Transpiration decrease in shaded hazelnuts: a green light for experimenting new orchard structures.

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Abstract
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Abstract

Global yields of cereals and fruit trees are projected to decrease as a consequence of the increasing air vapour pressure deficit (VPD) (Hsiao et al. 2019). VPD synthesize the effect of relative humidity and temperature of the air, which is unceasingly increasing due to anthropogenic global warming since 30 years of 0.2°C (IPCC 2018). Mediterranean regions are among the most affected areas by this change. At the same time, VPD is one of the most significant parameter affecting plant physiology because it controls stomata aperture and carbon inflow into leaves. Long term exposure to high VPD leads to reduced growth (Sanginés de Cárcer et al. 2018) and tree mortality even more than just high temperature rise (Eamus et al. 2013). Still, some food trees are more sensitive to high VPD than others are. Hazelnut (*Corylus avellana* L.) is one of these. Although it is a temperate forest species, it is cultivated since centuries for the nut production in the whole Europe. In recent years, its cultivated surface is rising significantly. Italy plans to reach 20.000 hectares of hazelnut orchards at national level. In the last years, the research on hazelnut eco-physiology highlighted the sensitivity of the species to VPD rise. Hazelnut resulted shade-tolerant, it barely stands wind (Baldwin et al. 2003), stomata closure occurs above 10hPa VPD thus reducing carbon assimilation.

This leads to the hypothesis that decoupling hazelnut trees from the atmosphere prevents water loss in case of VPD rise. During summer 2019, we set an experimental study in the University of Padova (45°20'55''N, 11°56'59''E, 5 m a.s.l.) hazelnut orchard, located in Legnaro (PD), Italy. Three 12 years old hazelnuts were covered with a polypropylene net in mid-June, while three other net-free individuals served as a control. Trees were rain-fed for the entire growing season. In each treatment, we measured carbon assimilation (*An*), stomatal conductance (*gs*) and light saturation curve at leaf level with a porometer from DOY 203 to 262. In parallel, we installed in all trees TDP probes to measure the sap flow. Sap flow measurements, together with meteorological parameters and soil water content were recorded by a datalogger with a 15 minutes record frequency. Diurnal sap flow data and VPD were used to calculate the canopy conductance G in the two treatments with G = k*E_L/VPD (mm s^{-1}), where k=115.8+0.4226*T°C (m3kPa°C kg-1), E_L= transpiration per unit of LAI (g m-2s-1) as described in Tang et al. (2006).

At the leaf level, the light saturation curve showed that 48% of the CO_2 assimilation was reached already at 100 µmol $m^{-2}s^{-1}$ of PAR and remained stable for PAR > 500 µmol $m^{-2}s^{-1}$, close to what found by Tombesi et al. (2015). The shading net did not change the response to light. Daily *An* resulted slightly higher in control respect to shaded treatment, especially between 7 and 8AM and between 3 and 5PM. The shading net provided 10% decrease in mean daily VPD compared to the control. This caused a decrease in the canopy transpiration per unit of leaf area (E_L) of 13.9% (max 30.5%) in shaded compared to control treatment (0.024 and 0.028 g $m^{-2}s^{-1}$ respectively). The whole tree canopy conductance (i.e. gas exchange capacity) between the two treatments was 8% higher in control respect to shaded trees (0.16

and 0.14 mol $m^{-2}s^{-1}$ respectively). The cover net shifted the maximum G from 6 to 10hPa, but the response of G to VPD remained similar in the two treatments (Wilcoxon test, $p>0.05$).

Even if the leaf carbon assimilation is negatively affected by shade only in the early morning and some afternoon hours, the relative gain in whole tree conductance remained lower in control respect to the amount of water saved by shading the trees. Indeed, it is possible to design agroforestry systems where hazelnut grows with other non-shade tolerant species (e.g. *Populus* spp.) as dominant trees. These partner trees can benefit from the water saved from the new hazelnut orchard layout, and on its turn, provide shelter from wind, heat waves or VPD increase in the long term. Still, more research is needed to include the effect of shade on nut yield, which is though difficult in hazelnut due to its alternate bearing of fruits. Still, this work suggests that hazelnut can tolerate the coexistence of dominant trees with water savings that might compensate carbon assimilation losses.

