

Comparative and Quantitative Analysis of Leaf Hydraulic Vulnerability in Mediterranean Tree Crops

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Overview

Leaf hydraulic conductance (**Kleaf**) is a fundamental regulator of plant water transport and stomatal function during drought. We investigated leaf hydraulic vulnerability in almond (*Prunus dulcis*), pistachio (*Pistacia vera*), and olive (*Olea europaea*) — three economically important Mediterranean tree crops — to compare hydraulic performance across species and establish a quantitative framework for predicting drought-induced hydraulic failure (embolism) as leaves transition from functional to embolized states.

- Water moves through leaves along water-potential gradients; leaf hydraulic conductance (**Kleaf**) measures how easily it flows. As drought intensifies, tension in the xylem rises until air bubbles (embolisms) block the conduits and conductance collapses — hydraulic failure.

California grows roughly 99% of U.S. almonds and pistachios, yet agriculture consumes about 80% of developed water. Under the 2014 Sustainable Groundwater Management Act, basins must reach sustainability by 2040, forcing growers to hold yields with less water. No clean, directly comparable vulnerability curves map exactly how leaf plumbing fails under drought across these crops. Growers need precise, species-specific hydraulic safety margins to schedule deficit irrigation. Hypothesis: olive maintains hydraulic conductance at lower (more negative) water potentials than almond and pistachio — greater resistance to hydraulic failure. The measurements below test that prediction.

- Measured **Kleaf** across leaf water potentials from 0 to -4 MPa (0–40 bar) with the Evaporative Flux Method (EFM). Excised shoots recut under water and connected to a custom dual-balance EFM system under controlled photosynthetically active radiation (PAR) and vapor pressure deficit (VPD). Water flow recorded every 30 s until steady state (coefficient-of-variation stability criterion). Leaf water potential measured right after each run with a Scholander pressure chamber (Fig. 3); leaf area from digital image analysis for conductance normalization (Figs. 4–5). Plotted **Kleaf** vs. water potential to map vulnerability curves and estimate **P50** — the water potential at 50% loss of conductance.

Preliminary Results

● Olive's first vulnerability curve ($n = 61$): **Kmax** 4.89, **P50** -1.28 MPa, **P80** -2.06 MPa. Pistachio ($n = 43$): **P50** ≈ -2.4 MPa — olive is roughly twice as vulnerable, counter to our hypothesis. Almond curves in progress; full comparison and **P50/P80** confidence intervals by presentation time.

