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Contribution to the Ecophysiological Study of Four Mediterranean Forest Species (*Quercus suber, Ceratonia siliqua, Tetraclinis articulata, Cedrus atlantica*) †

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Abstract: Forest degradation has been accentuated in recent years by climate change and drought. This study consists of producing quality plants and understanding their ecophysiological behavior in the face of water stress. Plants of two broadleaves (Quercus suber, Ceratonia siliqua) and two conifers (Tetraclinis articulata, Cedrus atlantica) aged 6 months subjected to water stress. The basic (Ψb) and minimum (Ψm) leaf water potential ware measured and processed according to climatic factors for the 4 forest species. The results show that the leaf water potential in Quercus suber presents more negative values (-0.42 MPa) for basic leaf water potential and (-1.43 MPa) for minimum leaf water potential than the other forest species studied. While Cedrus atlantica presents the least negative values for minimum leaf water potential (-0.89 MPa). These results allowed us to define the species that is more resistant to water stress and climate change. However, they refer us to more general questions concerning the mechanisms of water use in forest plants.

Keywords: *Quercus suber*; *Ceratonia siliqua*; *Cedrus atlantica*; *Tetraclinis articulata*; climatic data; water stress; leaf water potential.

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1. Introduction

Forest ecosystems are the terrestrial environment that contains several forms of life where forests play an essential role in the major biogeochemical cycles, the natural cycles of carbon, nitrogen, phosphor and contribute to the purification of air and water. In Morocco, forest ecosystems are located in semi-arid, sub-humid and humid climates, covering an area of 5,719,000 ha. They consist of 66% hardwood species, 18% coniferous species, 9% artificial plantations and 7% are occupied by low formations [1], with a geographical position between the 2 seas which gives it an original Mediterranean climate influenced by the Atlantic Ocean which gives it a real range of types of bioclimates, and therefore a wealth of biodiversity.

To ensure the sustainability of the forest, the Forest Research Center conducts research to identify the hardwood and coniferous species more resistant to drought stress for the regeneration and reforestation of degraded species. In this perspective, we studied the ecophysiological mechanisms of four forest species (*Quercus suber*, *Ceratonia siliqua*, *Tetraclinis articulata*, *Cedrus atlantica*) according to climatic parameters.

2. Materials and Methods

For this study we used seedlings of four forest species aged 6 months, two hardwoods (*Quercus suber*; *Ceratonia siliqua*) and two conifers (*Tetraclinis articulata*; *Cedrus atlantica*), were subjected to severe water stress by cessation of irrigation for 30 days under greenhouse conditions. Physiological measurements were collected every four days interval from 3 replications per treatment/species.

For physiological parameters, we determined basic (Ψ_b) and minimum (Ψ_m) leaf water potential. The basic leaf water potential (Ψ_b) is the leaf water potential of the plant, measured before sunrise, when the plant is considered to be in equilibrium with soil. The minimum leaf water potential (Ψ_m) is the leaf water potential of the plant, measured in the middle of the day. The study of the evolution of the leaf water potential of our forest plants was made using the *Scholander* pressure chamber, the principle consists in applying pressure to the sample (stem, branch) introduced into the chamber, via the nitrogen gas which is in the bottle, until the sap contained in the sample exudes through the section. The pressure exerted is read on a manometer, then corresponds to the water potential of the leaves in the sample.

For the climatic parameters, such as temperature, humidity, vapor pressure deficit (VPD) and solar radiation were noted with each hour of measurements.

The results obtained were statistically analyzed by the correlation coefficients to determine the relationship between the two variables. All these statistical analyzes were carried out using Excel software, version 2208.

3. Results and Discussion

The results of the average evolution in the daily leaf water potential of the 4 species studied in this work showed differences according to climatic parameters and time (Tables 1 and 2). The study of the evolution of the daily leaf water potential during the water stress cycle revealed differences between the species studied. At the end of the cycle, the average daily leaf water potential of *Quercus suber* reached the most negative values, with -0.42 MPa for the basic leaf water potential. On the other hand, the other species have an almost equal value for the basic leaf water potential (-0.2 MPa, -0.19 MPa and -0.17 MPa) respectively for *Ceratonia siliqua*, *Cedrus atlantica* and *Tetraclinis articulata*. The minimum values of leaf water potential depend on the evapotranspiration of the plant which is related to temperature, VPD and solar radiation. At maximum temperature the VPD and solar radiation reach their maximum as well as the minimum leaf water potential. The most negative value was recorded for *Quercus suber* which is about -1.44 MPa; similar results have been reported by other authors [2]. And almost equivalent values for *Tetraclinis articulata* (-1.09 MPa) and for *Ceratonia siliqua* (-1.01 MPa), the leaf water potential does not exceed -1.10 MPa for these 2 species [3-4]. *Cedrus atlantica* has the least negative value -0.89 MPa which fluctuates between -0.5 and -1.7 MPa [5].

According to the table 3 of leaf water potential and climatic parameters, it can be seen that the leaf water potential of forest species is negatively correlated with VPD and solar radiation. The negative correlation between water potential and climatic parameters (radiation, VPD) is explained by the decrease in water potential and the increase in climatic parameters, with opposite variation and similar intensity. When stress becomes stronger Stomatal closure in response to an increase in VPD has often been described [6-7]. It is a physiological response to water deficit.

Table 1. Average measurements of leaf water potential (Ψ_L).

	Leaf Water Potential (Ψ_L)			
Hours	***Quercus suber***	***Ceratonia siliqua***	***Tetraclinis articulata***	***Cedrus atlantica***
5h	**−0.42**	**−0.20**	**−0.17**	**−0.19**
8h	−0.75	−0.38	−0.56	−0.40
10h	−0.91	−0.64	−0.85	−0.78
12h	**−1.44**	**−1.01**	**−1.09**	**−0.89**
14h	−1.03	−0.67	−0.81	−0.62

Table 2. Mean measurements of climatological parameters.

Hours	Temperature (°C)	Relative Humidity (%)	VPD (kPa)	Solar Radiation (w/m2)
5h	**12.67**	**82.83**	**0.27**	**0**
8h	14.17	83.17	0.31	83.33
10h	19.67	63.83	0.87	479.33
12h	**22.17**	**56.33**	**1.22**	**732.33**
14h	21.67	55.17	1.02	706.33

Table 3. Correlation coefficient measurements of leaf water potential with VPD and Solar Radiation.

	Correlation coefficient (r)	
Species	**VPD**	**Solar Radiation**
Quercus suber	0.83	0.79
Ceratonia siliqua	0.90	0.84
Tetraclinis articulata	0.83	0.81
Cedrus atlantica	0.84	0.78

4. Conclusions

The present study highlighted the behavior and adaptation of four Mediterranean forest species (*Quercus suber*, *Ceratonia siliqua*, *Tetraclinis articulata* and *Cedrus atlantica*) to water stress. The evolution of daily leaf water potential differs according to forest species, with a strong negative correlation between leaf water potential and climatic parameters (VPD and solar radiation). moreover, the results obtained revealed that conifers tolerate water stress better than hardwoods.

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