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Assessing deep water uptake in a Mediterranean oak forest under soil water deficit

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The maximal depth of water uptake by trees is one of most important functional information for drought avoidance and for water balance issues, but it is also one of the most difficult to record. Despite the importance of the development of a deep root in Mediterranean species, to the moment, it has been thoroughly studied only in few species. The objective of this work was to discuss how deep soil water and roots contribute to surviving long dry summer in a Mediterranean oak forest (*Quercus pyrenaica*).

In this work soil and plant water status were determined in 2006 and 2007 from June to September. These months correspond to the growing season of the studied species as well as the driest period. Soil water content was measured every 2 weeks using Time Domain Reflectometry in the root zone of the studied trees, up to 50 cm, where the densest root system is located, and to a depth of 100 and 250 cm, to study the influence of deep roots and soil water content. Plant water status was determined through stem and leaf water potential measurements carried out at predawn and midday every 2 weeks with a Scholander chamber. Transpiration was determined every 10 mins from June to September of 2007 with the sap flow method of Granier. In addition, to examine the response of this forest to different water absorption depths, a soil-plant-atmosphere transfer model (SPA; Williams et al. 1996) was used. It was previously parameterised and tested mainly with in situ measurements. Finally, the root biomass and rooting depth of the trees was determined using two different methods, based on the study of soil cores and the counting root intersections with planes of observation on close opened road cuts (profile walls).

The results revealed a relatively good tree water status. Leaf and stem water potentials presented high values throughout the summer and no significant variation as soil water deficit increased. Accordingly, transpiration was not reduced either as summer drought progressed. However, this is not consistent with the decreasing levels of soil water content, which by the end of the growing season and at depths $\leq$100 cm were close to or equal to the wilting point. Therefore, it seems that although the highest density of roots is located in the first 50 cm, the roots have to explore deeper layers to access water in summer, thereby avoiding competition with grasses and bushes. This is corroborated by the correlations between tree water status measurements and soil water content, since they became higher when deeper soil layers were analysed. This is also in good agreement with the results of soil water content measured at 250 cm, which started to decrease later than the water content in shallower soil layers, and did not reach values as low as those in shallower horizons. The measurement of root biomass and depth confirmed that tap roots penetrated down the profile to depths $\geq$200 cm. Finally, model simulations showed that for the same total root biomass, a rooting depth of 300 cm reduced considerably the water stress experienced by the trees under extremely dry conditions compared to a rooting depth of 200 cm. These results highlight the importance of a deep root system to cope with water deficit.

It was concluded that the water status of the studied trees is highly dependant on the water stored in deep soil layers. The deep roots of *Q. pyrenaica* allows them to extract water reserves during the summer and provides a buffering mechanism against drought stress.