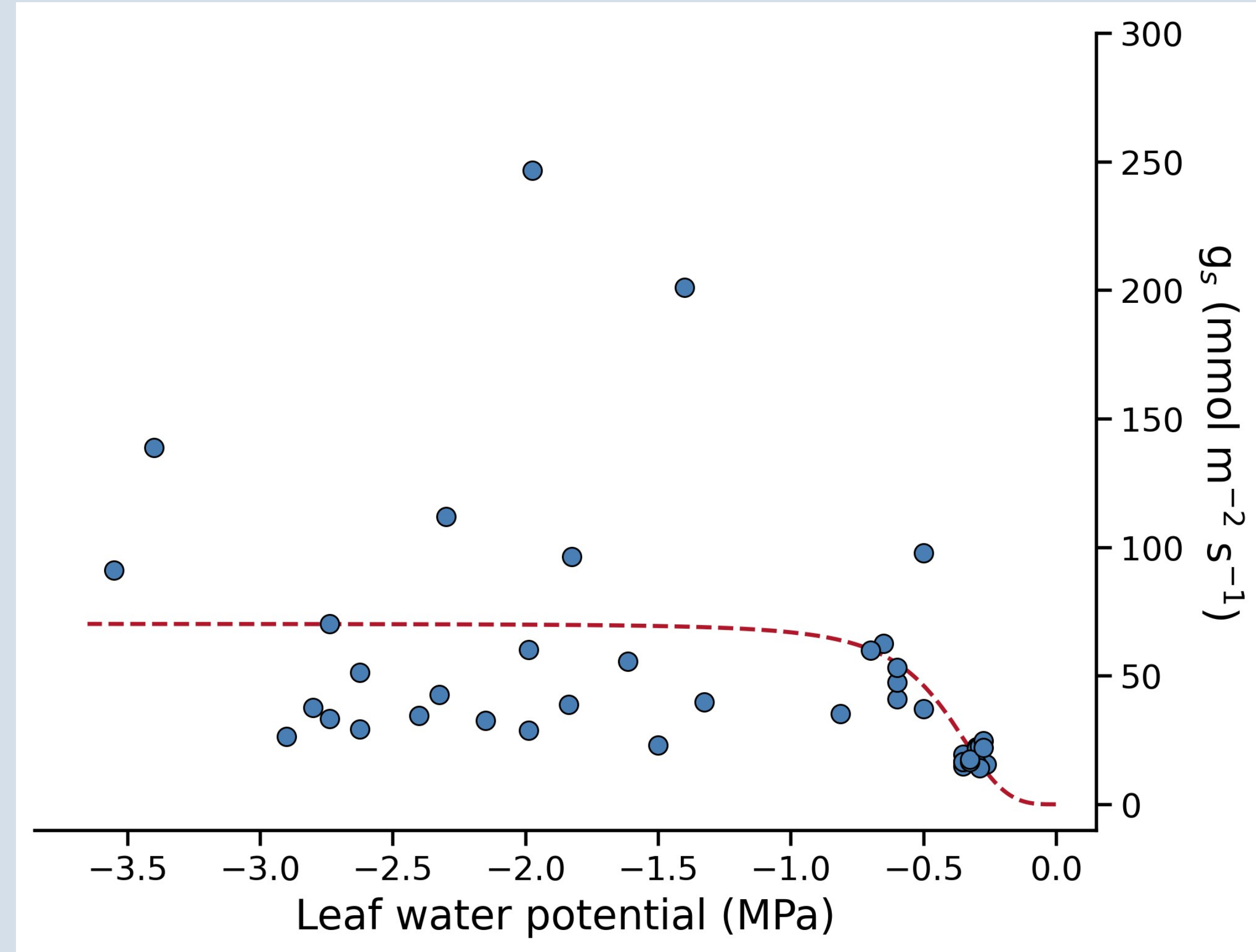


Figure 1. Preliminary pistachio leaf hydraulic conductance (**Kleaf**) versus leaf water potential, $n = 43$ leaves. Zero is a well watered leaf at right; leaves get drier and more stressed moving left. **Kleaf** stays high while the leaf is well watered and then falls as the leaf dries. The leaf loses about half of its water moving ability near -2.4 MPa (marked **P50**), a wide safety margin typical of a tough, drought resistant tree.

