From Forest Nursery Notes, Winter 2011

111. © Is light the key factor for success of tube shelters in forest restoration plantings under Mediterranean climates? Puertolas, J., Oliet, J. A., Jacobs, D. F., Benito, L. F., and Penuelas, J. L. Forest Ecology and Management 260:610-617. 2010.

Forest Ecology and Management 260 (2010) 610–617

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Is light the key factor for success of tube shelters in forest restoration plantings under Mediterranean climates?

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ARTICLE INFO

Article history:
Received 17 February 2010
Received in revised form 10 May 2010
Accepted 15 May 2010

Keywords:
Tube shelter
Shade tolerance
Root growth
Chlorophyll fluorescence
Dry climate

ABSTRACT

Tube shelters were designed to protect against browsing, but they improve seedling survival in Mediterranean dry climates. Mechanisms for this response, however, are not fully understood and this knowledge can be useful to help design optimal tube shelters for Mediterranean species and climates. Our objective in this study was to determine if the positive effect of tube shelters is due to enhanced growth during the wet season or to reduced light stress during the dry season. We performed two independent experiments. In the first, we assessed root growth during the wet season in two Mediterranean species with contrasting light tolerance (*Quercus ilex* L. and *Pinus halepensis* Mill.) growing in tubes with varying light transmissivity. In the second experiment, we studied the response of a *Quercus ilex* plantation to different shelter treatments. Root growth during the wet season was reduced with decreasing light transmissivity in the shade intolerant *P. halepensis*, but not in the shade tolerant *Quercus ilex*. Survival of *Q. ilex* shaded by a mesh shelter only during summer was higher than in unsheltered seedlings and similar to the survival in tube and mesh shelters during the whole season. This suggests that shade during the dry period was the main factor explaining survival in this species. This effect could be related to the lower leaf temperature recorded in sheltered seedlings. We conclude that *Q. ilex* (and perhaps other late successional, shade tolerant Mediterranean species) should be planted in tubes with the currently used light transmissivity because these shelters reduce light stress in summer without impairing root growth in the wet season. However, current tubes impair root growth in *P. halepensis* (and likely other pioneer, shade intolerant Mediterranean species), so higher transmissivity tubes may be necessary. Optimal transmissivity for tube shelter in Mediterranean climates is species-specific and identifiable as the point that minimizes light stress during summer without impairing root growth in the wet season.

1. Introduction

Tube shelters were first used in plantations several decades ago in the United Kingdom to provide herbivory protection to seedlings. Some positive effects on plant height growth were concurrently observed (Tuley, 1985), but many subsequent studies reported a decrease in shoot diameter with respect to unsheltered seedlings (Burger et al., 1996; Kjelgren and Rupp, 1997; Mayhead and Boothman, 1997). Some studies have even shown reduced shoot biomass of protected seedlings compared to unsheltered plants (Dupraz and Bergez, 1999). These contrasting results prompted studies on microclimatic conditions and plant physiology inside tube shelters under wet climates. These studies have generally concluded that tube shelters reduce light and CO_2 availability, while increasing air temperature and relative humidity. This leads to reduced transpiration (Bergez and Dupraz, 1997, 2009; Dupraz and Bergez, 1999; Kjelgren et al., 1997) and assimilation rates (Dupraz and Bergez, 1999) of sheltered plants. Tube shelters also suppress the mechanical stimuli induced by wind, which explains in part the smaller stem diameters and higher shoot to root ratios noted in sheltered seedlings (Coutand et al., 2008)

The effect of tube shelters on plant physiology and performance in wet climates is well studied and this research has prompted the design of new tube shelters more efficient for plant growth (Bergez and Dupraz, 2000). However, these effects in Mediterranean and other dry climates are not yet well understood. In these climates, where the main objective of afforestation is usually the restoration of degraded areas, survival is the main threat to the success of these operations (Chirino et al., 2009). Under these conditions, a number of studies have reported a positive effect of tube shelters

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doi:10.1016/j.foreco.2010.05.017