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Establishment of *Quercus ilex* L. subsp. *ballota* [Desf.] Samp. using different weed control strategies in southern Spain

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Abstract

Formerly cropped sites on Mediterranean areas that have been planted with hardwoods are typically associated with low tree survival and growth, with an enduring influence of agricultural weeds in the herbaceous stratum. This study evaluates the survival and growth of planted Holm oak (*Quercus ilex* L. *ballota* [Desf.] Samp.) in response to three weed control treatments on a cropland site in southern Spain. The weed control treatments (cultivation, herbicide, and mulch) were applied in combination with tree shelters. Survival, relative growth rate, biomass, and root architecture were monitored over a 1-year period. Shelter microclimate was measured 1 year after establishment. Trees in the ground management treatments consistently had greater levels of survival than the control. Although these effects were not significantly different between weed control treatments, we found that tree shelters had a significant effect on growth and biomass. There were also significant treatment effects on root architecture. The response of trees to weed control treatments and tree shelters are consistent with other studies, which suggest a positive effect related to the interplay of microclimate change and resource availability. Our results suggest that weed control may improve early survival in forest plantations and, in combination with tree shelters, merit consideration in Mediterranean afforestation programs.

Keywords: Afforestation; Herbaceous weed control; Oak plantations; *Quercus ilex*; Holm oak

1. Introduction

Since the early 1990s, afforestation of former agricultural fields has been the primary silvicultural activity on the low quality croplands of southern Spain.

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Survival and tree growth rates associated with these projects are usually inferior to those found on forest sites (Navarro Cerrillo et al., 2001a). Commonly cited causes include poor matching of species and site, changes in soil properties, presence of aggressive weed communities, and animal predation (Haywood et al., 1997; Truax et al., 2000; South et al., 2001). While all these factors are important determinants of stand success, efforts to increase afforestation success must focus on those management techniques that may be improved cost-effectively, specifically tree species selection and management of competing vegetation. Holm oak (*Quercus ilex* L. *ballota* [Desf.] Samp.) is a slow-growth Mediterranean species and is considered desirable for new plantations, but this species has shown low survival and growth rates when planted (Navarro Cerrillo et al., 2001c). Herbaceous weeds are known to compete with newly planted seedlings for water, nutrients and light (Truax et al., 2000; Dobois et al., 2000; South et al., 2001). Silvicultural practices, which are often adopted for managing ground cover, include the use of cultivation, herbicides and mulch, used alone or in combination with tree shelters (Dobois et al., 2000). When compared with plantings without herbaceous weed control, treated forest plantations are commonly characterized by increased plant survival and enhanced growth (Cogliastro et al., 1990; Devine et al., 2000; Truax et al., 2000; Ezell and Nelson, 2001). Research has not yet been sufficient to determine all of the causes underlying the variable growth response among these studies (Ezell and Nelson, 2001).

Mulching has been recognized as a beneficial practice in agronomic and forestry systems (Adams, 1997; Haywood, 1999). This enhancement has been attributed to the reduction of vegetative competition (Haywood and Youngquist, 1991; Haywood, 2000; Green et al., 2003) and to an increase in the availability of key soil resources such as nitrogen (Truax and Gagnon, 1993) and water (Haywood and Youngquist, 1991; Wien et al., 1993). More recently, the utility of mulching (e.g. plastic or wood-fiber sheeting) has been assessed in various forestry applications, including the establishment of hardwood and conifer plantations (Adams, 1997; Haywood, 1999, 2000; Green et al., 2003). The success of such applications depends on improvements in survival and early growth, and it is assumed that mulching should enhance both factors, with beneficial effects in certain cases (Gupta, 1991; Adams, 1997; Haywood, 1999), but not in others (Davis, 1988a, 1988b; Haywood and Youngquist, 1991; Houle and Babeux, 1994).

Tree shelters are widely used to protect tree seedlings against animal browsing and as a complement to weed control. Research to date has shown that tree shelters strongly affect the microclimate surrounding the plant. The variables affected are temperature, light intensity, or radiation, relative humidity, vapour pressure deficit, CO_2 concentration and wind (Potter, 1991; Kjelgren et al., 1997; Dupraz, 1997a; Dupraz and Berger, 1999). Survival appears to be enhanced by tree shelters (Potter, 1991; Navarro Cerrillo et al., 2001b; Bellot et al., 2002). Stem diameter growth does not, however, appear to increase, and in fact, reduced growth of stems has been observed (Potter, 1991; Kjelgren et al., 1994; Burger et al., 1996; Mayhead and Boothman, 1997; Dupraz, 1997b).

A small number of studies have included the combined effect of weed control and tree shelters on tree establishment (Dobois et al., 2000). Thus, the objective of the present study was to gauge the effect of weed control treatments in combination with tree shelters on early tree survival, growth, biomass, length and root attributes in a Mediterranean Holm oak (*Q. ilex* L. *ballota* [Desf.] Samp.) plantation.

2. Material and methods

2.1. Experimental site

The experimental plot was located in Córdoba (Andalucia, southern Spain) (coordinates 37°51′N and 4°48′E, 92 m altitude), in an area with homogeneous flat loam soil (Xerofluvents). The site has been periodically cropped and was left fallow during the 2000–2001 growing seasons, supporting a mixture of native and introduced herbaceous species associated with agricultural bottomlands. The experiment was carried out during the period of February 2002 to December 2002. The area has a dry Mediterranean climate with an average annual rainfall of 670 mm, with hot and dry summers and warm winters. No watering was done during the trial in order to reproduce field conditions. The selected species for the study was *Q. ilex* L. subsp. *ballota* [Desf.] Samp.