

A simple glasshouse experiment to test the isotopic fractionation in olive trees

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Daniele Penna, Jeffrey J. McDonnell, Marco Borga
EGU | Virtual | 26 April 2021

Start



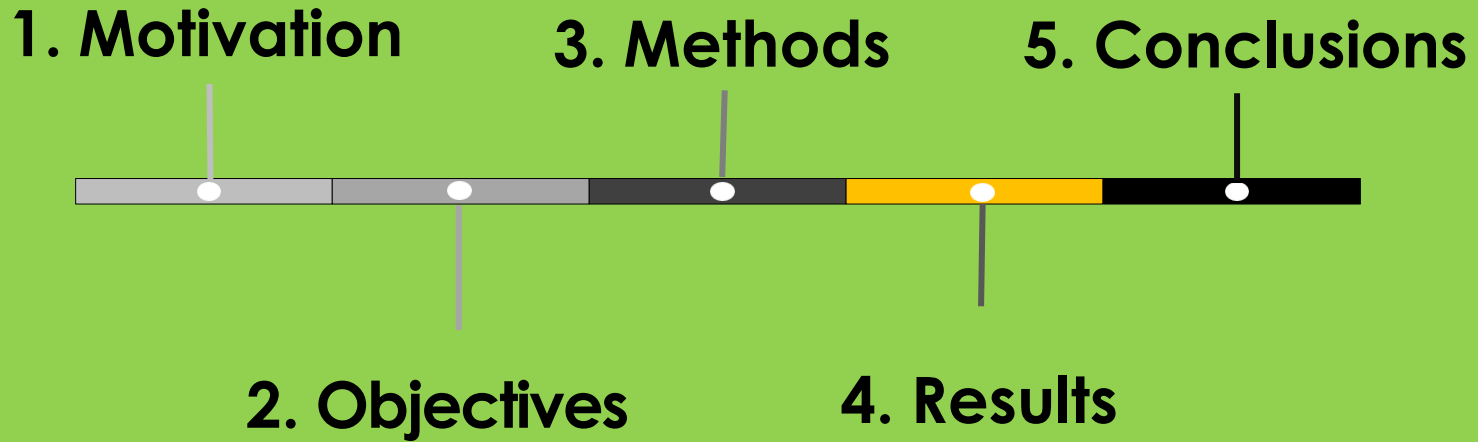
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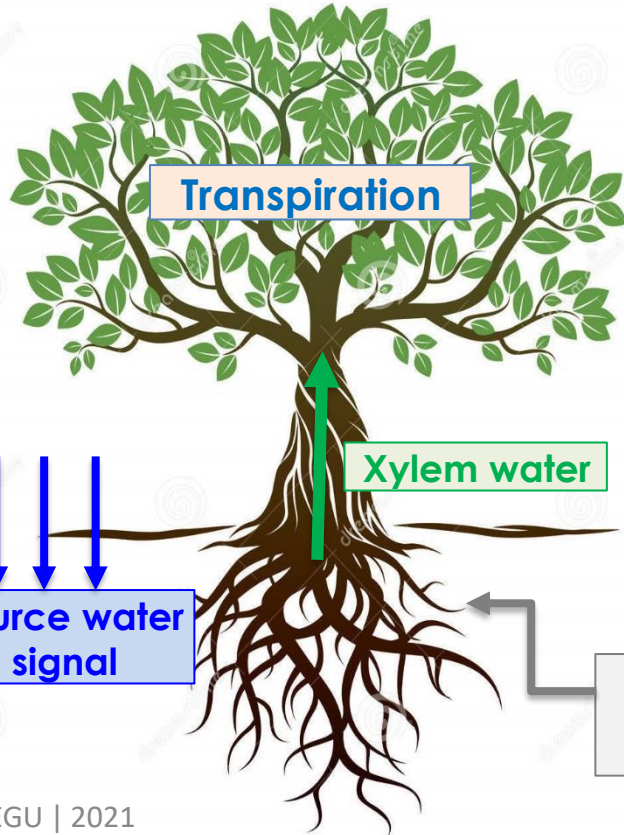


Isotopic tracing technique to identify plant water sources

Stable isotopes of oxygen and hydrogen are often used for the identification and quantification of plant water sources but based on an assumption

BASIC ASSUMPTION: No isotopic fractionation

Q: Does isotopic fractionation take place during water uptake and transport within the plant?



