# Novel insights into the biochemical drivers shaping $\delta^2H$ of sugar and cellulose within a plants' leaf

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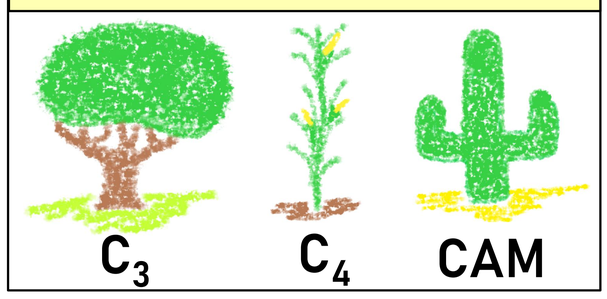
If you want to understand the whole plant, you must first understand the biochemical processes within the leaves

- The drivers responsible for $^2H$ fractionation before and after photosynthesis are not yet understood
- Studying the underlying biochemical reactions and physiological drivers:
  1. Plants with different photosynthetic pathways ($C_3$, $C_4$, CAM) under constant climatic conditions
  2. Temperature response of $\delta^2H$, $\delta^{18}O$, and $\delta^{13}C$ in leaf sugar, and what are the physiological drivers

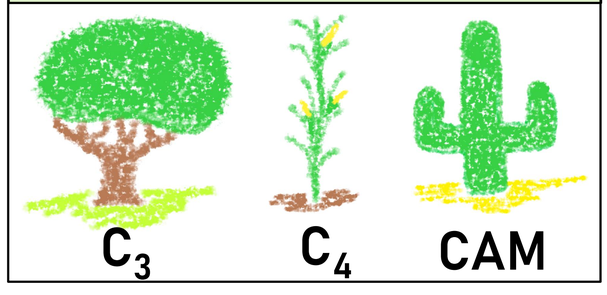
## Chapter 3: What we can learn from plants with $C_3$, $C_4$, and CAM photosynthesis

