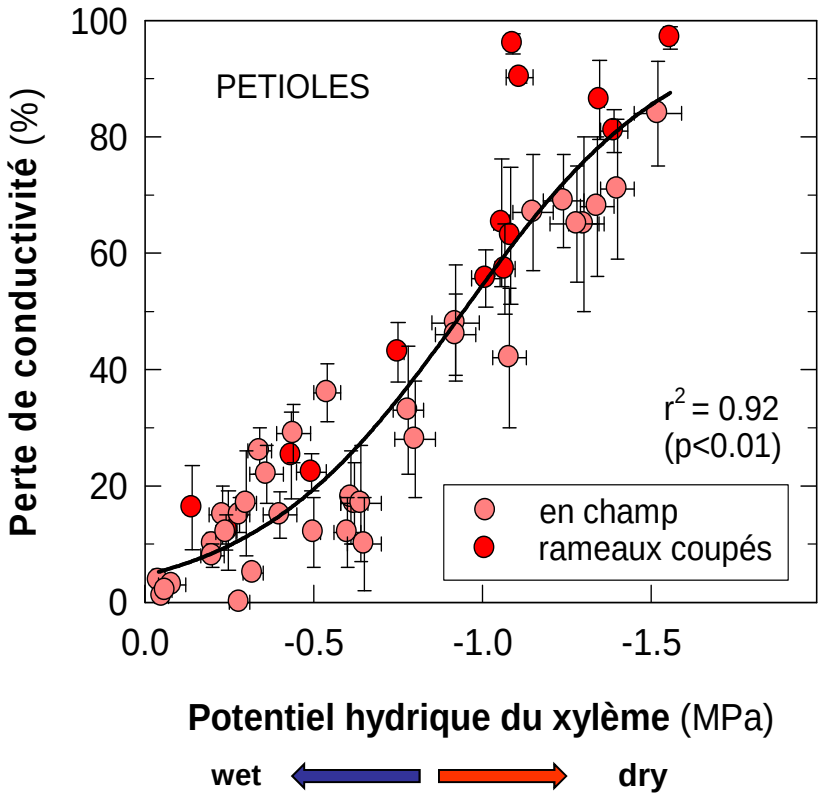
X-ray Tomography Synchrotron

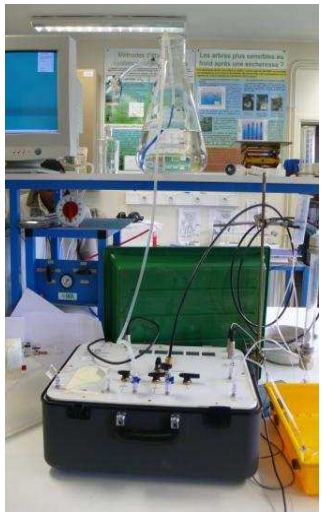
Brodersen *et al*. 2011

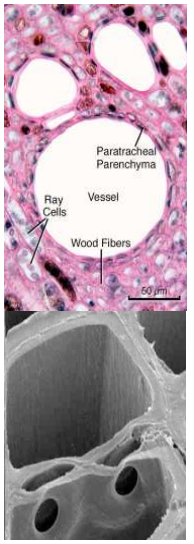


Vulnerability to cavitation
PLC (percent loss of conductivity)

