Comparison of δ13C and WUE between seedlings of Quercus petraea and Q. robur subjected to different irradiance regimes and water availability levels

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Introduction

Very few functional traits distinguish *Quercus petraea* from *Q. robur,* whereas their ecological behaviours are clearly divergent, particularly towards drought.

In a previous study, we have shown that, in a mixed adult stand, dominant trees of *Q. petraea* display a higher water-use efficiency (WUE) than *Q. robur.*

In this study, objectives were:

- to determine whether the higher WUE is a specific trait of *Q. petraea,* using seedlings grown in a common garden experiment.

- to test for environment*genotype interactions on WUE using irradiance and water availability as environmental factors.

Intrinsic WUE was calculated at leaf and instantaneous level from measurements of net carbon assimilation (A) *vs* stomatal conductance for water vapour (g). Time- and plant-integrated estimation of intrinsic WUE was provided by carbon isotope composition ($\delta^{13}C$).

Material and methods

Acorns of *Q. petraea* and *Q. robur* were sown during spring 1998 under four distinct irradiance conditions (8, 15, 40 and 100% of external global irradiance).

At the end of summer 1998, 10 seedlings of each species were harvested in each of the four treatments, and leaf and stem $\delta^{13}C$ were measured.

During the second year of growth, half of the seedlings growing under full irradiance were submitted to a moderate drought. Each treatment included 10 seedlings of each species.

Gas exchange measurements were performed weekly on all the seedlings during summer. At the end of summer 1999, all the seedlings were harvested. Biomass was measured by compartment (leaves, stems and roots). $\delta^{13}C$ was analysed in leaves and stems.

Effect of the irradiance regime on $\delta^{13}C$

- $\delta^{13}C$ increased with irradiance (which corresponds to an increase of intrinsic WUE).

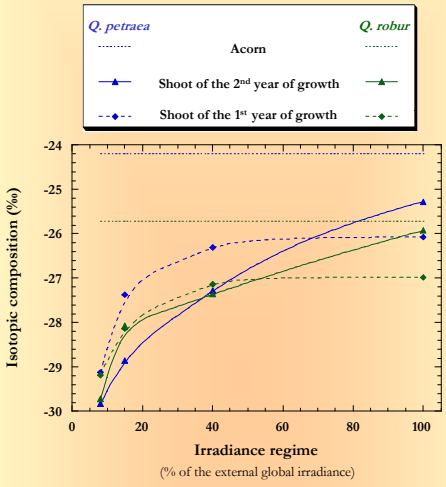
- the impact of irradiance was larger during the 2nd year of growth, as compared to the 1st one, and was more severe on *Q. petraea* than on *Q. robur.*

Interspecific difference of $\delta^{13}C$

- $\delta^{13}C$ was 1.5 ‰ higher in acorns of *Q. petraea* than in *Q. robur* ones.

- 1st year: *Q. petraea* displayed a significantly higher $\delta^{13}C$ under 15, 40 and 100% irradiance.

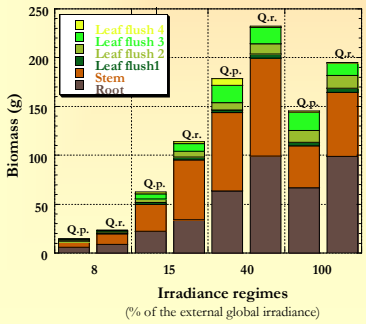
- 2nd year: this interspecific difference was still observed under full irradiance, whereas *Q. robur* displayed a higher value of $\delta^{13}C$ under 15% irradiance.



These results of $\delta^{13}C$ were strongly correlated with values of A/g (r=0.85) and followed the same pattern.

⇒ effect of the initial $\delta^{13}C$ of acorns on seedling $\delta^{13}C$ was negligible, as shown by the absence of interspecific difference between seedlings growing under 8% irradiance (with the smallest biomass, *see below*).

⇒ in 2 years old seedlings, the higher WUE of *Q. petraea* was confirmed only under full irradiance. There were significant irradiance*genotype interactions on WUE.

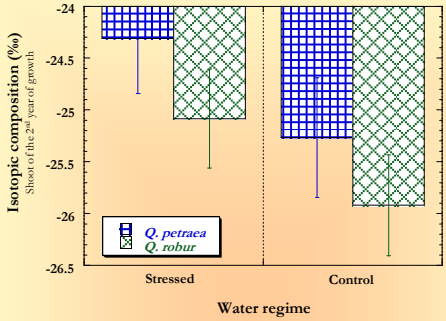


Whatever the irradiance regime, the seedling biomass was larger for *Q. robur* than for *Q. petraea.*

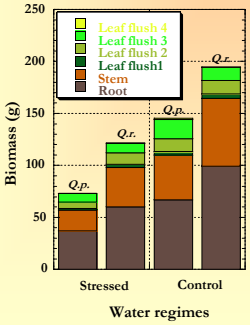
Effect of water availability on $\delta^{13}C$ and on the interspecific difference of $\delta^{13}C$

- as expected, the moderate drought (ψ_{pdw}=-0.5 MPa) increased $\delta^{13}C$ in the two species grown under full irradiance (+0.9 ‰ in average).

- the interspecific difference of $\delta^{13}C$ was slightly increased during drought.



Intrinsic WUE calculated from gas exchange measurements were in agreement with these isotopic results.



Water stress reduced more severely the total biomass of seedlings of *Q. petraea* (-50%) than *Q. robur* (-38%). Root/shoot ratios were not modified by the drought.

Conclusion

These results confirmed (i) the occurrence of WUE differences of genetic origin between *Q. petraea* and *Q. robur* (ii) the expression of these differences at the seedling level. Under full irradiance, *Q. petraea* displayed a larger intrinsic WUE than *Q. robur.* This interspecific difference was not modified under water stress conditions, but was not maintained when the irradiance decreased.

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