**Climate Chambers:**

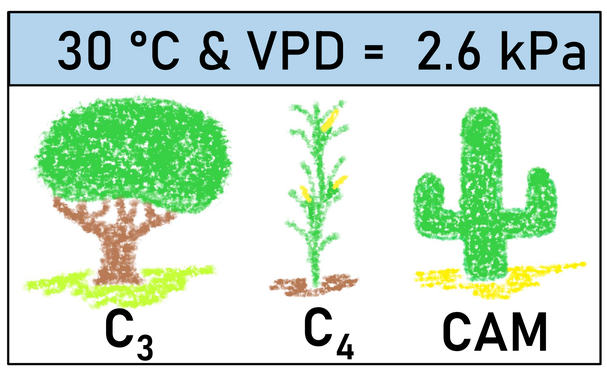
20 °C & VPD = 1.2 kPa




30 °C & VPD = 1.3 kPa

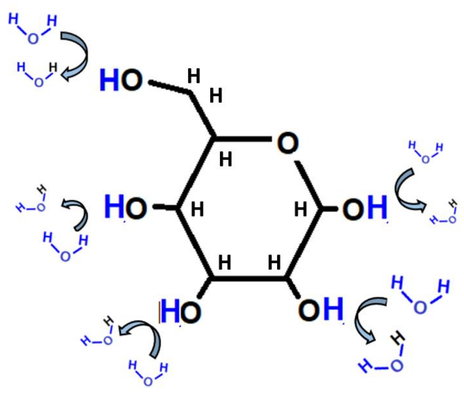



30 °C & VPD = 2.6 kPa

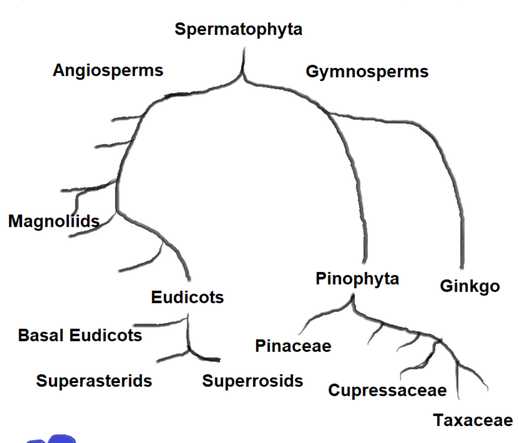



## Overview Ph.D. Thesis: $^2H$ fractionation in plant carbohydrates

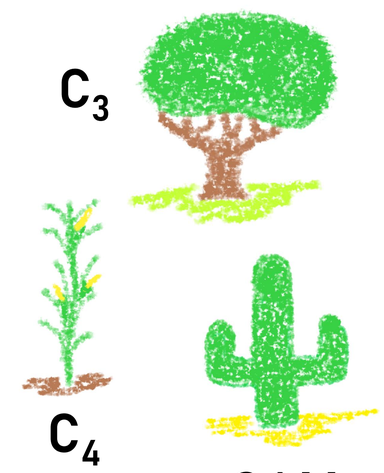
**Chapter 1:** Method
Schuler et al. 2022; PCE



**Chapter 2:** Phylogeny
Schuler et al. 2023; New Phytologist




**Chapter 3:** $C_3$, $C_4$, CAM




**Chapter 4:** Temperature Response Curve

**Chapter 5:** Temp, VPD, Drought → Leaf Sugar to Tree-Ring ($\delta^2H$, $\delta^{18}O$, $\delta^{13}C$)



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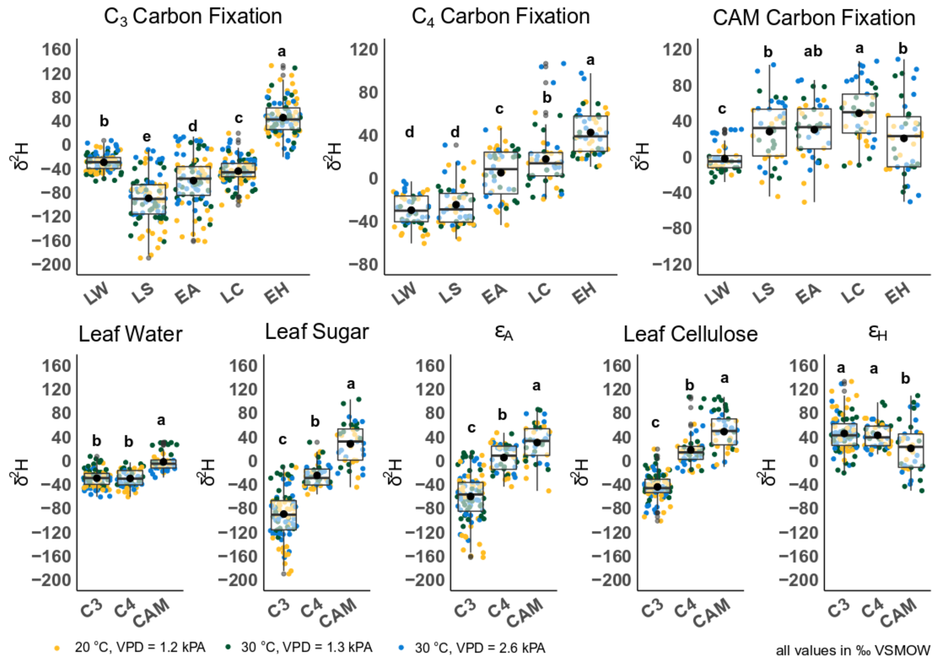
EGU General Assembly

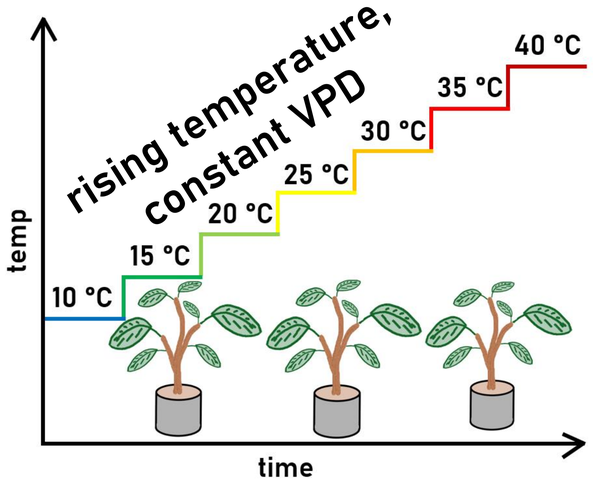
## Results Chapter 3: The biochemical drivers of $^2H$ fractionation