Chasselas, Switzerland 2009



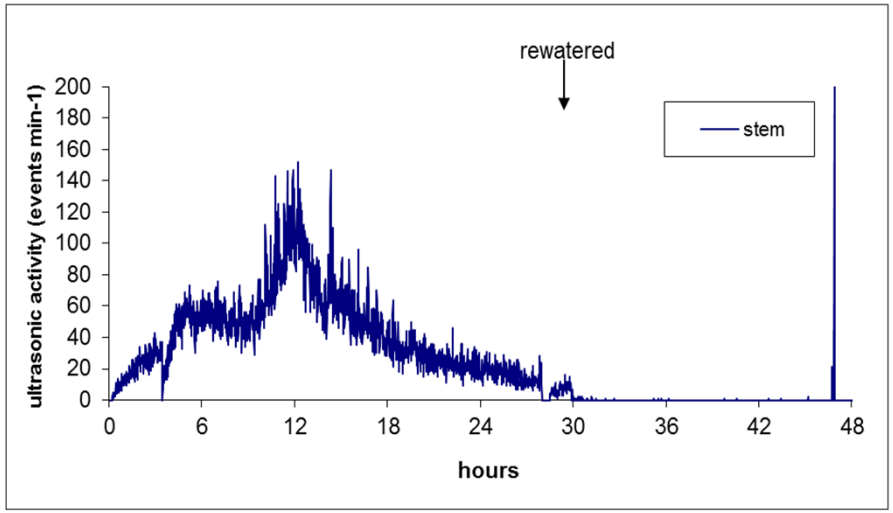




Ultrasonic and acoustic emissions

Chasselas, 2013

Mayr S., B. Choat, S. Jensen, V. Zufferey



Synchrotron, e- accelerator, X-ray tomography
Didcot, England 2013

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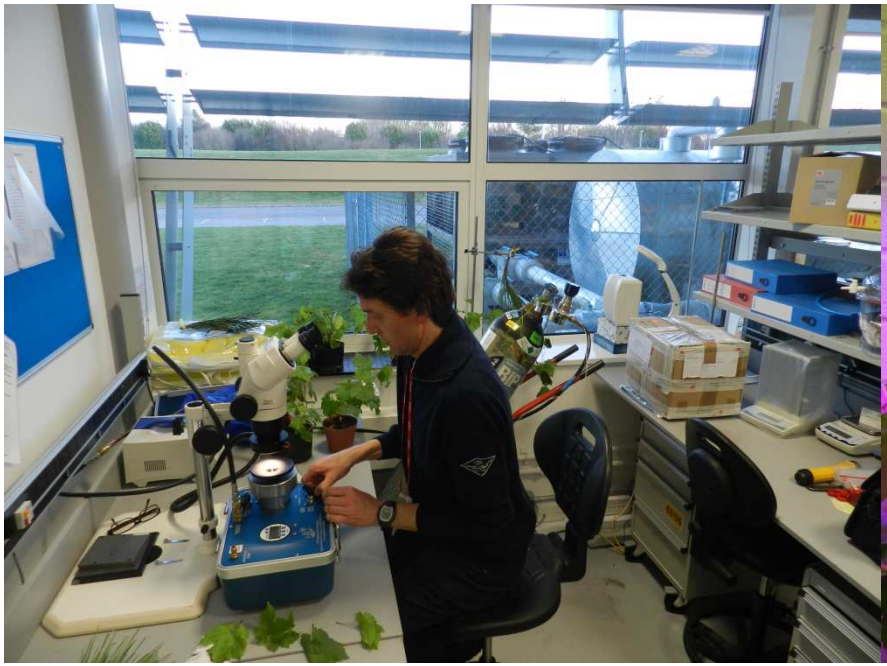
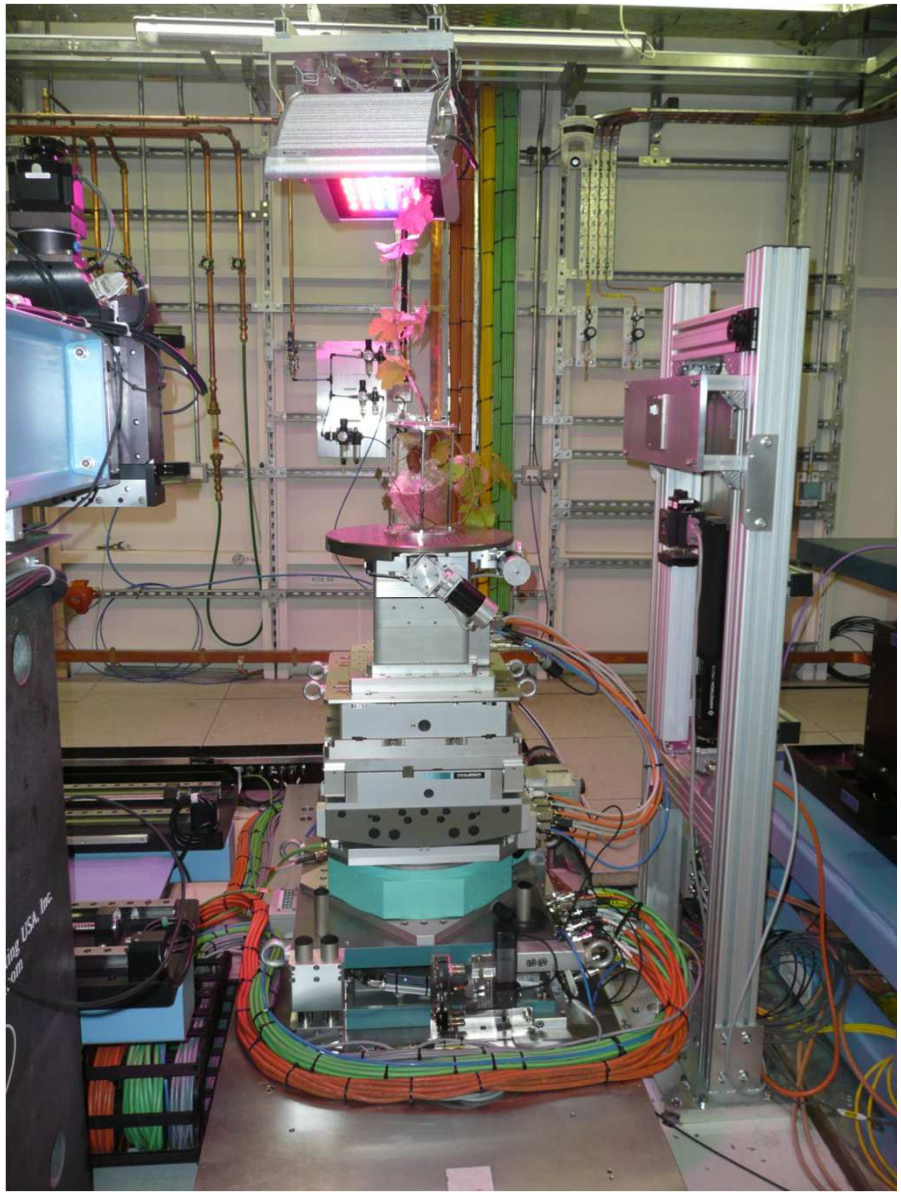
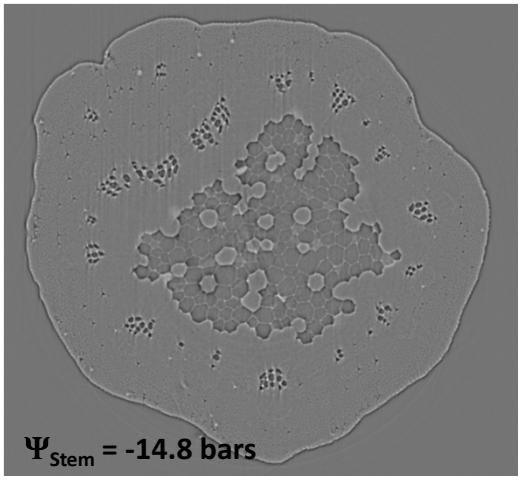
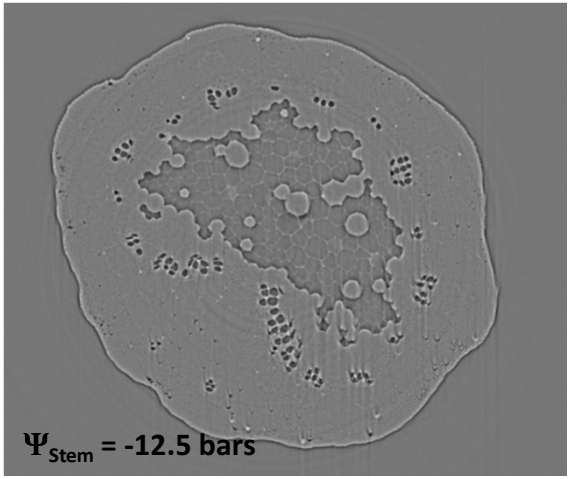


