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CONTRASTING FUNCTIONAL STRATEGIES FOLLOWING SEVERE DROUGHT IN TWO MEDITERRANEAN OAKS WITH DIFFERENT LEAF HABIT

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Introduction

Two types of oaks (*Quercus* L.; Fagaceae) with different palaeogeographic origin, different types of leaves, and different contrasting strategies to cope with water limitations, coexist in Mediterranean-type climates (see Figure 1). Both *Q. faginea* and *Q. ilex* subsp. *rotundifolia* are considered as representatives of these two types of oaks that coexist in many areas of the western Mediterranean basin . However, this coexistence is a complex issue that has been the subject of debate (Nardini et al.1999, Montserrat-Martí et al. 2009, Peguero-Pina et al. 2015) and more research is needed to understand it. It would be expected that both species show different functional strategies to deal with water limitations that go beyond their differences in leaf habit. Thus, the aim of this study it is to analyze the existence of differential response to severe droughts in hydraulic traits of *Q. faginea* and *Q. ilex* subsp. *rotundifolia*.

Material and methods

- As occurs during the summer in Mediterranean-type climates, we induce severe water stress in both species, to study the ability of plants to supply water to the transpiring leaves.
- The percentage of green, yellow and brown leaves was estimated by visual scoring during the dry period.
- The maximum dark-adapted quantum efficiency of PSII calculated as F_V / F_M was also taken into account.
- At the same time, the hydraulic conductivity (K_{stem}) and the hydraulic conductance of the shoots (K_{shoot}) were measured for *Q. faginea* and *Q. ilex* subsp. *rotundifolia* throughout the dry period following the methodology detailed in Brodribb et al. (2005).

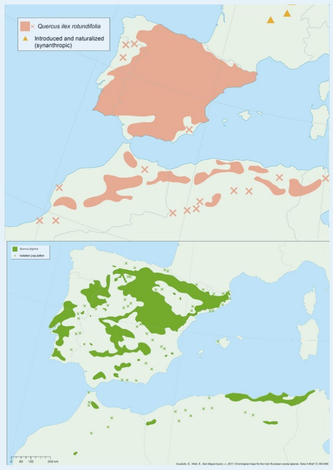

Figure 1 Geographical distribution map of *Quercus ilex* subsp *rotundifolia* (upper panel) and *Q Quercus faginea* (lower pannel). Maps modified from Caudullo et al. (2017).

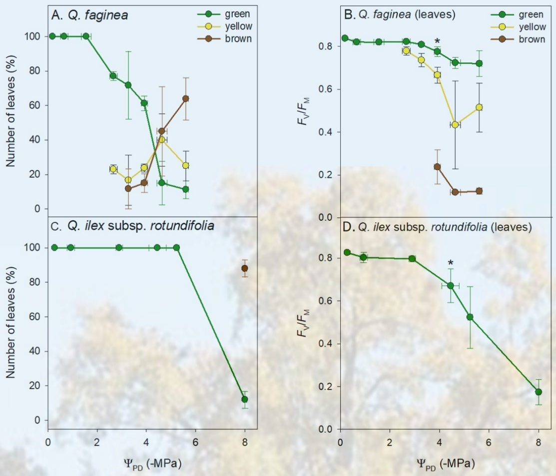

Figure 2 Time course of the percentage of green, yellow and brown leaves and maximum potential PSII efficiency (F_V/F_M) with predawn water potential (Ψ_{PD}) for *Q. faginea* (A and B, respectively) and *Q. ilex* subsp. *rotundifolia* (C and D, respectively) during the drought period.

Results

Q. faginea showed a gradual decrease in the percentage of green leaves as the percentage of yellow and brown leaves gradually increased (Figure 2A). The percentage of green leaves experienced a drastic reduction when water potential (WP) was below −4.5 MPa. By contrast, *Q. ilex* subsp. *rotundifolia* maintained all the leaves green at this stage, and only experienced a sharp increase in the percentage of brown leaves at the end of the drought period (Figure 2C).

