Non-destructive measurements for destructive experiments: how to assess damages?

G. Charrier & T. Améglio
Context – Facing extreme climatic events

More heat-waves and drought events

Still some frost events
Abiotic stress – Physiological damages

Charrier et al., Plant Physiology 2016
Charra-Vaskou et al., J. Exp. Bot. 2015

0°C $\Psi \approx 0$ MPa
Frost -4°C $\Psi = -4.8$ MPa

Glace extracellulaire
Déshydratation

0.5 Osm
2.0 Osm

Glace intracellulaire

Freezing/Thawing

T = +5°C
T = -40°C
T = +8°C

Charrier et al., Plant Physiology 2016
Non-invasive techniques to monitor damages *in situ*

- **Dendrometer**
  - Water fluxes (drought and frost stress)
  - Growth (resilience to stress)

- **Ultrasonic acoustic analysis**
  - Cavitation events (drought and frost stress)
  - Other signals?
Radial growth monitoring since 1919

Daniel Tremblay MACDOUGAL (1919)

Pépi = thirst  sta= stabilize
For automatic fruit trees irrigation

Pépista ®, JG Huguet (1985)
Mini data logger integrated:
- LVDT (resolution <1µm (16 bit acquisition) & Temperature sensor (± 0.5 °C)
  Power Supply: 2 AA Autonomy for 12 months)
- Memorization: average according to selected frequency (1, 5, 10, 15, 30 mn, 1h, 3h)
- Memorization: from 2160 to 10800 measurements (ex, for 30 mn = a history over 45 to 225 days)
- Authorized distributor: Hydrasol licensed INRA Transfert
- PépiDataSoft remote download software, allowing to view and dialogue with the PépiPIAF and to edit the data in txt or excel format and to interpret them
- PC Transmission; Radio HF 43.3 Mhz: range of 150 m to PS and Sigfox or LoRa
Extreme drought conditions to determine mortality

Work in progress of a PhD student Lia Lamacque (UMR PIAF-Iteipmai) on the links between extreme drought and mortality on Lavanda
Winter damages

The $\Psi$ of ice changes at about 1.16 MPa K$^{-1}$ decrease in temperature.

Rajashekar and Burke (1982)
Rajashekar et al. (1983),

If the ice formation start at -5°C when the temperature decrease at -10°C, the $\Psi$ decrease about $\approx$-6.0 Mpa

Similar to Extreme drought stress!
Extreme stress at the treeline: Winter drought

Daytime shrinkage ($E$)

Nighttime shrinkage ($\Psi_{\text{ice}}$)

Nighttime AEs: Freezing-cavitation = bubbles formation

Daytime AEs: Embolism development due to transpiration $\Psi_{\text{stem}}$

Charrier et al., Plant Physiology 2017
Frost-induced acoustic emissions
Interspecific variability

Sigmoid relation with temperature,
\(0.928 < R^2 < 0.994\)

Wide variability in \(T_{50}\),
\(-10<T_{50}<-32^\circ C\)

Charrier et al. (2014) Plant Physiology
Frost-induced acoustic emissions is related to drought resistance

Freeze-Thaw expansion hypothesis with $\Psi_{\text{ice}}$ as driving force:

- $\Rightarrow$ displacement of the air-water menisci in pits
- $\Rightarrow$ cause bubble to expand or collapse

Drought-induced and frost-induced embolisms may share the same mechanism.

Charrier et al. (2014) Plant Physiology
Are UEs only from vessel origin?

Are AEs only from vessel origin?

- 2 stages of AEs
  1\textsuperscript{st} => embolism & cell damages
  2\textsuperscript{nd} => cell damages
Capturing acoustic parameters across stages to predict PLC and cell damages

Sounds promising!
Thank you for your attention

guillaume.charrier@inra.fr
thierry.ameglio@inra.fr