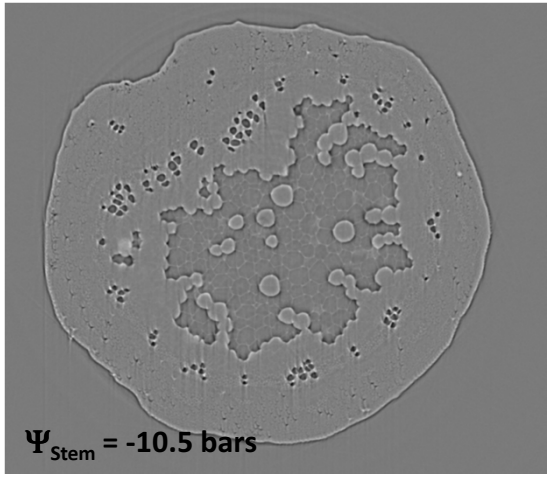


X-ray tomography on leaf petioles (Chasselas, 2013)

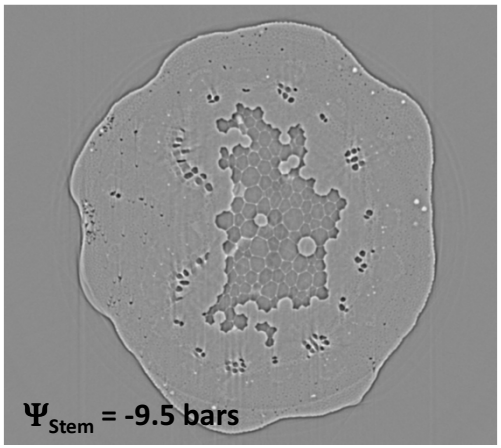
Vessels with cavitation on leaf petioles (Chasselas, 2013)