Objectives

1. to **quantify the isotopic fractionation of plant water source** along transport pathway
2. to examine **possible effects** of the **extraction systems** on the isotopic compositions of **plant water extracts**

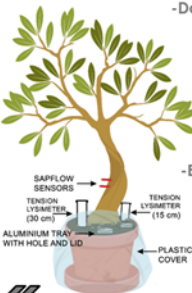


Methods | Set up of the experiment [Menu](#)

-Dataset-

Sampling rounds	LAB 1				LAB 2			
	O1	O2	O1	O2	O1	O2	O1	O2
Preliminary samplings	2	7	-	9	3	2	-	-
Conditioning period	7	5	7	5	7	7	5	5
Tracer experiment	22	31	21	21	24	33	23	22
Last sampling (after cutting down plant O1 entirely)	8	22	6	5	12	25	9	5
Total number of samples	39	65	34	40	46	67	37	32

-Experiment-



Two 6-year-old Olive trees (O1 and O2) having a 0.06 m diameter and a 1.9 m height were placed in a glasshouse.

Shallow soil moisture (0-6 cm depth) measurements taken manually twice a day using a soil moisture probe.

Daily Sap flow rates using Thermal dissipation sap flow sensors (Granier, 1985).

Air temperature, relative humidity, and global solar radiation measured continuously at 5 min intervals by a weather station installed inside the glasshouse 1 m from the two olive plants.

Step 1

Step 1 | The tracer experiment and sample collection [Menu](#)

Plants were irrigated with local tap water during the conditioning period and with labelled water during the experiment!

Two Tension lysimeters (15 and 30 cm) for the collection of **mobile soil water**:

LYS-Soil 15 cm
LYS-Soil 30 cm



Weekly sampling of Twigs, Wood cores, Roots

Soils sampled at different depths (0-5, 5-15, and 15-25 cm):

CVD-Soil 0-5 cm
CVD-Soil 5-15 cm
CVD-Soil 15-25 cm
CVD-Soil 25-35 cm



Step 2

Step 2 | Soil and plant water extraction by cryogenic vacuum distillation [Menu](#)

Both laboratories adopted system developed by **Koeniger et al. (2011)**

LAB 1 - University of Bolzano (Italy)



LAB 2 - Global Institute for Water Security (Canada)



Step 3

Step 3 | Data Analysis [Menu](#)

One-way analysis of variance was performed to assess the differences in the isotopic composition of plant and soil waters across different plant tissues and soil water depths. Consequently, significantly different ($p < 0.05$) were identified using a multiple comparison test.

The differences in the isotopic compositions of plant and soil water samples at Lab 1 and Lab 2 were determined with **Z-scores (Equation 1)**

