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Interaction of Light and Water Stress on the Ecophysiological Response of *Nothofagus Antarctica* (G. Forster) Oerst.

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ABSTRACTS

Nothofagus antarctica (G. Forster) Oerst. (ñire) occupies a latitudinal gradient ranged from 36° 30´ to 56° 00’ S, and extends from sea level to 2,000 m a.s.l. It is the species with widest ecological amplitude in *Nothofagus spp*. from south-America covering in southern Patagonia (Argentina) 431,000 ha and growing mainly between the *N. pumilio* forests and steppe where water conditions are limiting. Productivity and different ecological issues of ñire forests have been previously assessed. However, specific studies related to the functional response to water stress of species are scarce. Therefore, the main subject of present study was to evaluate the functional response and growth of ñire seedlings under the interaction of water stress and two light conditions. Ten seedlings were grown during 6 months in a climatic chamber under a photoperiod 14/10 hours of light/darkness, a temperature range of 25ºC day / 20ºC night, and 65% relative humidity. One shoot on each seedling was shaded from the beginning of the experiment with a shading mesh (transmittance of 5 % of full light). The rest of plant received at the top 800 $\mu molm^{-2}s^{-1}$ PPFD. After five months of well-watering conditions, half of seedlings were submitted to a water stress cycle by one additional month. By the end of experiment, diameter growth at the base of stem seedling was measured. In addition, different leaf functional parameters were recorded: specific leaf área (SLA), net photosynthesis (A_n), stomatal conductance to water vapor (gwv), and different parameters from building P-V curves: osmotic potential at maximum and zero turgor (Π^{100}; Π^{0}), relative water content at zero turgor (RWC_0), maximum modulus of elasticity (E_{max}), and dry/full-hydrated weight ratio (DW/TW). Plant water status was recorded measuring predawn water potential (Ψ_{pd}). Light and water stress affected most leaf functional parameters with synergic to antagonistic impacts depending on a particular trait.

INTRODUCTION

The deciduous tree species *Nothofagus antarctica* (G. Forster) Oerst. (ñire) has the widest ecological amplitude in *Nothofagus spp*. from south-America (Donoso et al. 2006) occupying a latitudinal range from 36° 30´ to 56° 00’ S, and extends from sea level to 2,000 m a.s.l. (Veblen et al. 1996). In southern Argentinean Patagonia the “*ñire*” forests cover an area of

431,000 ha (Collado 2001; Peri and Ormaechea 2013), growing in contrasting environmental conditions ranging from poorly drained sites with high precipitations and enduring flooding to dry sites limiting with the Patagonian steppe. However, most of these forests grow in an ecotone zone between the *N. pumilio* forests and steppe where water conditions severely limits growth of forest trees. Several ecological and productive issues of ñire forests have been studied in southern Patagonia (Lencinas et al. 2002; Peri et al. 2010; Bahamonde et al. 2012; Gargaglione et al. 2013), but specific studies related to the functional response to water stress of species are scarce, especially in southern Patagonia. Some previous reports on the ecophysiological response of the species are those from Peri et al. (2009) in northern Patagonia who studied the photosynthetic response of seedlings of *N. antarctica* to different radiation levels and water availability; Bucci et al. (2013) evaluated hydraulic characteristics of leaves and stems of six species of *Nothofagus*, being one of them *N. antarctica*. In Chile, Dettmann et al. (2013) studied xylem anatomy of four *Nothofagus* including *N. antarctica* and calculated the hydraulic conductivity and Ψ_{50}. Therefore, the main objective of present study was to evaluate the functional response and acclimation of ñire leaves under the interaction of water stress and two levels of light availability.