- Photosynthetic $^2H$ depletion is likely due to activity of PSII: strong in $C_3$, only in M cells in $C_4$, absent in CAM
- $^2H$ enrichment sugar to cellulose most likely due to enzymatic fractionation (e.g. respiration)
- Temp. & VPD impact only at the species level




LW = Leaf Water, LS = Leaf Sugar, EA = autotrophic $^2H$ fractionation, LC = Leaf Cellulose, EH = heterotrophic $^2H$ fractionation

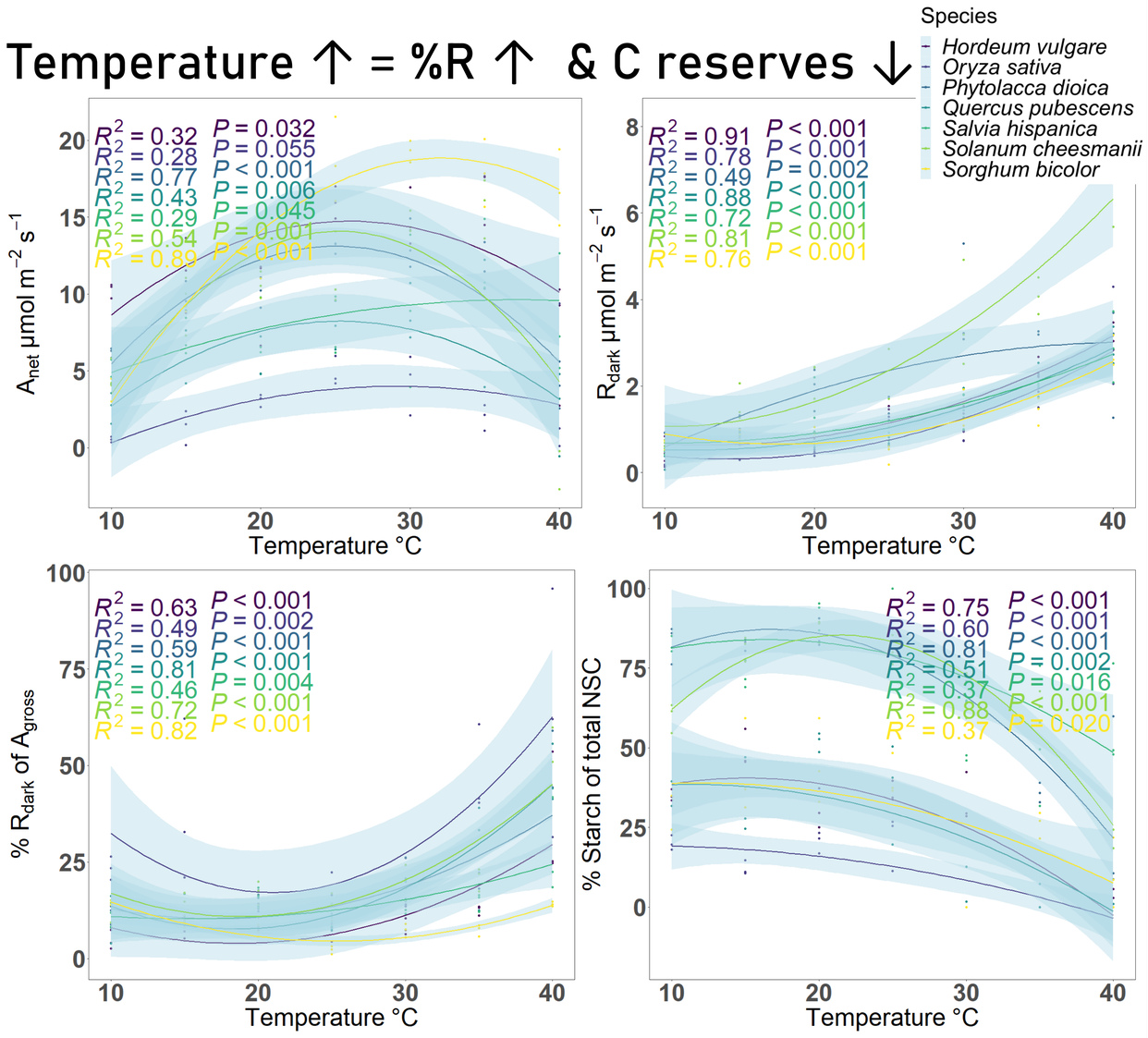
# Chapter 4: Plant physiological drivers of $\delta^2H$ in leaf sugar and their temperature response




