

Impact of Water Deficit on the Functioning of LowSugarBerry Wine Varieties

Raimundo Prieto^{1,2}, Die Wu¹, Luciana Wilhelm de Almeida^{1,3}, Jana Kändler⁴, Laurent Torregrosa^{1,3}, and Anne Pellegrino^{1,3}

¹LEPSE, Montpellier Uni, INRAE, Institut Agro, Montpellier, France; ²Chair of Vine and Wine, Montpellier Uni, INRAE, Institut Agro, Montpellier, France; ³Biology and Ecology Department, Institut Agro Montpellier, France, ⁴Centre of Vine and Wine Studies, Institut Agro, France

Introduction

Context: Like other perennial crops, grapevine is increasingly affected by climate change, particularly rising temperatures and water scarcity. In Mediterranean viticulture, excessive sugar accumulation in berries leads to high-alcohol wines lacking balance. **Low Sugar Berry (LSB) genotypes**, derived from *Vitis/Muscadinia* crosses (Bigard et al., 2022), **import higher amount of water for the same amounts of sugars** while maintaining other berry main characteristics, offering potential for moderate alcohol wines under warming conditions (Wilhelm de Almeida et al., 2023; 2024).

Objectives: To determine whether the **LSB genotypes** display better adaptation to water deficit through lower **carbon demand at a given berry fresh weight** and improved **water use efficiency**.

Materials & Methods



Figure 1. Phenodyn phenotyping platform at LEPSE research center.

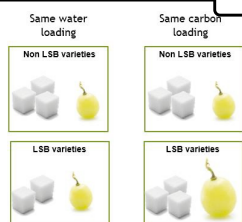


Figure 2. Conceptual comparison of carbon and water relationships in LSB versus non-LSB grapevine genotypes.

Two LSB (**G5, G14**) and two non-LSB (3159, 3176) genotypes were phenotyped at the LEPSE's **Phenodyn** automated phenotyping platform (<https://www6.montpellier.inrae.fr/lepse/Plateforme-de-phenotypage-M3P>, Fig. 1). A **moderate sustained deficit (WD)**, Fraction of Transpirable Soil Water 'FTSW' ~0.25) throughout the 6-7 week ripening period was compared to well watered treatment (**WW**, FTSW ~0.6). Berry numbers were adjusted by +/-~35% in LSB genotypes to reach **same water loading (WW, WD)** or **same sugar loading (WW-C, WD-C) to non-LSB genotypes** (Fig. 2). Measurements included gas exchange, biomass partitioning, fruit carbon accumulation (varC) in fruits, and $\delta^{13}C$ analysis.

Results

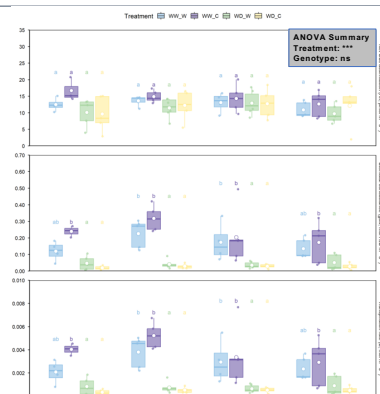


Figure 3. Leaf-level gas exchange responses to water deficit in G5 genotype. Other genotypes showed similar patterns with no significant genotypic differences.

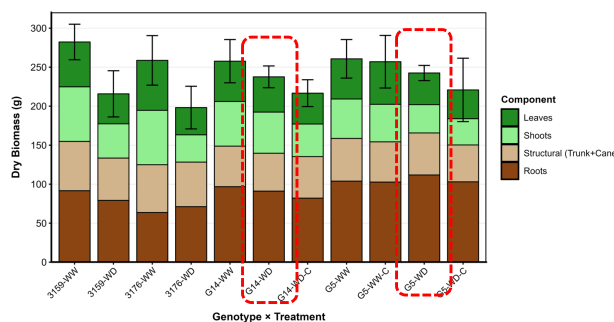


Figure 4. Biomass partitioning by genotype and treatment.

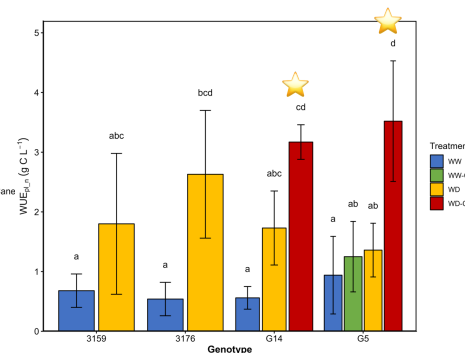


Figure 5. Normalized whole-plant water use efficiency (WUEpl_n).

Leaf-level gas exchange measurements revealed **no genotypic differences** in photosynthetic functioning, with water deficit reducing net photosynthesis (A_n), stomatal conductance (g_{sw}), and transpiration (E) similarly across all genotypes (Figure 3). However, biomass partitioning analysis showed **substantial variation in carbon allocation strategies**, with carbon-normalized LSB genotypes under water deficit investing **40- 75% more in root biomass** compared to conventional genotypes while maintaining fruit production (Figure 4). This enhanced root investment translated into **higher plant-level water use efficiency**, with carbon-normalized LSB genotypes achieving values **30-50% greater** than conventional varieties under the same water stress conditions (Figure 5).

Discussion

The LSB trait emerged as a **system-level characteristic** enabling adaptive resource allocation. The mechanism operates through allocation flexibility manifesting only when **high carbon sink demand, sustained moderate water deficit, and sufficient duration align**. Carbon isotope analysis ($\delta^{13}C$) confirmed advantages operate through **plant trade-off modulation rather than leaf-level processes**. These findings provide **critical implications**: breeding programs must **screen with elevated crop loads under sustained stress**; commercial deployment requires **high fruit loads and deficit irrigation**. These genotypes display **potential profitable traits** to select varieties coping with both warming and water supply limitations. The LSB trait offers a **practical climate adaptation tool** for maintaining productivity and moderate alcohol wines under Mediterranean warming, with allocation flexibility mechanisms potentially extending to other perennial fruit crops facing similar challenges.

References

- Bigard, A., Romieu, C., Ojeda, H., & Torregrosa, L. J. (2022). The sugarless grape trait characterised by single berry phenotyping. *OENO One*, *56*(3), 89-102.
 Wilhelm De Almeida, L., Pastenes, C., Ojeda, H., Torregrosa, L., & Pellegrino, A. (2024). Water deficit differentially modulates leaf photosynthesis and transpiration of fungus-tolerant *Muscadinia* x *Vitis* hybrids. *Frontiers in Plant Science*, *15*.
 Wilhelm De Almeida, L., Pellegrino, A., Fontez, B., Torregrosa, L., & Ojeda, H. (2023). Short and long-term acclimation to water status at leaf and plant level of fungus-tolerant genotypes. *OENO One*, *57*(2), 203-218.