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ORIGINAL PAPER

Physiological and morphological response to water deficit in seedlings of five provenances of *Pinus canariensis*: potential to detect variation in drought-tolerance

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Abstract To assess the potential of short-term screenings for drought resistance at the seedling stage to detect ecotypic variation and predict field performance, we studied the responses to water deficit of seedlings of *Pinus canariensis* from five geographic origins under controlled conditions and compared these responses with the performance of provenances in a multi-site field trial. Leaf water potential, the osmotic component, leaf chlorophyll fluorescence and growth and biomass partitioning were measured as seedlings were subjected for 11 days to two levels of osmotic potential generated by polyethylene glycol (PEG 6000), −1 MPa (slowly imposed water deficit; S) and −1.5 MPa (fast imposed water deficit; F), and a control treatment (no PEG added to the nutrient solution; C). Leaf water potential declined to final mean values of −1.2, −2.7 and −4.7 MPa in the C, S and F treatments, respectively. The ratio of variable to maximum chlorophyll fluorescence declined to final mean values of 0.77, 0.66 and 0.40 in the C, S and F treatments, respectively, with no differences amongst provenances. All provenances showed an active osmotic adjustment (OA) in response to water deficit which varied depending on the drying rate. A slow imposition of water deficit favoured solute accumulation. Pooling all treatments, the index of OA ranged from 0.28 to 0.40, but rose considerably when only C and S treatments were considered (0.56 to 0.70). There was a positive and significant correlation between the overall index of OA (all treatments pooled) and the drought period in the site of origin, suggesting ecotypic variation in OA as a result of drought duration. Seedlings allocated more dry matter to roots than shoots when subjected to moderate and slowly imposed water deficit; only one provenance showed no increase in the root to shoot ratio at the end of the treatment period compared with control seedlings. Responses to controlled water deficits were only qualitatively related to performance (survival and growth) of provenances in several field sites, indicating the involvement of complex mechanisms to cope with drought under natural conditions. However, the provenance with the highest overall index of OA outgrew and outsurvived the other provenances in the most arid site, and the only provenance not modifying the root to shoot ratio in response to water deficit survived the least in all field sites. Acclimation of root to shoot ratio and net solute accumulation to water deficit could hence favour drought-tolerance beyond the seedling stage and be used as preliminary predictors of field performance.

Keywords Drought · Drying rates · Osmotic adjustment · Chlorophyll fluorescence · Dry matter allocation · Early screening

Introduction

In Mediterranean-type ecosystems, seasonal water shortage is the main factor constraining survival and growth of plants (Di Castri et al. 1981). Therefore, the assessment of response mechanisms to water deficit can help to identify life history traits associated with drought-tolerance, and in turn, they can be used as predictors of species performance. Genetic improvement programs aim at reducing establishment failure in seasonally dry ecosystems by identifying and selecting

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