Plant/Leaf traits and adaptive strategies of *Cistus* species to Mediterranean drought and insolation in southern Portugal

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INTRODUCTION

The effects of climate change can result in dramatic consequences in specific ecosystems such as *montados* that are seriously threatened by the absence of cork and holm oak (*Quercus suber* and *Q. rotundifolia*) natural regeneration. Shrubs of the genus *Cistus*, which are among the most important elements of encroached *montados*, seem to promote soil rehabilitation and enhance oak regeneration (Simões et al. 2009). In this context, we compared the life strategies and evaluated the potential ability of *Cistus* species to adapt to the increasing drought expected for the Mediterranean region, and thus their role on the sustainability of cork oak *montados*.

Fig. 1 – Location of the study area.

STUDY AREA

The study was carried out in a *montado* located in southern Portugal, close to Évora (Fig. 1). The area has the typical winter-wet, summer dry pattern of the Mediterranean-type climate. Mean annual rainfall is 609.4 mm and mean annual temperature is 15.9°C. The vegetation of the study site is an open cork oak woodland with an understorey of shrubs, dominated by *Cistus ladanifer* (hereafter CLAD), *C. monspeliensis* (hereafter CMON), *C. populifolius* (hereafter CPOP), and *C. psilosepalus* (hereafter CPSI) (Fig. 2), which accounted for >70% of the community cover.

METHODS

- Stomatal conductance (*gs*) was measured with a portable steady-state photosynthetic system (Li-6400; Li-Cor, Lincoln, NE) in spring, late-summer and autumn 2012.
- Xylem vulnerability curves were obtained by the 'Cavitron' technique (Cochard 2002; Cochard et al. 2005), with a Sorvall RC5 high speed centrifuge and the Cavisoft software, by measuring the percentage of loss of conductance (PLC) after air infiltration, in mature branches of the year (2012).
- Predawn and mid-day leaf water potential (Ψ_{PD}, Ψ_{MD}) was measured on a monthly basis, from April to November 2012, with a Scholander pressure chamber (PMS 1000, PMS Instruments, Corvallis, USA).

RESULTS

- CPSI and CLAD had the highest stomatal conductance (*gs*) in both spring and autumn, while CMON with the lowest spring value showed the greatest recovery after the autumn rains (Figs. 3 and 4). CPOP presented the smallest *gs* seasonal variation.

Fig. 2 – *C. ladanifer* - CLAD (A), *C. monspeliensis* - CMON (B), *C. populifolius* - CPOP (C), and *C. psilosepalus* - CPSI (D).

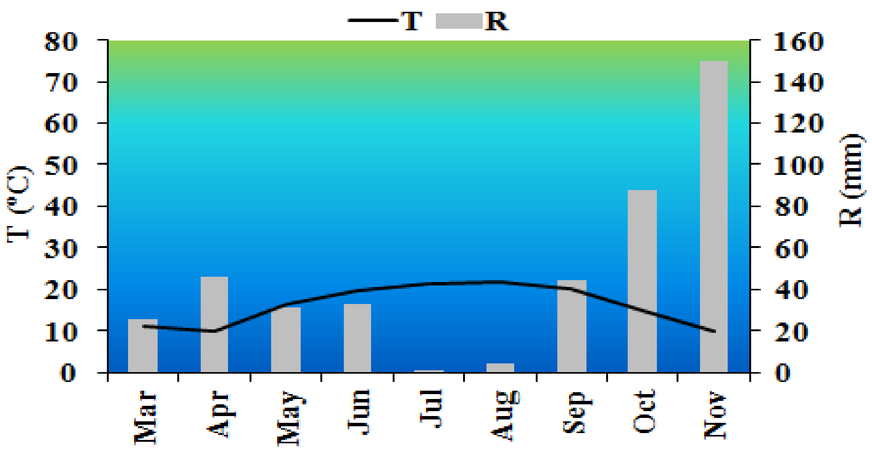

Fig. 3 – Mean air temperature (T) and rainfall (R) during the study period, by a meteorological station located in the study area.

- CMON was the most resistant to increasing xylem pressure (P50 was -10.2±0.16 MPa), followed by CLAD (-8.95±0.03 MPa) and CPOP (-8.14±0.05 MPa). CPSI (-6.51±0.09 MPa) was the most sensitive species (Fig. 5).

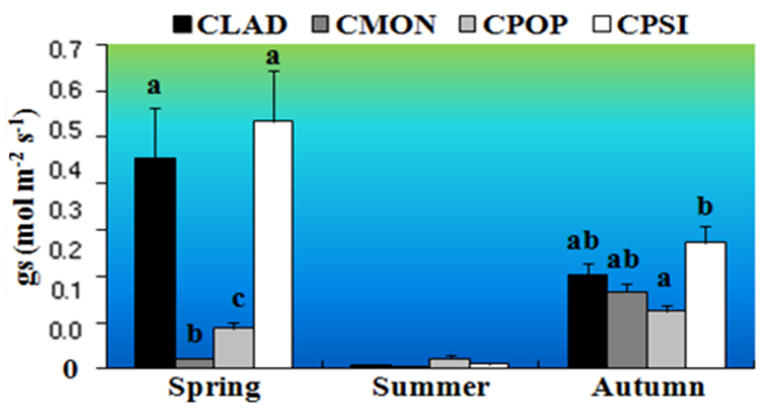

Fig. 4 - Stomatal conductance (*gs*) in the study *Cistus* species. Values are mean±SE (n=24). Significant differences (P<0.05) between species are indicated by different letters.