$$Z - score = \frac{|Lab1 - Lab2|}{SD}$$

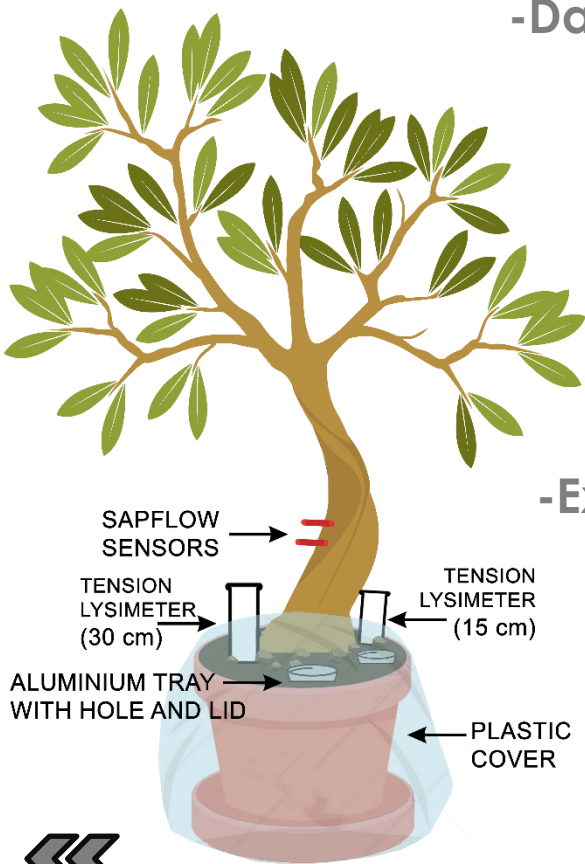
Ołowski, et al. 2016



-Dataset-

Sampling rounds	Sample size							
	LAB 1				LAB 2			
	O1		O2		O1		O2	
	Soil	Plant	Soil	Plant	Soil	Plant	Soil	Plant
Preliminary samplings	2	7	-	9	3	2	-	-
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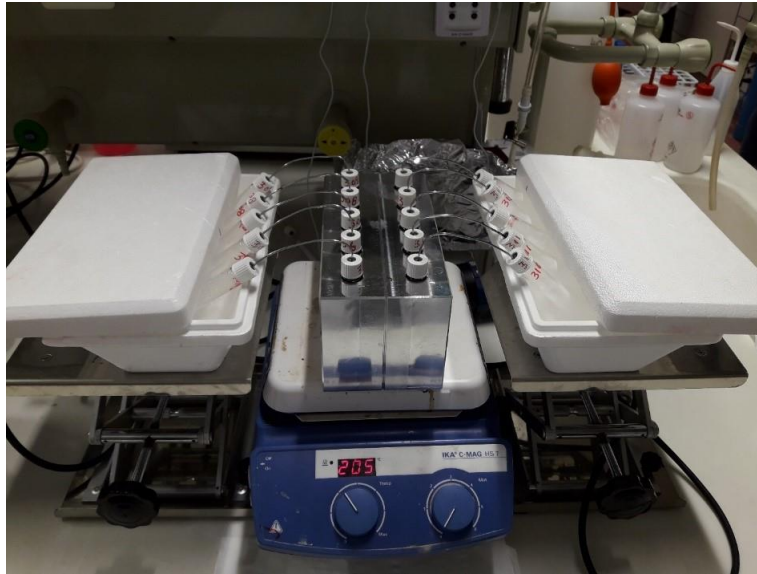
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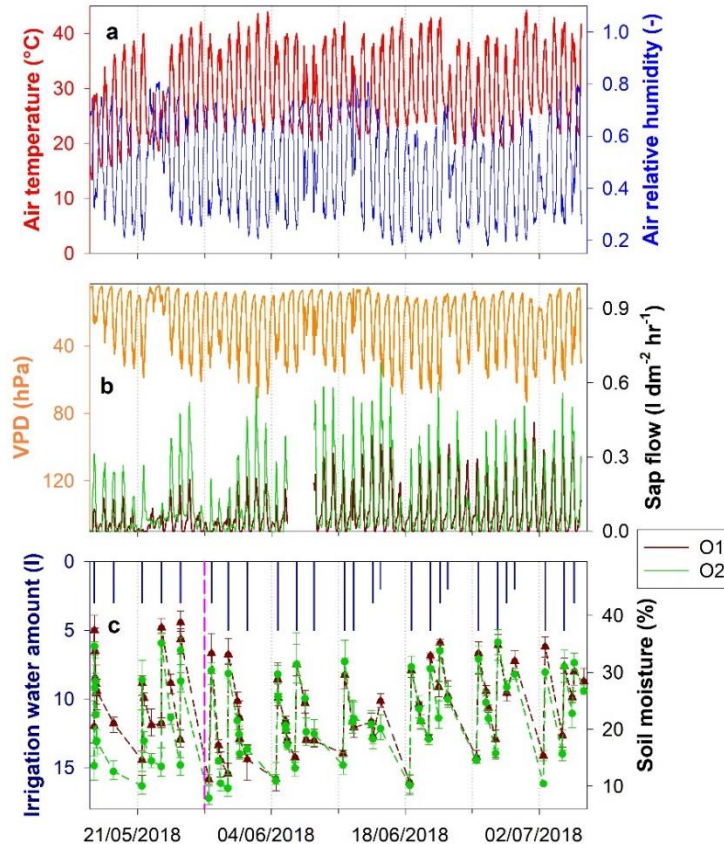
$$Z - score = \frac{|Lab1 - Lab2|}{SD}$$

Orlowski, et al. 2016



Results | Time series: weather variables, soil moisture and sap flow

Menu



Mean daily temperatures ranged between 22 °C and 33 °C, and average **relative humidity** of 48% inside the glasshouse.

Sap flow rates for the two trees were quite similar. Pronounced daily sap flow dynamics indicates efficient transpiration by the two plants throughout the entire duration of the experiment.

