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Light acclimation at the end of the growing season in two broadleaved oak species

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Abstract

The ability of plants to increase their net CO_2 assimilation rate in response to increased irradiance is due to morphological and physiological changes, which might be related to their shade tolerance and leaf ontogeny, but few studies have considered morphology and physiology. Two sympatric oak species (the shade-tolerant *Q. petraea* and the comparatively shade-intolerant *Q. pyrenaica*) were grown in hydroponic solution in low-light (LL) and high-light (HL) conditions. 5 months after leaf expansion under these conditions, half of the LL plants were transferred to high light (TLH). Transfer of *Q. pyrenaica*, from low- to high light led to photoinhibition and after 21 days in higher light there was little acclimation of the maximum rate of carboxylation (V_{Cmax}) or the maximum rate of electron transport (J_{max}). *Q. pyrenaica* TLH plants showed lower stomatal conductance at all times compared to plants growing in LL. Stomatal closure was the main limitation to photosynthesis after transfer in *Q. pyrenaica*. The increase in evaporative demand upon TLH did not affect hydraulic conductivity of *Q. pyrenaica*. In contrast, the more shade-tolerant *Q. petraea* showed a greater degree of acclimation of gas exchange in TLH than *Q. pyrenaica* and two weeks after transfer gas-exchange rates were as high as in LL plants. In *Q. petraea*, the most important changes occurred at the level of leaf biochemistry with significant increase in V_{Cmax} that decreased the J_{max}/V_{Cmax} ratio below values recorded in HL plants. However, this potential increase in photosynthesis was at least partially hamstrung by a decrease in internal conductance, which highlights the importance of internal conductance in acclimation to higher light in mature leaves. Neither oak species reached the photosynthetic rates of HL plants; however a trend towards leaf acclimation was observed in *Q. petraea* while the transfer was harmful to the leaves of *Q. pyrenaica* developed in the shade.

Additional key words: hydraulic conductivity; internal conductance; light acclimation; mature leaves; *Quercus petraea*; *Quercus pyrenaica*.

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Abbreviations: A_{leaf} – plant leaf surface area; Car – total carotenoids pool content; C_c – $[CO_2]$ inside chloroplasts; Chl *a* and *b* – chlorophyll *a* and *b* contents; C_i – $[CO_2]$ in mesophyll air spaces; C_i* – apparent CO_2-photocompensation point; ETR – rate of noncyclic electron transport through PSII; F_v'/F_m' – PSII maximum efficiency of the light-adapted state; g_i – internal conductance to CO_2 diffusion; g_{sc} – stomatal CO_2 conductance; g_{sw} – stomatal water conductance; HL – high-light grown conditions; J_{max} – maximum rate of photosynthetic electron transport; LL – low-light grown conditions; LMA – leaf mass per area; l_s, l_{mc}, l_b – relative limitations to photosynthesis due to: stomatal conductance (l_s), leaf-internal conductance (l_{mc}), and biochemical capacity (l_b) of the leaf; P_N – net assimilation rate under saturating light; PSII – photosystem II; q_L – fraction of PSII centres which are in open state; q_P – PSII efficiency factor; R_l – mitochondrial respiration in light; TLH – transferred plants from low- to high light; V_{Cmax} – maximum rate of carboxylation; Γ^* – chloroplast CO_2 photo-compensation point; Φ_{PSII} – PSII operating efficiency; Ψ_{midday} – midday water potential.
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