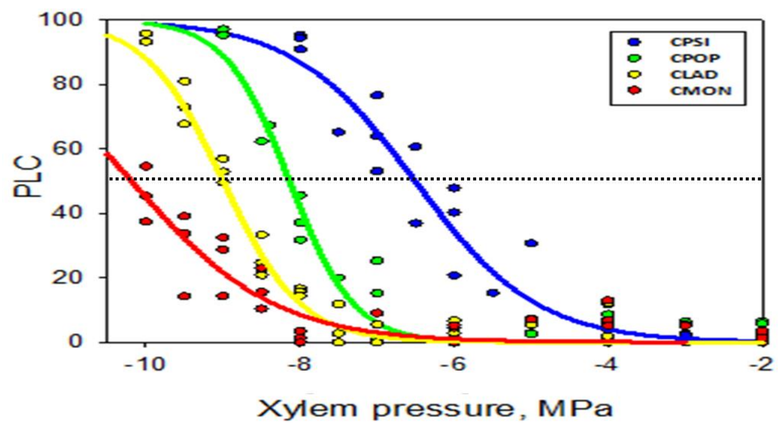

Fig. 5 – Xylem vulnerability curves of the study *Cistus* species. PLC - percentage of loss of conductance.

- Seasonal variation of predawn and mid-day leaf water potential (Ψ_{PD}, Ψ_{MD}) followed the same pattern (Fig. 6). However, the significant (P<0.05) decline observed in summer with rain scarcity was less marked for CPSI than for the other species. After autumn rains, Ψ recovered to spring values in all species.

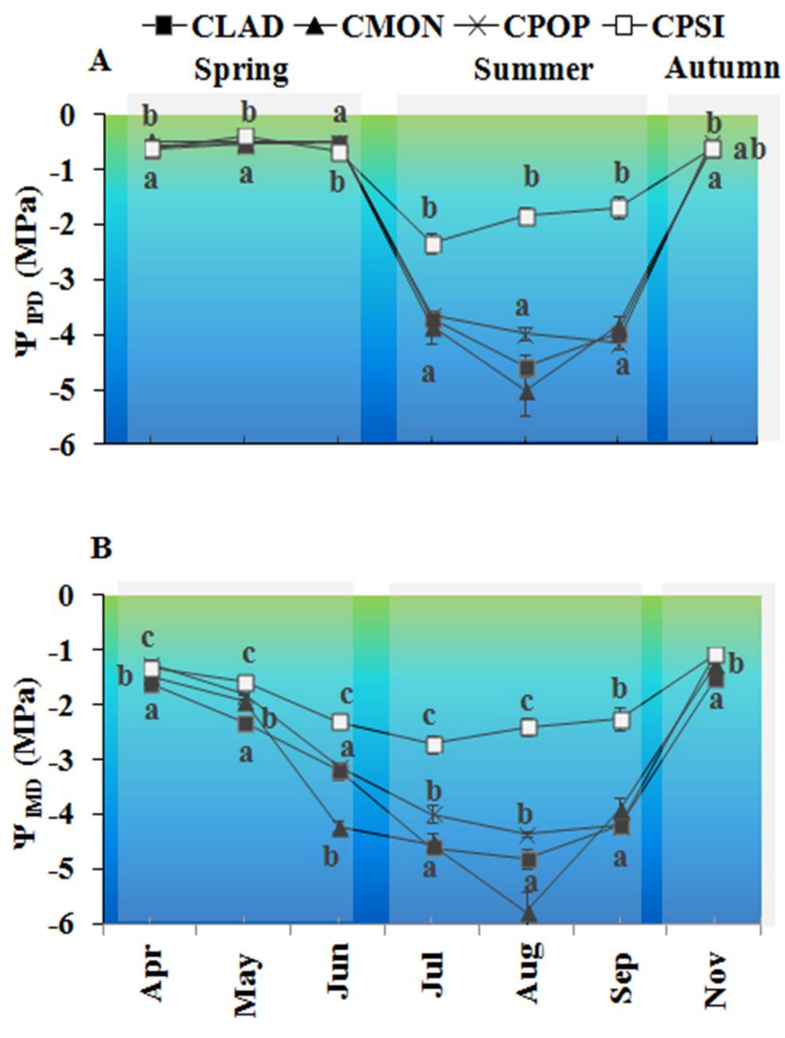

Fig. 6 - (A) Predawn leaf water potential (Ψ_{PD}) and (B) mid-day leaf water potential (Ψ_{MD}) of the study *Cistus* species. Values are mean±SE (n=12). Significant differences (P<0.05) between species are indicated by different letters.

CONCLUSIONS

- All studied *Cistus* showed a water status and stomatal conductance with maximum values in spring followed by a progressive decline or interruption during the summer drought and a partial recovery in response to autumn rains.
- *C. monspeliensis* and *C. ladanifer*, exhibited a drought-tolerance mechanism, *C. psilosepalus* an avoidance mechanism and *C. populifolius* is in-between avoidance and tolerance mechanisms.

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