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Why do large, nitrogen rich seedlings better resist stressful transplanting conditions? A physiological analysis in two functionally contrasting Mediterranean forest species

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ABSTRACT

We analysed the physiological bases that explain why large and high nitrogen (N) concentration seedlings frequently have improved survival and growth relative to small seedlings in Mediterranean woodland plantations. Large seedlings of Aleppo pine (*Pinus halepensis* Mill.) and holm oak (*Quercus ilex* L.) with high N concentration (*L+*), and small seedlings with either high (*S+*) or low (*S−*) N concentration, were planted on two sites of different weed competition intensity that created contrasting stress conditions. Seedling survival, growth, gas exchange, N remobilization (N_R) and uptake (N_U), and water potential were assessed through the first growing season. Weeds reduced survival and growth, but seedling response to weed competition varied among phenotypes and between species. At the end of the first growing season, *L+* Aleppo pine seedlings had higher survival than both small seedling types in presence of weeds but no differences were observed in absence of weeds. Mortality differences among phenotypes occurred in spring but not in summer. *L+* Aleppo pines grew more than small Aleppo pines independently of weed competition. No holm oak seedling type survived in presence of weeds and no mortality differences among phenotypes where observed in absence of weeds, although *L+* holm oak seedlings grew more than small seedlings. Mortality and growth differences in Aleppo pine were linked to marked physiological differences among phenotypes while physiological differences were small among holm oak phenotypes. *L+* Aleppo pines had greater root growth, gas exchange, N_R, and N_U than small seedlings, irrespective of their N concentration. Seedling size in Aleppo pine had a greater role in the performance of transplanted seedlings than N concentration. The functional differences among oak phenotypes were small whereas they were large in pine seedlings, which led to smaller differences in transplanting performance in holm oak than in pine. This suggests that the nursery seedling quality improvement for planting in dry sites could depend on the species-specific phenotypic plasticity and functional strategy. Improved transplanting performance in large Aleppo pine seedlings relative to small seedlings was linked to greater gas exchange, root growth and N cycling.

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1. Introduction

Water stress, caused by weed competition and summer drought, are major factors that limit establishment of planted seedlings in abandoned Mediterranean croplands (Rey Benayas et al., 2005). Seedling transplanting performance also depends on seedling morphological and physiological attributes, which can be determined to a great extent by cultivation practices in the nursery (van den Driessche, 1991a; Villar-Salvador et al., 2004a). Much evidence indicates that, for a given species, large seedlings frequently have improved survival and growth relative to small seedlings in Mediterranean environments (Puértolas et al., 2003; Villar-Salvador et al., 2008; Luis et al., 2009; Oliet et al., 2009; and references there in). Similar trends have also been reported in boreal and humid temperate environments, where large seedlings are more competitive against weeds than small seedlings (Lamhamedi et al., 1998; Noland et al., 2001; South et al., 2005). However, large seedlings can perform worse than small seedlings in very dry reforestation sites (Rose et al., 1993; Trubat et al., 2008). Several studies have also reported a positive correlation between transplanting performance of forest species and plant nitrogen (N) concentration (van den Driessche, 1988; Puértolas

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