MATERIAL AND METHODS

Seeds from Tierra del Fuego (54°20´LS – 67°52´LW) were germinated according to existing protocols (Bahamonde et al. 2011) and planted in 100 cc trays. After an initial growth phase of two months in the greenhouse, ten seedlings were transplanted to 2 L pots and grown for 6 months in a climatic chamber under a photoperiod of 14/10 hours of light/darkness, a temperature range of 25ºC day / 20ºC night, and 65% relative humidity. One shoot on each seedling was shaded from the beginning of the experiment with a shading mesh (transmittance of 5 % of full light). Rest of plant received a PPFD at the top of 800 µmolm^{-2}s^{-1}. After five months of well-watering, half of seedlings were submitted to a water stress cycle for one additional month. The diameter at the base of stem seedling was measured at the beginning and the end of the experiment. Thus, relative diameter growth at the base of stem seedling was calculated. In addition, at the end of the experiment different leaf functional and morphological parameters were recorded: specific leaf area (SLA), net photosynthesis (A_n), stomatal conductance to water vapor (g_{wv}). In addition different water parameters from building P-V curves were also recorded: osmotic potential at maximum and zero turgor (Π_{100}; Π_0), relative water content at zero turgor (RWC_0), relative water content of the apoplast (RWC_A), maximum modulus of elasticity (E_{max}), and dry/full-hydrated weight ratio (DW/TW). Plant water status and soil water availability were recorded from measuring predawn water potential (Ψ_{pd}) at the end of the experiment, and soil water content (SWC) at different times during the cycle of watering withdrawal.

RESULTS AND DISCUSSION

Water stress affected negatively plant growth. The diameter relative growth at the stem base was significantly higher in the control compared to the stressed plants (Table 1), which confirms the drought sensitivity of the species previously reported (Gyenge et al. 2011). SLA values were higher in shaded leaves regardless of water status. Similarly, Varela (2010) reported a trend of higher values of SLA in seedlings of *Nothofagus nervosa* and *N. obliqua* growing under shade compared to plants at full sun, but there was not an effect of different water levels on SLA either the interaction light x watering treatments was significant. Light was the main driver in prompting changes in SLA. A_n was affected by shade, but no statistical significant differences were detected under water stress, even though there was a trend to be lower in stressed plants (Table 1). However, for stomatal conductance there were statistically significant differences, with lower values due to both water stress and light limitation compared to control plants ($P < 0.05$ both main effects, and $P < 0.05$ interaction term). Peri et al. (2009) reported a decrease of A_n in seedlings of *N. antarctica* either with shade and water stress. Our results suggest that *N. antarctica* seedlings closed the stomata to avoid water loss, but probably the level of water stress was not high enough to imply a decrease in photosynthesis. The differential impact of water stress according to light environment on A_n and g_{wv} translated in significant differences for Ci, being significant the interaction term ($P < 0.05$). In the last, this result would point out to a differential impact of water stress in gas exchange regulation according to light environment. In relation to water parameters, only light affected to DW/TW, while not differences were observed for rest of parameters (Table 1). There are not antecedents about the effect of water or light stress on these parameters for *N. antarctica*. However, Varela (2010) informed that water stress did not generate an osmotic adjustment in *N. obliqua* and *N. nervosa*, close related species to *N. antarctica*.

Table 1. Functional parameters of *N. antarctica* seedlings growing under light and water stress.

	Full light/WW	Shaded/WW	Full light/WS	Shaded/WS
SLA	22.4 b	38.0 a	26.0 b	38.3 a
A_n	8.27± 1.12a	2.43 ± 0.48 ab	5.64 ± 2.39 a	0.91± 0.42 b
g_{wv}	0.186 ± 0.028 a	0.061 ± 0.008 b	0.050 ± 0.027 b	0.016 ± 0.006 b
C_i	315 ± 4 a	315 ± 23 ab	183 ± 27 b	302 ± 6 ab
Π^{100}	-1.43 ± 0.18 a	-1.15 ± 0.23 a	-1.13 ± 0.20 a	-0.92 ± 0.18 a
Π^{0}	-1.95 ± 0.23 a	-1.55 ± 0.29 a	-1.60 ± 0.25 a	-1.34 ± 0.23 a
RWC_0	0.81 ± 0.03 a	0.80 ± 0.04 a	0.84 ± 0.04 a	0.80 ± 0.03 a
DW/TW	0.31 ± 0.01 a	0.26 ± 0.01 b	0.28 ± 0.01 a	0.26 ± 0.01b
Emax	5.89 ± 1.18 a	5.35 ± 1.52 a	4.34 ± 1.32 a	3.36 ± 1.18 a

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