1. 2 days dark @20°C: removal of old NSC
2. Growing for 5 days
   - Day 4: leaf sampling
   - Day 5: physiological measurements
3. Repeat with +5°C

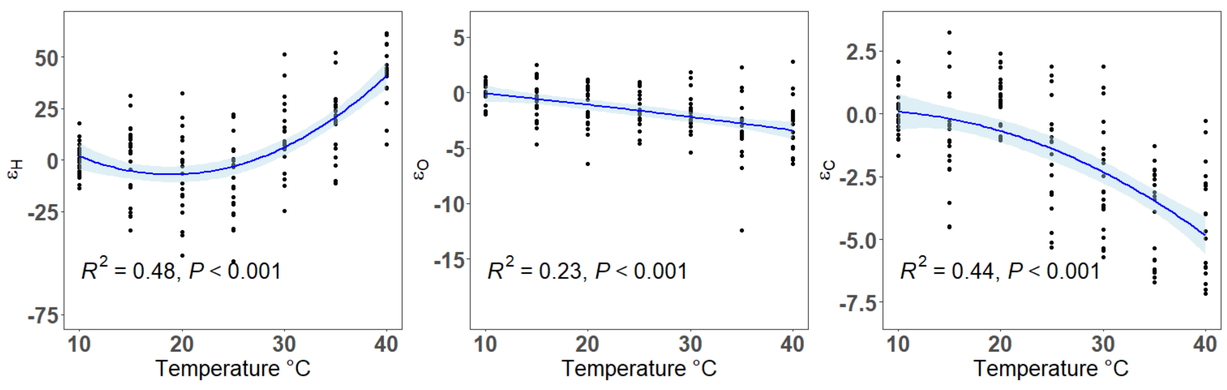
## Results 1 Chapter 4: Hot and Hungry

Temperature ↑ = %R ↑ & C reserves ↓




Normalized Temperature Response Isotope Fractionation:

Temperature ↑ = $^2H$ ↑, $^{18}O$ & $^{13}C$ ↓

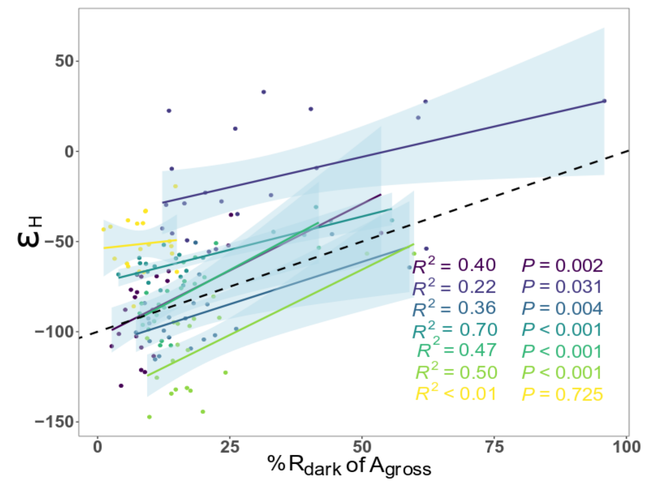



All values in ‰ relative to their isotope standard

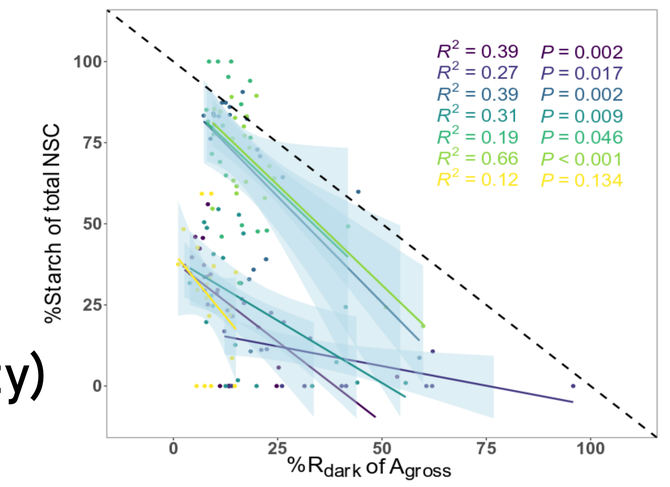
## Results 2 Chapter 4: The physiological drivers of the $^2H$, $^{18}O$, and $^{13}C$ fractionation