Shallow soil moisture was almost similar in the two pots and showed a clear temporal dynamics of wetting up due to irrigation water inputs

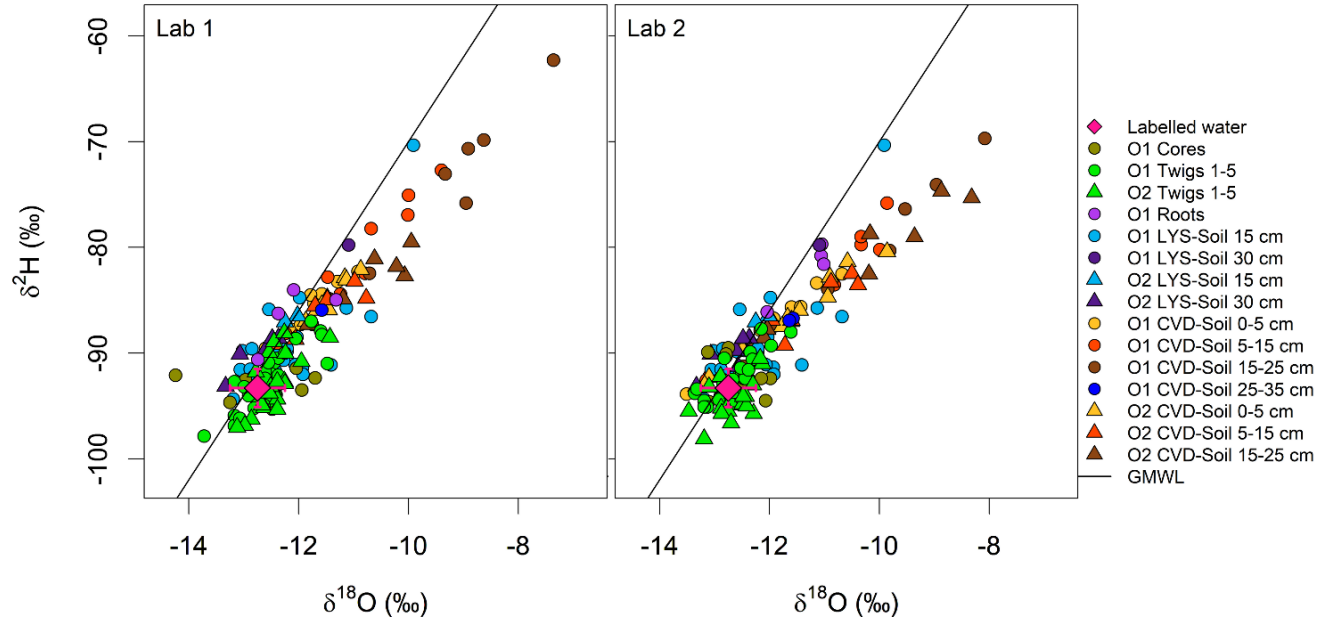


Results | Isotopic response of soil and plant waters to the labelled water

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Results 1.

Overall, plant water reflected the isotopic signature of labelled water and mobile soil water, suggesting no isotopic fractionation



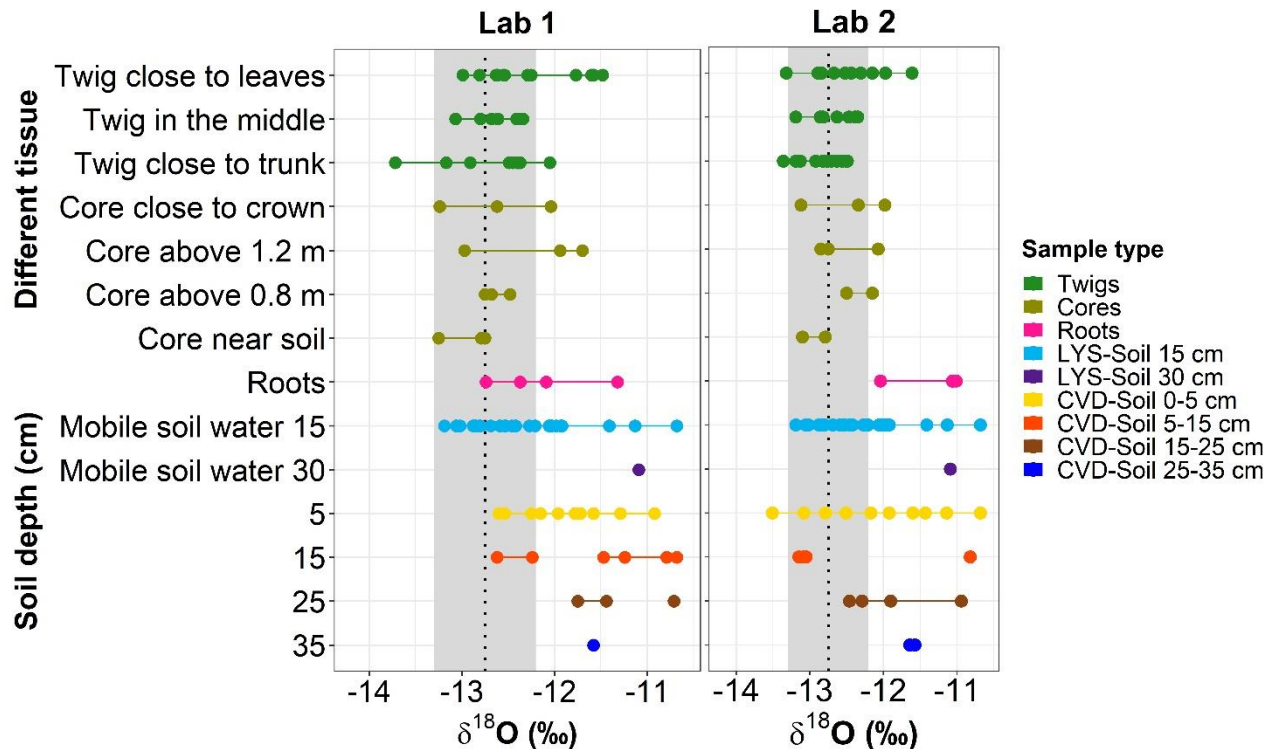
Results | Isotopic variability across plant tissues and soil water

