Physiological responses of *Fagus sylvatica* and *Quercus robur* seedlings to light intensity

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Introduction

- Broadleaf planting has become increasingly important in Ireland over recent years, with oak (*Quercus robur*) and beech (*Fagus sylvatica*) as two of the most popular species planted.
- Light is one of the main environmental factors affecting tree development, but to date there has been little research on broadleaf responses to light intensity.
- Continuous-cover forestry is increasing as an alternative to clear-felling and uses the control of light through thinning to produce stand benefits.
- An understanding of broadleaf responses to light will provide information for the management of such stands.

Objective

- Determine photosynthetic responses of beech and oak seedlings grown under different shade levels.

Materials and Methods

- Seedlings were grown in soil in a randomised block design experiment (Fig. 1).
- Shade cloths were used to simulate a spectrum of thinning intensities (Fig. 2):
  - ❖ 100%, 62%, 51% and 28% of incident photosynthetically active radiation (PAR).
- Photosynthetic responses to irradiance (PAR) were measured in 2013 on healthy, fully expanded leaves in three randomly selected seedlings per plot in the 100% and 28% of PAR treatments.
- Photosynthetic CO_2 assimilation, stomatal conductance and water use efficiency were determined in all treatments using the PAR value derived from the light-response curves at which the photosynthesis rates had reached their maximum.

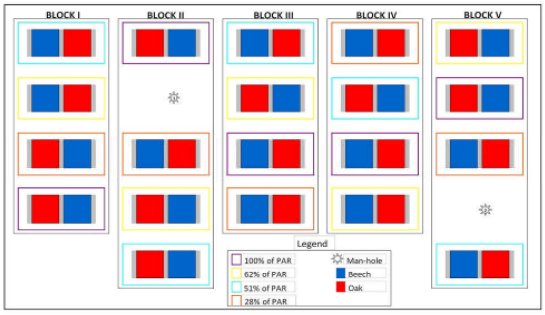

Fig. 1. Experimental design.

Fig. 2. An example of the shadehouses used during the experiment.

Results

- Photosynthetic light-response curves differed significantly ($P < 0.001$) between no shaded and heavy shaded beech seedlings, while no significant differences were found in oak seedlings (Fig. 3).
- Oak and beech generally reached maximum CO_2 assimilation at 1,500 µmol m^{-2} s^{-1} in the 100% and 28% of PAR treatments.
- Stomatal conductance and CO_2 assimilation were significantly greater ($P < 0.001$) in oak than in beech under 62%, 51% and 28% of PAR treatments (Table 1), similar to previous findings for beech and oak seedlings [1].
- There were no significant differences between oak and beech for CO_2 assimilation and stomatal conductance in 100% of PAR, or for water use efficiency in all treatments.
- Beech leaves under no shade developed maximum CO_2 assimilation, stomatal conductance and water use efficiency than beech leaves in the other treatments. A similar trend was observed in oak leaves (except under 51% of PAR) for CO_2 assimilation and stomatal conductance.

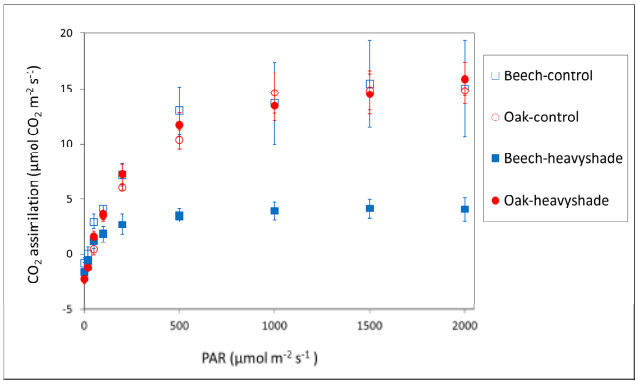

Figure 3. Photosynthetic light-response curves for beech and oak seedlings grown under 100% (full sunlight) and 28% (heavy shade) of incident PAR. Data are means ± standard errors.

Table 1. Gas exchange variables (means ± standard errors, n = 240) when PAR = 1,500 µmol $m^{-2}s^{-1}$. Different letters indicate means are significantly different.

Variable	Treatment	Species	
		Beech	Oak
CO_2 assimilation (µmol CO_2 m^{-2} s^{-1})	100% (control)	15.83±0.69 ab	17.89±0.89 a
	62%	7.60±0.88 c	12.89±0.91 b
	51%	4.28±0.60 d	15.25±0.65 ab
	28%	4.13±0.54 d	13.48±0.58 b
Stomatal conductance (mmol H_2O m^{-2} s^{-1})	100% (control)	205.90±13.22 ab	248.56±16.72 a
	62%	114.34±11.59 c	194.96±15.62 b
	51%	69.74±8.11 c	206.33±8.96a ab
	28%	63.99±6.67 c	194.13±12.28 b
Water use efficiency (µmol CO_2 / mol H_2O)	100% (control)	84.35±4.96 a	78.74±4.44 ab
	62%	62.76±4.73 bc	73.68±5.15 abc
	51%	59.02±4.77 c	75.67±2.75 abc
	28%	62.63±4.87 bc	76.18±4.20 abc

Conclusion

- Beech and oak seedlings exhibited different physiological responses when acclimatised to shade.
- Oak seedlings grown in heavy shade are better able to respond, as measured by CO_2 assimilation, to increased incident light than beech seedlings.
- There was no difference between the species when acclimatised to full sunlight.
- Beech seedlings showed greater physiological plasticity than oak seedlings in response to changing shade levels.

Acknowledgements

- Funding was provided by the COFORD Forest Research Programme under the 2007-2013 National Development Plan, administered by the Department of Agriculture, Food and the Marine.

Literature cited: 1. Valladares, F., Chico, J., Aranda, I., Balaguer, L., Dizengremel, P., Manriwue, E. and Dreyer, E. 2002. The greater seedling high-light tolerance of *Quercus robur* over *Fagus sylvatica* is linked to a greater physiological plasticity. Trees 16 (6): 395-403.