$\delta^2H$:

Respiratory/enzymatic $^2H$ enrichment

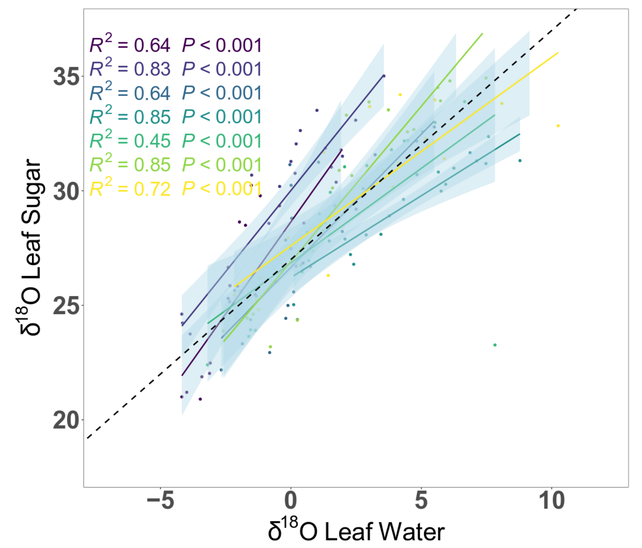



Depletion of carbon reserves due to increased respiration (R → metabolic activity)




$\delta^{18}O$:

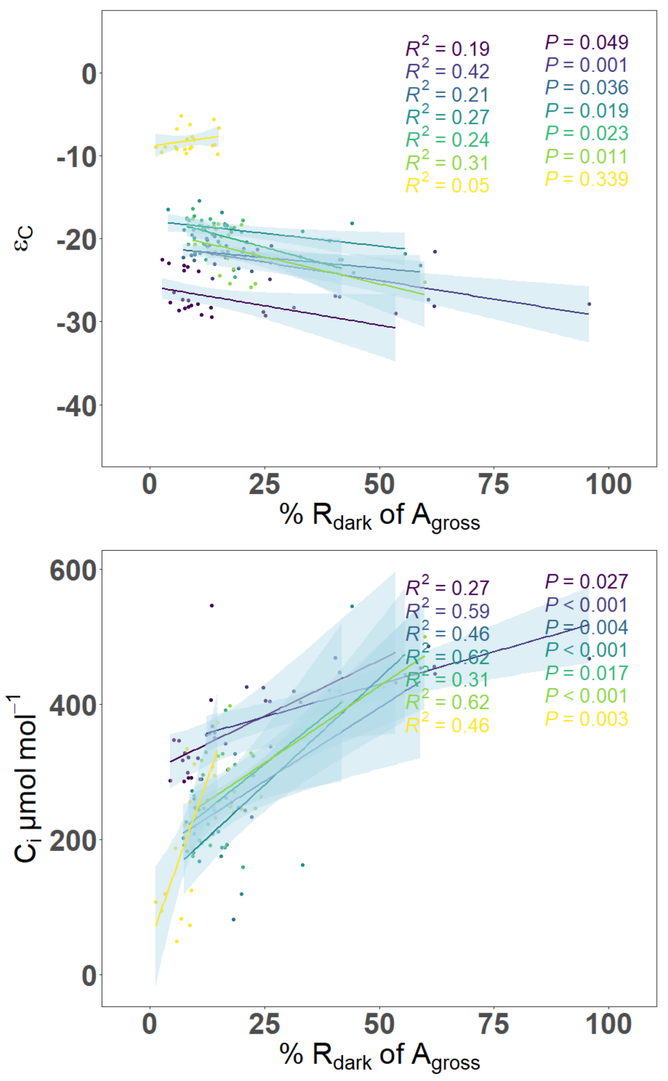
Leaf Water $\delta^{18}O$ is driving Leaf Sugar $\delta^{18}O$




$\delta^{13}C$:

$^{13}C$ depleted sugar with increasing respiration

R increases internal $CO_2$ (Ci) → internal refixation of $^{13}C$ depleted $CO_2$ from R





