

Leaf anatomical trait modifications in response to heat and elevated air [CO₂] in *Coffea arabica* L. genotypes

Simões-Costa, M. C.^{1,2*}, Sousa, V.^{1,3*}, Silva, M. J.^{1,3,4}, Marques, I.^{1,3}, Ribeiro-Barros, A. I.^{1,3,4}, Ramalho, J.C.^{1,3,4}

¹ U LISBOA ² INSTITUTO SUPERIOR D AGRONOMIA ³ TERRA ⁴ N VA ⁵ geobiotec ⁶ these authors contributed equally to this work

Introduction

Coffea arabica L. genotypes show different potentials for heat tolerance and acclimation, namely under elevated air CO₂ (eCO₂) [1, 2]. We aim to detail the impacts and responses of the photosynthetic related structures to heat and eCO₂ by assessing leaf anatomical traits in different cultivars: Geisha3 (G3), Marsellese (Mar), and their hybrid (Hy).

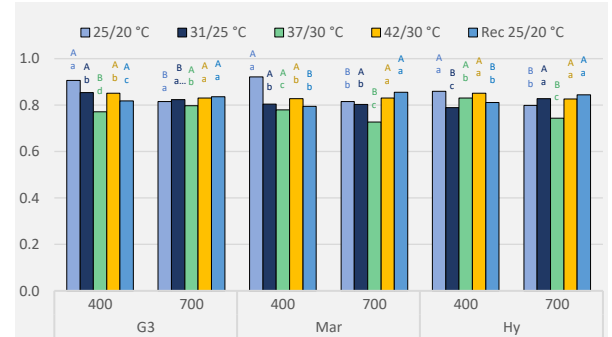


Figure 1: Effect of heat and eCO₂ on upper cuticle (UC) thickness (μm) of G3, Mar and Hy. Means with different letters were statistically different, minor for heat and capital for CO₂ levels (one-way ANOVA and Tukey test).

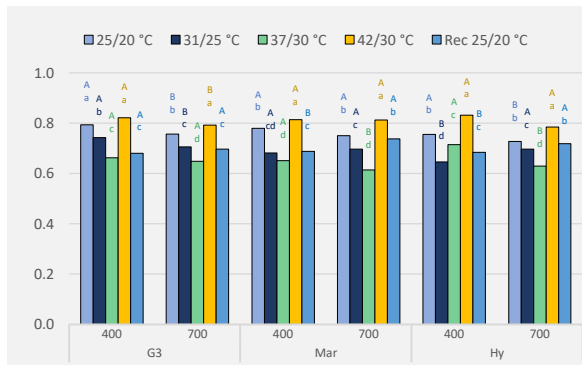


Figure 2: Effect of heat and eCO₂ on lower cuticle (LC) thickness (μm) of G3, Mar and Hy. Statistics as in Fig. 1 caption.

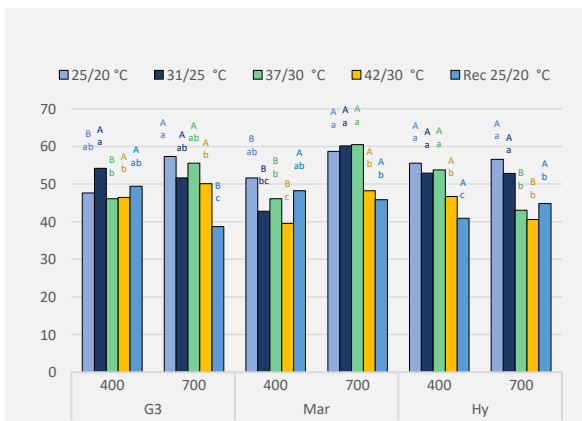


Figure 3: Effect of heat and eCO₂ on palisade parenchyma (PP) thickness (μm) of G3, Mar and Hy. Statistics as in Fig. 1 caption.

Materials/Methods

G3, Mar
Hy

☀ 700 μmol m⁻² s⁻¹, 12 h

💧 70 %

🌱 Well-watered

🌡 25/20 °C (day/night) ➡ 42/30 °C (0.5 °C day⁻¹)

☁ 400 μL L⁻¹ (aCO₂) ➡ 700 μL [CO₂] L⁻¹ (eCO₂)

🔄 Recovery 14 days period, 25/20 °C (Rec14)

🔬 Leaf samples were prepared for microscopic anatomical quantitative analysis [3, 4]

Results/Discussion

Heat (37/28 and/or 42/30 °C) had large impact on the upper (UC) and lower (LC) cuticles across genotypes, while for the palisade parenchyma (PP) it was also observed an impact on the recovery period (Rec14), with differences between genotypes (Figs. 1, 2, 3).

Single eCO₂ (at 25/20 °C) decreased UC and raised PP in G3 and Mar (Figs. 1, 3), and mitigated heat changes on PP at 42/30 °C in Mar and Hy, thus in line with greater physiological resilience under eCO₂ [1, 2]. At eCO₂ an increase of both UC and LC thickness was observed by Rec14 in Hy and Mar (Figs. 1, 2).

Conclusion/Perspectives

Heat or eCO₂ promote relevant impacts on key leaf anatomical traits, namely the upper and lower cuticles (UC, LC), pointing to likely structural/anatomical adjustments. In addition, eCO₂ seems to attenuate heat impact on palisade parenchyma (PP) in Marsellese and Hybrid genotypes.

References:

- [1] Rodrigues WP, et al. 2016. *Global Change Biology*, 22:415-431. DOI: 10.1111/gcb.13088.
- [2] Ramalho JC, et al. 2013. *Plos ONE*, 8(12), e82712. DOI: 10.1371/journal.pone.0082712.
- [3] Johansen DA. 1940. *Plant microtechnique*, 1st edn. New York, USA: McGraw-Hill Book Co. Ltd.
- [4] Barbosa ACF, et al. 2010. *IAWA J.* 31(4):373-383. DOI:10.1163/22941932-90000030.

Acknowledgements: Coffee plants from genotypes G3, Mar, and their hybrid were provided by Hervé Etienne (Cirad-UMR DIADE, France) in the framework of the BreedCAFS project funded by European Union's Horizon 2020 (H2020) research and innovation program (grant agreement No. 727934). Funding support was also provided by Fundação para a Ciência e a Tecnologia, I.P., Portugal, through the contract DL57/2016/CP1382/CT0004 to VS, the Scientific Employment Stimulus-Individual Call - CEEC Individual, 2021.01107.CEECIND/CP1689/CT0001, to IM, and the projects CoffeeFlower (2022.01547.PTDC), CEF (UIDB/00239/2020), LEAF (UIDB/04129/2020), GeoBioTec (UIDP/04035/2020), and the Associate Laboratory TERRA (LA/P/0092/2020).