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Interactions between plastic responses to light and water availability in experiments with tree seedlings

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ABSTRACT: Phenotypic plasticity, water stress and shade tolerance have been separate targets of numerous studies concerned with plant ecology and distribution. The main objective of the study was to combine these three topics in a single study case. In this study we quantified the plastic phenotypic responses to light, exploring the interactions between light and water availability and determining the influence of phenotypic plasticity on survival. Phenotypic plasticity partially explained the differences among species in survival in sun and deep shade. The interactions between light and water availability found in plant responses showed that phenotypic plasticity involves costs that negatively influenced survival under some specific environmental conditions, pointing to the need for detailed studies of the adaptive value of phenotypic plasticity in response to co-occurring stresses.

1 INTRODUCTION

Phenotypic plasticity has long been considered as advantageous for plants, but its costs, which have been only seldom estimated, may overcome the advantages, DeWitt et al. (1998). Water stress and shade are two of the most important ecological factors determining plant distribution and also structure and dynamics of plant communities, Zavala et al. (2000). Consequently plant responses to different levels of water and shade has been the target of numerous studies. Here we address again this main target, but with new specific objectives: i) to quantify the plastic phenotypic responses to light, ii) to explore the interactions between light and water availability, iii) to determine the influence of phenotypic plasticity on survival, as an approximation to the costs of plasticity. By tackling these objectives with seedlings, we have experimentally explored the regeneration niche of four important Iberian tree species characteristic from the transition temperate -Mediterranean forest (*Quercus pyrenaica* Willd, *Quercus. robur* L., *Pinus pinaster* Ait. and *Pinus sylvestris* L.).

2 MATERIALS AND METHODS

We have performed a factorial experiment with four species, four light levels (1, 6, 20 and 100% of full sunlight) and two watering levels (low and well-watered levels). Seedlings were allowed to grow from early spring to late autumn 2001 and four censoring times were established to monitor seedlings' survival. Chlorophyll fluorescence, carotenoids and chlorophyll concentrations were measured as physiological leaf features. Specific Leaf Area (SL), Leaf Area Ratio (LAR),

Shoot/Root ratio and Slenderness Index were measured as whole-plant features. An index of phenotypic plasticity was calculated for each variable and species as in Valladares et al. (2000).

3 RESULTS

The ranking of species according to their survival in the sun was the reverse of that in deep shade, which could be partially explained by inter-specific differences in phenotypic plasticity. Overall phenotypic plasticity in response to light was inversely related to survival in deep shade (Fig. 1A) while the relationship was positive in the sun (Fig. 1B). However, the increased survival in the sun with increased plasticity was only observed under water stress, since no relationship was found in the well-watered plants (Fig. 1C).

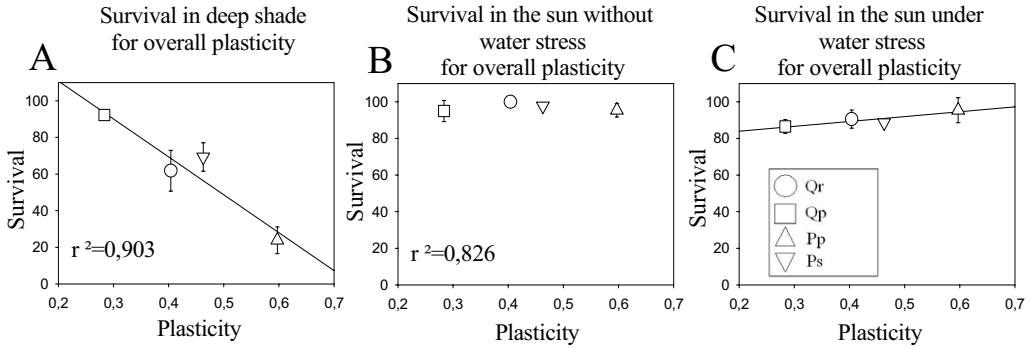

Figure 1. Relationships between survival and overall plasticity obtained from the studied variables under different environmental conditions. The bars represent standard error, n=3 blocks with 22 individuals each. No significant regression was obtained with data in Graph C.

4 CONCLUSIONS

The significant interactions between light and water availability are essential for understanding plant performance in temperate-Mediterranean forests, emphasizing the need for detailed studies of the adaptive value of phenotypic plasticity in response to co-occurring stresses. Comparisons of these results with previous studies of plastic responses of seedlings of Mediterranean trees, Valladares et al. (2002), and that of tropical shrubs, Valladares et al. (2000), suggests a gradient of decreasing plasticity in plants from the most favorable to the most adverse ecosystem.

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