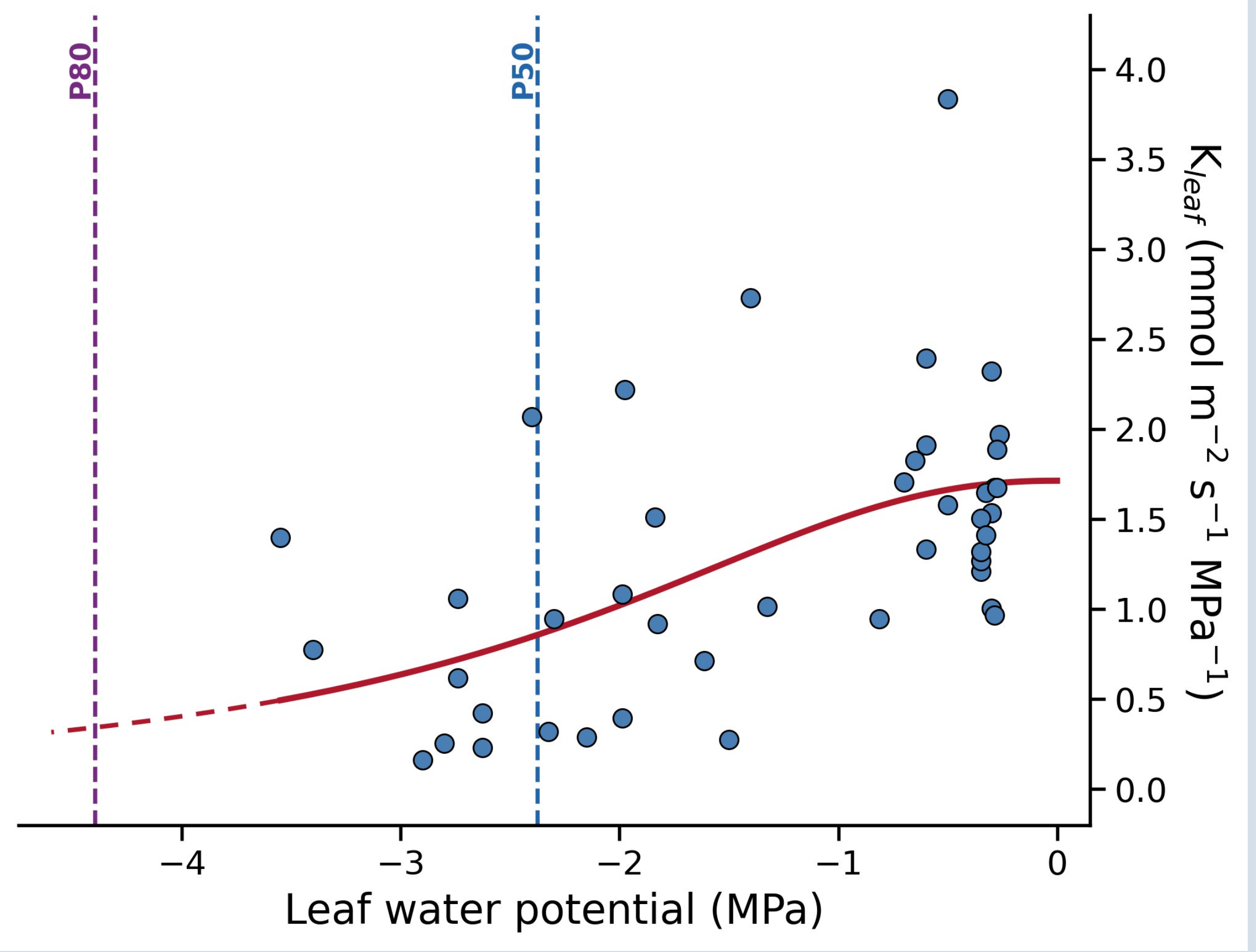


Figure 2. Pistachio stomatal conductance (g_s), same leaves, computed from water loss and the leaf to air vapor pressure difference. These preliminary values do not yet show the expected closing of the pores as leaves dry, which points to a measurement effect we are correcting, leaves refilling water during the reading and the pores briefly reopening, rather than a true response. Shown as a work in progress, being refined with steadier readings and an infrared leaf temperature sensor.

Conclusions

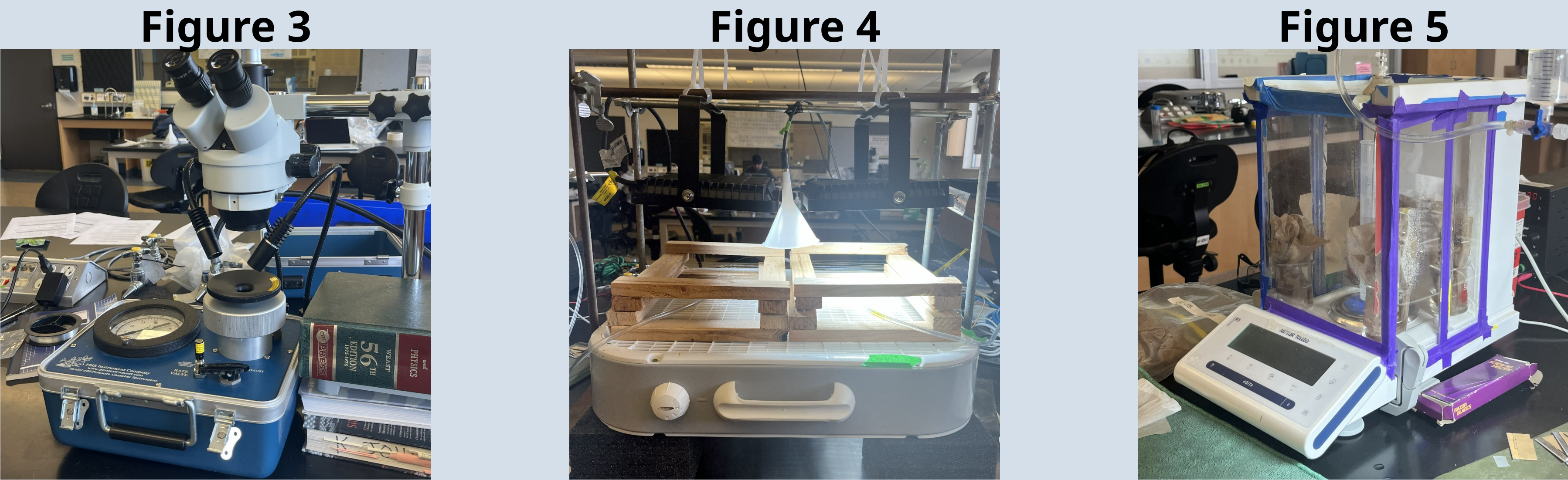
- First olive **Kleaf** vulnerability curve: **Kmax** 4.89, **P50** -1.28 MPa, **P80** -2.06 MPa ($n = 61$). Head-to-head: olive reaches 50% conductance loss at -1.28 MPa vs. -2.4 MPa for pistachio — olive is the vulnerable one. The data overturned our hypothesis. That is a finding, not a failure — it reframes which crop needs the most careful deficit-irrigation scheduling. Next: finish almond curves, tighten confidence intervals on **P50/P80**, and pair with micro-CT imaging to tie conduit embolism (structure) to conductance loss (function). Payoff: honest hydraulic safety margins for SGMA-constrained irrigation of Mediterranean orchard crops. Update to our submitted abstract: it reported early trends favoring olive, but the expanded dataset ($n = 61$ olive, 43 pistachio) reverses that conclusion — these numbers supersede the abstract.

Acknowledgements

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Graphic / Images



- Objective: Compare leaf hydraulic vulnerability curves across almond, pistachio, and olive; quantify P50 safety thresholds; and build a predictive framework for drought-induced hydraulic failure in Mediterranean tree crops.