Leaf damage in *Q. faginea* was followed by a decrease in F_V/F_M in yellow and brown leaves with respect to green leaves. In *Q. ilex* subsp. *rotundifolia* F_V/F_M showed a decrease in green leaves (Figure 2B and 2D).

The increasing levels of maximum daily drought stress induced a progressive loss of hydraulic conductivity in in shoots and stems of both species (Figure 3).

Regarding K_{stem}, both species reached similar values of native xylem embolism ~50% at similar WP values (Figure 3A).

By contrast, the water potential inducing the 50% loss of hydraulic conductivity in the shoots occurred at water potential values much more negative in *Q. ilex* subsp. *rotundifolia* than in *Q. faginea* (Figure 3B).

Discussion

According to the results obtained, the stems of *Q. faginea* were protected from an extensive xylem embolism as leaves can act as hydraulic 'safety valves' being more vulnerable to embolism (embolizing at less negative pressures) and thus were able to develop new leaves after the dry period.

This capacity is crucial for the survival and growth of this species, in addition to partially compensating for the loss of competitiveness with the coexisting Mediterranean evergreen oaks with longer leaf life. This was the case with *Q. ilex* subsp. *rotundifolia*, which showed a conservative foliar strategy, characterized by a high resistance to cavitation induced by drought and a maintenance of its functional leaves even in conditions of intense drought.

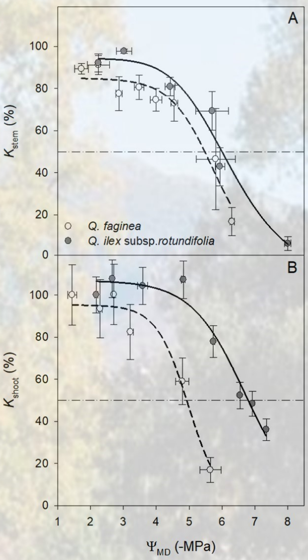

Figure 3 Relationship between midday water potential (Ψ_{MD}) and the percentage of (A) shoot hydraulic conductance (K_{shoot}) and (B) stem hydraulic conductivity (K_{stem})

Conclusions

- *Q. faginea* and *Q. ilex* subsp. *rotundifolia* show a differential response in terms of hydraulic traits under intense drought.
- *Q. ilex* subsp. *rotundifolia* showed a conservative leaf strategy, characterized by a high resistance to drought-induced cavitation which kept their leaves functional even under intense drought conditions.
- The stems of *Q. faginea* were protected from extensive xylem embolism using leaves as hydraulic 'safety valves' under intense drought.

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References:

- Hochberg, U., Windt, C.W., Ponomarenko, A., Zhang, Y.J., Gersony, J., Rockwell, F.E., Holbrook, N.M. (2017). Stomatal closure, basal leaf embolism, and shedding protect the hydraulic integrity of grape stems. Plant Physiol 174:764–775.
- Brodribb, T.J., Holbrook, N.M., Zwieniecki, M.A., Palma, B. (2005) Leaf hydraulic capacity in ferns, conifers and angiosperms: impacts on photosynthetic maxima. New Phytol 165:839–846.
- Caudullo, G., Welk, E., San-Miguel-Ayanz, J., (2017). Chorological maps for the main European woody species. Data in Brief 12, 662-666. DOI: doi.org/10.1016/j.dib.2017.05.007
- Montserrat-Martí, G., Camarero, J.J., Palacio, S., Pérez-Rontomé, C., Milla, R., Albuixech, J., Maestro, M. (2009). Summer-drought constrains the phenology and growth of two co-existing Mediterranean oaks with contrasting leaf habit: implications for their persistence and reproduction. Trees 23:787–799.
- Nardini, A., Lo Gullo, M.A., Salleo, S. (1999). Competitive strategies for water availability in two Mediterranean Quercus species. Plant Cell Environ 22:109–116.
- Peguero-Pina, J.J., Sancho-Knapik, D., Martín, P., Saz, M.A., Gea-Izquierdo, G., Cañellas, I., Gil-Pelegrín, E. (2015). Evidence of vulnerability segmentation in a deciduous Mediterranean oak (Quercus subpyrenaica E. H. del Villar). Trees 29:1917–1927.