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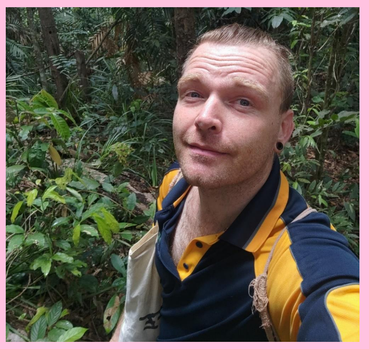
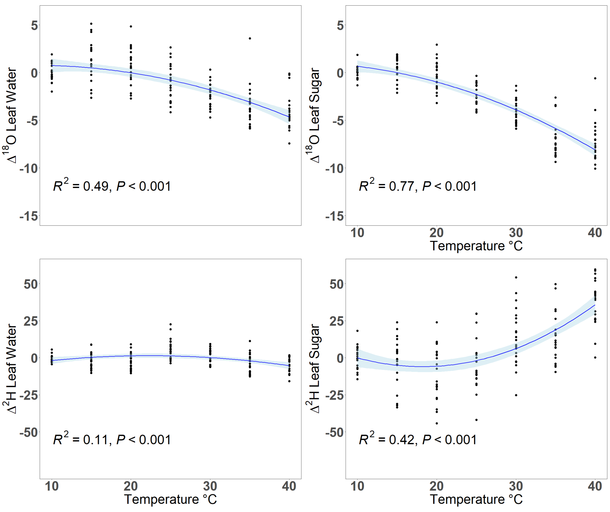
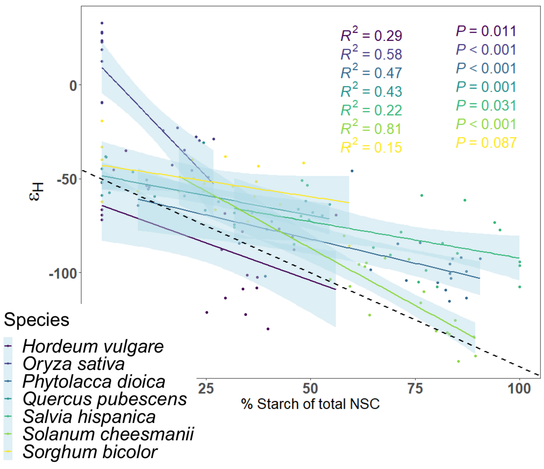


# Supporting Information Chapter 4

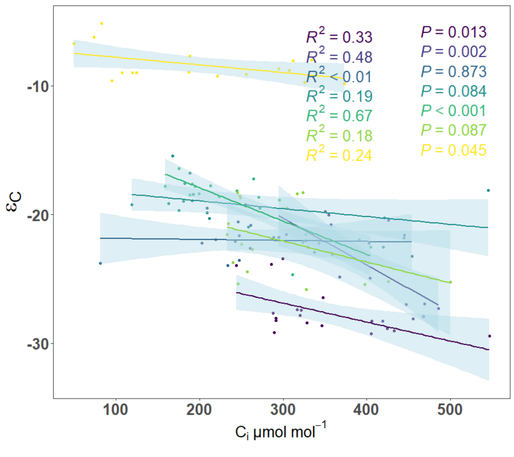
## $^{18}O$ and $^{2}H$ temp response of leaf water and sugar



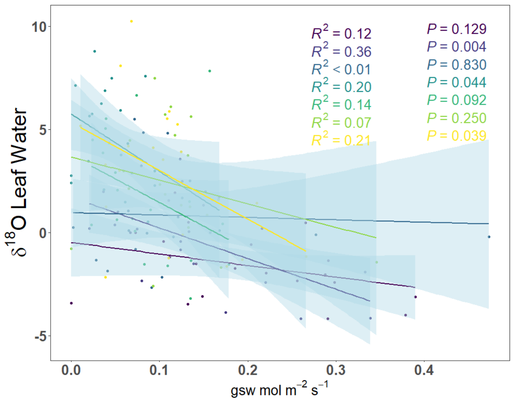

## $\varepsilon_H$ in response to depleting NSC reserves




## $\varepsilon_C$ in response to increasing $C_i$




## $\delta^{18}O$ of the Leaf Water in response to increasing gsw (stomatal conductance)

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