References

Baldwin B, Gilchrist K, Snare L (2003) Hazelnut Variety Assessment for South-eastern Australia. Report. Australian Government - Rural Industries Research and Development Corporation

Eamus D, Boulain N, Cleverly J, Breshears DD (2013) Global change-type drought-induced tree mortality: Vapor pressure deficit is more important than temperature per se in causing decline in tree health. Ecol Evol 3:2711–2729. doi: 10.1002/ece3.664

Hsiao J, Swann ALS, Kim SH (2019) Maize yield under a changing climate: The hidden role of vapor pressure deficit. Agric For Meteorol 279:. doi: 10.1016/j.agrformet.2019.107692

IPCC (2018) Summary for Policymakers. In: Global Warming of 1.5°C. Intergov. Panel Clim. Chang. 7–22

Sanginés de Cárcer P, Vitasse Y, Peñuelas J, et al (2018) Vapor–pressure deficit and extreme climatic variables limit tree growth. Glob Chang Biol 24:1108–1122. doi: 10.1111/gcb.13973

Tang J, Bolstad P V., Ewers BE, et al (2006) Sap flux-upscaled canopy transpiration, stomatal conductance, and water use efficiency in an old growth forest in the Great Lakes region of the United States. J Geophys Res Biogeosciences 111:1–12. doi: 10.1029/2005JG000083

Tombesi S, Palliotti A, Poni S, Farinelli D (2015) Influence of light and shoot development stage on leaf photosynthesis and carbohydrate status during the adventitious root formation in cuttings of Corylus avellana L. Front Plant Sci 6:973. doi: 10.3389/fpls.2015.00973

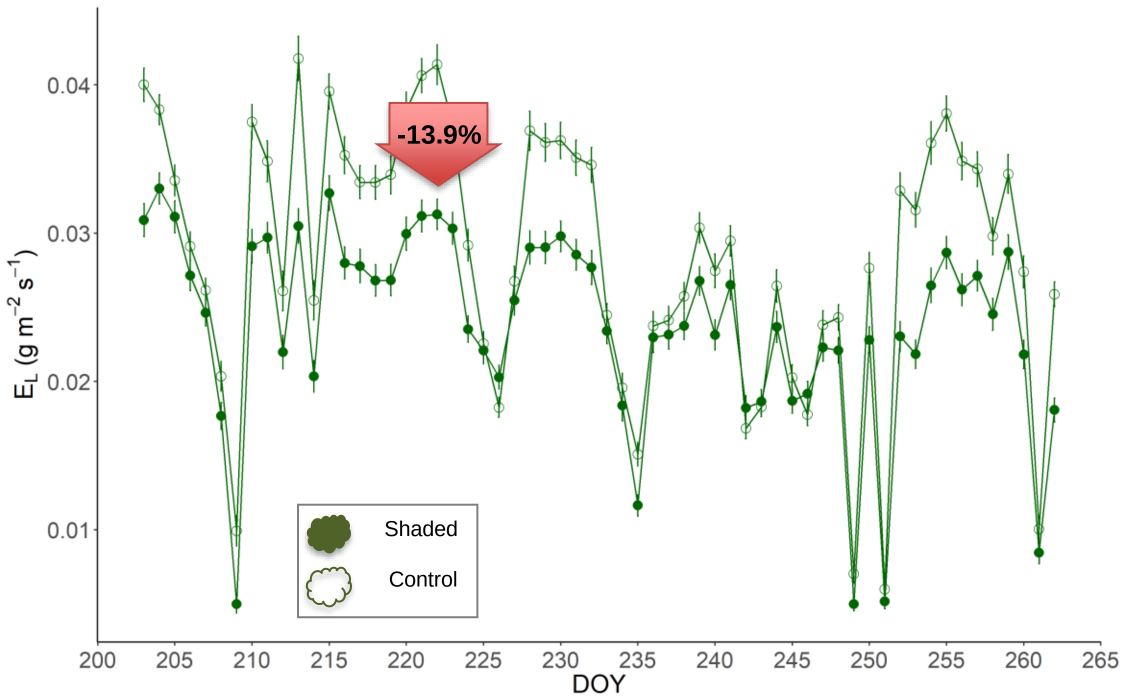

Figure 1. Mean daily canopy tanspiration per leaf area (E_L) in shaded trees and control treatment during the days of the year (DOY from 203 to 262). The red arrow shows the average decrease in EL in shaded respect to control treatment over the study period.