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Proceeding Paper

Eucalyptus Genotypes Water Use and Site Interactions on Water Resource Sustainability and Productivity †

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Abstract: Water use, water use efficiency, and water use sustainability are challenging issues for the expansion of Eucalyptus plantations around the world nowadays. Fast-growing species' effects on water resources are of concern to society, and the forest industry wonders about the effects on productivity and water sustainability under climate change. We evaluated growth, water use, and water use efficiency response at canopy closure (3 to 4 years of age) of eight selected E. globulus, E. nitens, and E. nitens × globulus (E. gloni) genotypes at four contrasting environments. Across sites and genotypes, the growth rate and water use ranged from 35–70-m^3/ha/year and 350 to 900 mm ha^{-1}. Despite specific genotype cases, our results showed similar water use vs. productivity relationships for a single taxon (90 m^3 of water per m^3 of wood) but suggested large differences among taxa across sites. Our results suggest that hybrids may provide large productivity benefits but may need a more precise understanding of their physiological mechanisms. Interesting opportunities exist for matching genotypes to sites in order to reduce environmental concerns on water resource use for Eucalyptus plantations.

Keywords: water use; water sustainability; clonal; growth efficiency; eucaliptus

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1. Introduction

Eucalyptus is one of the most extensively planted genera world-wide, and several concerns have been raised about the effects on water resources, water sustainability and survival, and productivity of intensively managed plantations under climate change ([1,2]). Despite the fact that several detailed ecophysiological assesments have been made over the last decade on the most extensively planted species [3–6], scarce information exists about the opportunity on selecting specific genotypes that may reduce the potential effects of plantations on water resources and their risk for sustained production of forest resources [7,8]. The objective of our study was to understand the differential growth response, water use, and water use efficiency of the mediterranean Eucalyptus in order to evaluate opportunities on specific taxa and genotypes selection for increasing site water sustainability of intensively managed plantations.

2. Materials and Methods

2.1. Site Characteristics

Four sites, from the regional validation genetic trials of CMPC and ARAUCO forest companies in Chile representing a gradient of soils of contrasting soil water holding capacity

and atmospheric water demand, this last characteristic represented by the regional gradient in summer atmospheric vapor pressure deficit (Figure 1) were selected for evaluation of Eucalyptus globulus, Eucalyptus nitens, and Eucalyptus nitens × globulus hybrids top genotypes. North sites considered evaluation of five E. globulus and three E. nitens × globulus hybrids clones at "Los Patos" (LP) trial farm located on granitic derived clay soils of the Coastal Range and "Vegas de Saldia" (VS) trial farm located on recent volcanic ash loamy soils of the Piedmont of the Andes. South sites considered evaluation of two E. globulus and four E. nitens × globulus clones, and two E. nitens family genotypes at "El Derrumbe" (ED) trial farm located on metamorphic derived clay soils of the Coastal Range and "San Andres" (SA) trial farm located on red clay old volcanic ash of the Central Valley. All stands were established with the best early silvicultural treatments to secure full survival and early growth by considering subsoiling, fertilization, and weed control up to crown closure (preplanting and postplanting). North stands were four years old and were planted at 1666 trees per hectare; South sites were five years old and were planted at 1430 trees per hectare.

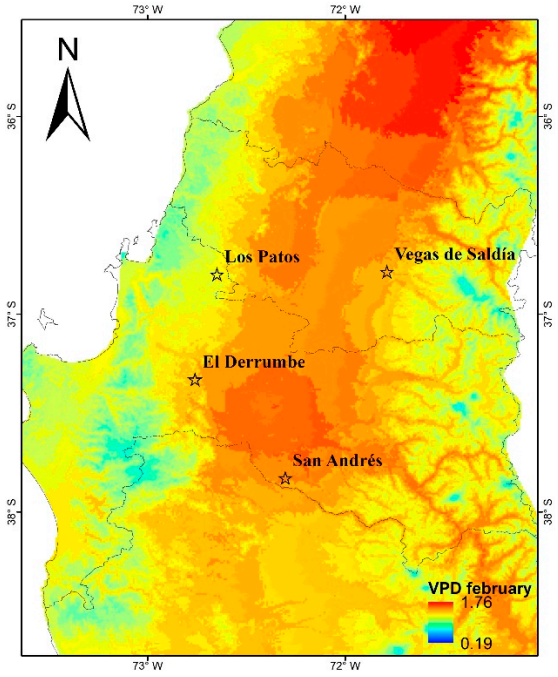

Figure 1. Mean daily vapour pressure deficit during the February summer month map representing the regional gradient in atmospheric water demand for all sites selected and genotypes within each site.

2.2. Annual Growth and Sapflow Assessments

For each selected genotype and three replicates at each site, 36 trees (measurement plots of 6 × 6 trees) were measured for diameter at breast height (1.3 m height) and total height in March 2017, March 2018, and March 2019. Genotype annual volume growth (m^3 wood ha^{-1} $year^{-1}$) was estimated from annual plot volume estimates scaled to hectare level. From the diameter distribution of each genotype at each site, measured in 2017, six trees were selected for sap flow assessments. Granier sensors, located at DBH height on each selected tree, were monitored continuously and sap flux density records were obtained every 15 min. Annual sapwood area wood cores were obtained at DBH height from three buffer trees of each plot in order to develop a DBH vs. sapwood area relationship. Estimates of water use at individual tree levels were obtained from sapwood area and sap flux density estimates and scaling estimates to a plot and hectare level to obtain water use estimates (m^3 water ha^{-1} $year^{-1}$).

