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REGULAR ARTICLE

A comparison of root architecture and shoot morphology between naturally regenerated and container-grown seedlings of *Quercus ilex*

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Abstract We explored the different mechanisms developed by naturally regenerated seedlings of *Quercus ilex* L. (Holm oak) under Mediterranean conditions compared to container-seedlings commonly used in plantations. We examined the differences in root architecture (including topology and morphology) and shoot parameters. The results showed that there are many differences in the architecture of the root system as well as in the shoot morphology between the two types of seedlings. The naturally regenerated seedlings were smaller with regard to most of the shoot and root parameters, but they developed a longer taproot, only first order lateral roots, and presented a more herringbone-like root system compared to the container seedlings. Conversely, all types of container seedlings, were larger and had a more extended root system with many orders of lateral roots, while their taproot length was restricted within the container's depth. The quotient log (α)/ log (μ) for all seedlings, showed a tendency to decrease with plant size. A strict herringbone root system with an elongated taproot may be the optimal root architecture for *Quercus ilex* L. seedlings in order to survive under Mediterranean conditions.

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Introduction

Quercus ilex L. (Holm oak) is among the most commonly used oak species in western European Mediterranean restoration projects (Vallejo et al. 2000). This species is a slow-growing, sclerophyllous evergreen oak with resprouting capabilities and is a major structural component of the natural forests and woodlands in western European and northern African Mediterranean regions, and thus a valuable species for restoration of abandoned cropland and other deforested areas (Rey Benayas and Camacho-Cruz 2004; Villar-Salvador et al. 2004b). However, the two important factors that limit the establishment and growth of woody seedlings in Mediterranean environments, particularly in abandoned cropland and in deforested areas, are excessive irradiation and reduced water availability (Rey Benayas and Camacho-Cruz 2004; Valdecantos et al. 2006).

Q. ilex regeneration is facilitated by co-occurring woody plants, since wild oak seedlings appear mostly under shrubs or trees in most ecosystems where they have the highest emergence and survival (Puerta-Piñero et al. 2006; Retana et al. 1999).

The establishment of container planted seedlings of woody species in degraded Mediterranean environments may be aided by nursery treatments that