Menu

Results 2.

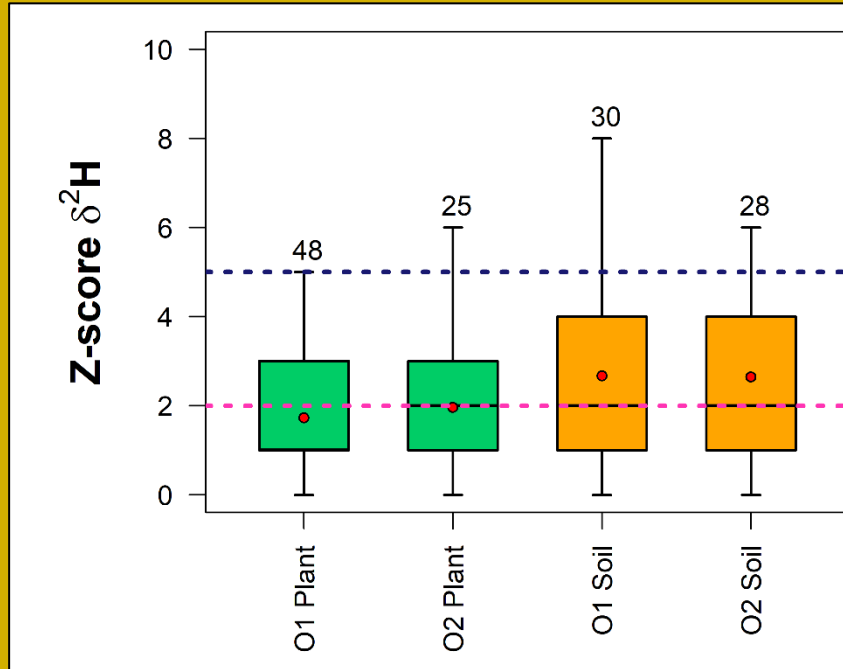
No significant differences were detected for twigs and wood cores extracted from distinct sections of the tree.

Only significant differences were found between plant tissue water (twigs, cores) and cryogenically extracted deep CVD-Soil water (i.e., >15 cm).



Results | Z-score Analysis

Plant and soil water cryogenically-extracted in the two laboratories



Results 3.

No significant effects of the two extraction systems on the isotopic composition of water extracts.

- ✓ Overall results from our preliminary experiment indicate that **plant water extracted from twigs had an isotopic composition similar to that of labelled water.**
- ✓ **Unlike plant water and gravity-drained soil water (LYS-Soil),** cryogenically extracted soil water (CVD-Soil) at depths above 15 cm reflected the signature of the labelled water only towards the experiment end.
- ✓ The observation that the isotopic composition of plant water was similar with that of the labelled water and the gravity-drained mobile soil water, and the positive d-excess of plant water lead us to conclude that **no isotopic fractionation occurred during the root uptake and transport of sap water** through the stem of the two olive trees, at least under the specified conditions of the experiment.
- ✓ Furthermore, we found **no significant effect of the two cryogenic extraction systems** on the isotopic composition of plant and soil water.



Thank you!

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Questions? Feedback? Come to chat box..!!!



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