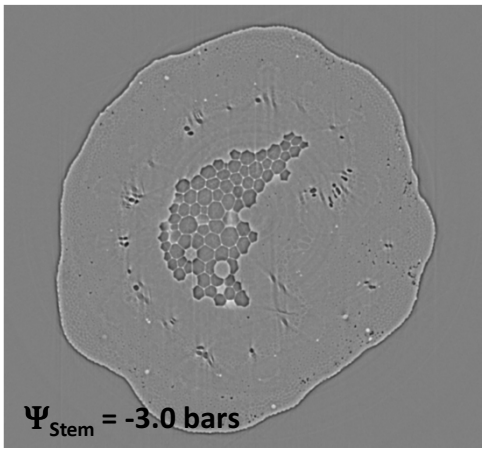


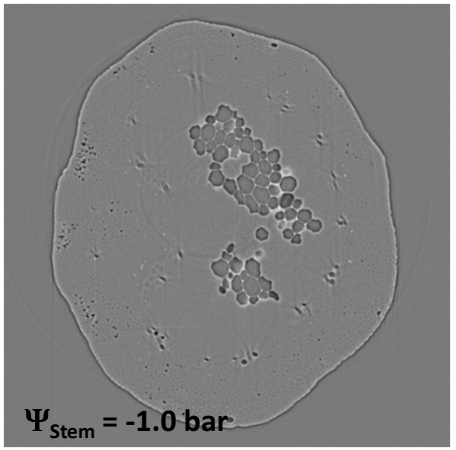




Water stress

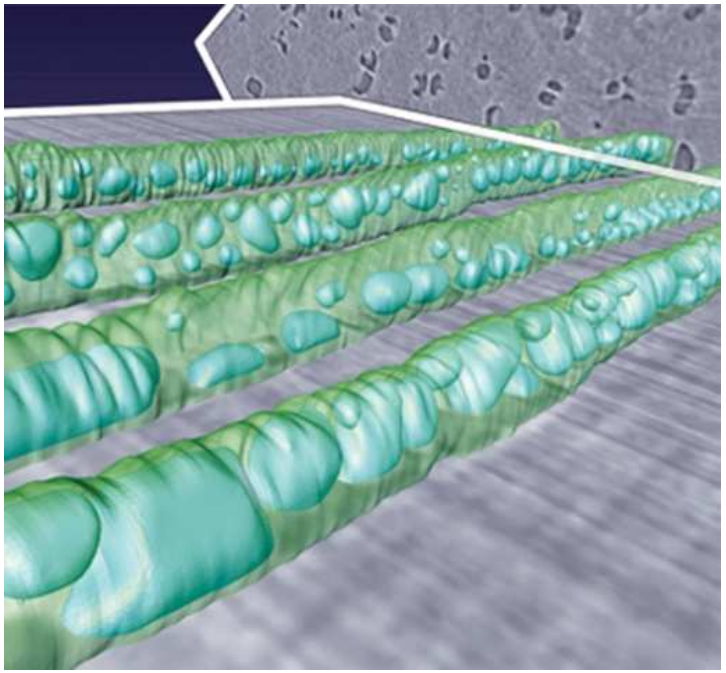


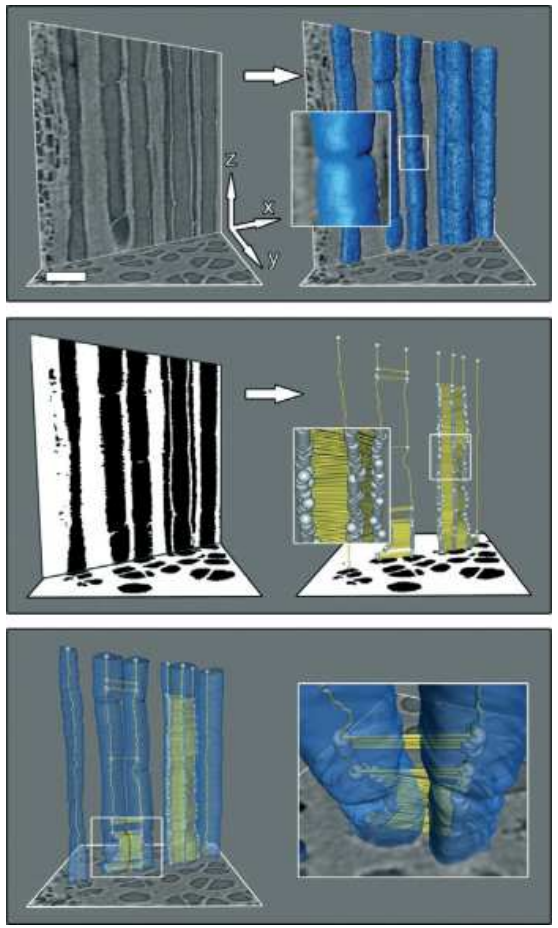




Non stressed vines

Imagery in 3D from X-ray Tomography on stems of grapevines (Brodersen *et al*., 2011)





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Thank you for your attention
diamond