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Research paper

Differences in hydraulic architecture between mesic and xeric *Pinus pinaster* populations at the seedling stage

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We studied the intraspecific variability of maritime pine in a set of morphological and physiological traits: soil-to-leaf hydraulic conductance, intrinsic water-use efficiency (WUE, estimated by carbon isotope composition, $\delta^{13}C$), root morphology, xylem anatomy, growth and carbon allocation patterns. The data were collected from *Pinus pinaster* Aiton seedlings (25 half-sib families from five populations) grown in a greenhouse and subjected to water and water-stress treatments. The aims were to relate this variability to differences in water availability at the geographic location of the populations, and to study the potential trade-offs among traits. The drought-stressed seedlings demonstrated a decrease in hydraulic conductance and root surface area and increased WUE and root tip number. The relationships among the growth, morphological, anatomical and physiological traits changed with the scale of study: within the species, among/within populations. The populations showed a highly significant relationship between the percentage reduction in whole-plant hydraulic conductance and WUE. The differences among the populations in root morphology, whole-plant conductance, carbon allocation, plant growth and WUE were significant and consistent with dryness of the site of seed origin. The xeric populations exhibited lower growth and a conservative water use, as opposed to the fast-growing, less water-use-efficient populations from mesic habitats. The xeric and mesic populations, Tamrabta and San Cipriano, respectively, showed the most contrasting traits and were clustered in opposite directions along the main axis in the canonical discriminant analysis under both the control and drought treatments. The results suggest the possibility of selecting the Arenas population, which presents a combination of traits that confer increased growth and drought resistance.

Keywords: carbon allocation, forest genetics, hydraulic conductance, root architecture, water-use efficiency, xylem anatomy.

Introduction

The Mediterranean Basin is located in the transitional zone between a sub-oceanic climate, with regular precipitations from the polar front, and a subtropical arid climate, with high pressures. As a consequence, two clearly differentiated zones exist in the Iberian Peninsula, with an Atlantic and a Mediterranean influence, and several climatic regions: arid, semi-arid, semi-humid and humid. The Mediterranean species *Pinus pinaster* covers a wide range of climates with dry and wet conditions, and is widely used in forestation and tree breeding. Understanding the physiological adaptations to water stress between and within *P. pinaster* populations is a desirable goal due to its applicability to the current selection programmes.

Whole-plant water balance in woody plants has a major influence on plant growth and depends on many variables. The morphology and architecture of roots greatly influences water uptake (Fitter et al. 1991). *Pinus pinaster* root architecture is adapted to the prevailing wind and soil profile (Danjon et al. 2005) and there is variation in three-dimensional coarse root architecture among populations. The French Atlantic populations showed a unique and deep taproot and large root biomass and the populations from dry areas more shallow and branched roots (Danjon et al. 2009).