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Article *in* Catena · April 2018

DOI: 10.1016/j.catena.2018.04.011

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Catena 166 (2018) 271–278

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Soil legacies determine the resistance of an experimental plant-soil system to drought

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ARTICLE INFO

Keywords:
Soil legacy treatments
Forest fragmentation
Drought
Soil respiration
Quercus ilex
Provenances

ABSTRACT

This study examines the effects of climate and the degree of forest fragmentation legacies on response of oak to drought. A microcosm approach was set up with holm oak seedlings from three provenances grown in soils coming from two regions of contrasting climate (drier vs. wetter), and three scenarios of forest fragmentation (low, mid, and high agricultural matrix influence). We measured different indicators of the plant-soil system functioning such as ecosystem respiration, net ecosystem exchange, gross primary productivity, stomatal conductance, quantum yield, biomass allocation, and mycorrhization. Legacies of the bioclimatic region and the degree of forest fragmentation on soil properties drove the response to drought of an experimental plant-soil system, masking the effects of seedling provenance. The system was functionally more resistant to drought in soils from forest fragments with more agricultural influence and from the drier region. Our results indicate that the degree of forest fragmentation and bioclimatic legacies on soil properties exerted a much more decisive effect on the response of the plant-soil system to drought than holm-oak seedling provenance.

1. Introduction

The functioning of Mediterranean ecosystems is usually constrained by water availability, given that both plant productivity and soil activity are strongly subjected to seasonal and spatial variations of this resource (Rey et al., 2002). The expected reduction in soil water availability due to forecasted temperature increase and rainfall decline for this region (IPCC, 2013) is likely to be associated with profound modifications of carbon and water cycles (Reichstein et al., 2002). In fact, the increased intensity of drought in recent decades has led to a decrease in tree productivity and even to forest decline in some areas of the Mediterranean Basin, which has been related to changes in soil microbial communities and CO_2 fluxes (Barba et al., 2013, 2015; Curiel Yuste et al., 2012).

Climate change is not the only threat affecting the ecology and functioning of ecosystems in the Mediterranean Basin. Other factors such as habitat fragmentation can be considered among the most impacting human-related activities that have contributed to the transformation of this area in the past (Alados et al., 2004), although its effects on the ecosystem functioning have been less studied than those related with climate (e.g. drought). The impacts of landscape change (e.g. land-use intensification, forest fragmentation) have been widely analyzed (Fischer and Lindenmayer, 2007; Gossner et al., 2016; Tscharntke et al., 2005). However, most of these studies have focused on the above-ground compartment, while only a few have paid attention to below-ground components in the soil system (Flores-Rentería et al., 2016; Malmivaara-Lämsä et al., 2008; Riutta et al., 2012; Zheng et al., 2005). The effect of forest fragmentation is largely dependent upon the matrix that surrounds the remnant fragments (Fernández et al., 2002); for instance, Flores-Rentería et al. (2015) demonstrated that the agricultural matrix improved local environmental conditions (e.g. at small fragments tightly surrounded by agricultural land) by increasing soil water and nutrient contents, thus buffering the negative drought effects on the soil functioning (e.g. soil respiration and

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https://doi.org/10.1016/j.catena.2018.04.011
Received 29 November 2017; Received in revised form 28 March 2018; Accepted 8 April 2018