3. Results and Discussion

Across sites and genotypes, growth rate ranged from 35–70-m^3 ha^{-1} $year^{-1}$. Eucalyptus nitens showed the largest growth of all genotypes at southern sites ranging from 50 to 70 m^3 ha^{-1} $year^{-1}$, and E. globulus genotypes showed the highest growth at northern sites ranging from 30 to 65 m^3 ha^{-1} $year^{-1}$. The lowest average site productivity was osberved at Los Patos North clayey soils across sites and the highest average site productivity was observed at San Andrés, and sites mainly sustained by Eucalyptus nitens growth (Figure 2).

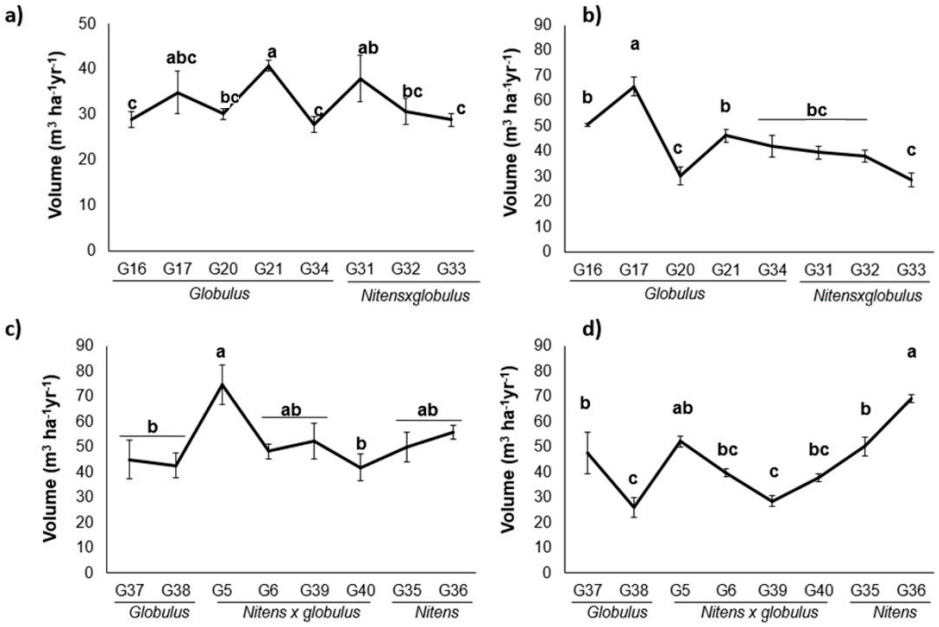

Figure 2. Average annual volume growth (m^3 ha^{-1} $year^{-1}$) of each genotype by taxa at sites: (**a**) Los Patos (**b**) Vegas de Saldia North, (**c**) El Derrumbe, and (**d**) San Andrés from 2017 to 2018.

Across sites and genotypes, annual water used ranged from 300 to 950 mm of water transpired annually (Figure 3). Eucalyptus nitens × globulus hybrid clones showed, on average, the largest water use (675 mm $year^{-1}$), and except for a single genotype E. globulus showed the lowest average water use (535 mm $year^{-1}$).

Despite specific genotype cases, our results showed similar water use vs. productivity relationships for a single taxon. In fact, average annual water use reached an average of 90 m^3 per m^3 of annual wood growth. However, analysis of specific genotypes within each taxa and among taxa suggest large differences across sites.

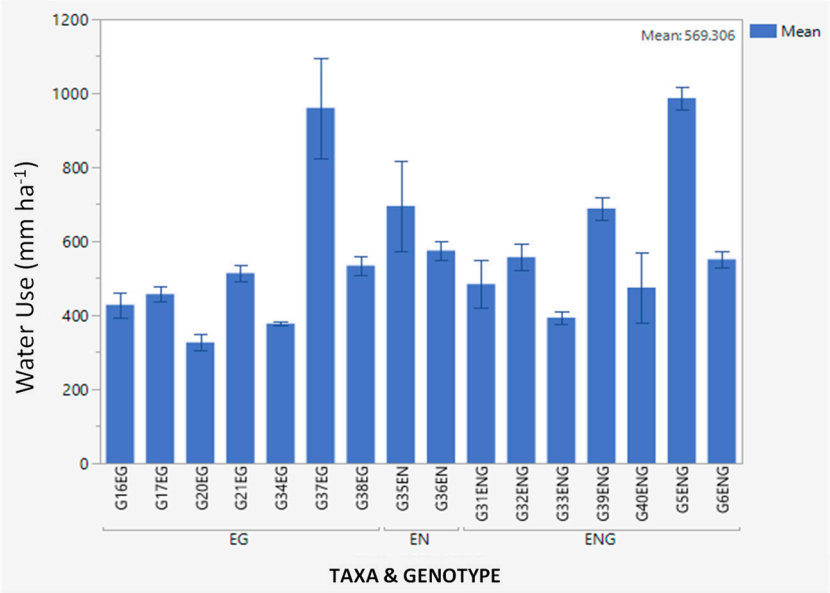

Figure 3. Average annual water use (mm ha^{-1}) for each selected genotype, evaluated across all sites from 2017 to 2018.

4. Conclusions

Our results suggest that hybrids may provide large productivity benefits but may need a more precise understanding of their physiological mechanisms. Interesting opportunities exist for matching genotypes to sites in order to reduce environmental concerns on water resources used for Eucalyptus plantations.

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