From Forest Nursery Notes, Summer 2013

103. © Industrial-age changes in atmospheric [CO_2] and temperature differentially alter responses of faster- and slower-growing *Eucalyptus* seedlings to short-term drought. Lewis, J. D., Smith, R. A., Ghannoum, O., and Logan, B. A. Tree Physiology 33:475-488. 2013.

Tree Physiology 33, 475–488
doi:10.1093/treephys/tpt032

Research paper

Industrial-age changes in atmospheric [CO_2] and temperature differentially alter responses of faster- and slower-growing *Eucalyptus* seedlings to short-term drought

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Received November 6, 2012; accepted April 1, 2013; handling Editor João Pereira

Climate change may alter forest composition by differentially affecting the responses of faster- and slower-growing tree species to drought. However, the combined effects of rising atmospheric CO_2 concentration ([CO_2]) and temperature on drought responses of trees are poorly understood. Here, we examined interactive effects of temperature (ambient, ambient + 4 °C) and [CO_2] (290, 400 and 650 μl l^{-1}) on drought responses of *Eucalyptus saligna* Sm. (faster-growing) and *E. sideroxylon* A. Cunn. ex Woolls (slower-growing) seedlings. Drought was imposed via a controlled reduction in soil water over 1–2 weeks, re-watering seedlings when leaves visibly wilted. In ambient temperature, the effect of drought on the light-saturated net photosynthetic rate (A_{sat}) in *E. saligna* decreased as [CO_2] increased from pre-industrial to future concentrations, but rising [CO_2] did not affect the response in *Eucalyptus sideroxylon*. In contrast, elevated temperature exacerbated the effect of drought in reducing A_{sat} in both species. The drought response of A_{sat} reflected changes in stomatal conductance (g_s) associated with species and treatment differences in (i) utilization of soil moisture and (ii) leaf area ratio (leaf area per unit plant dry mass). Across [CO_2] and temperature treatments, *E. saligna* wilted at higher soil water potentials compared with *E. sideroxylon*. Photosynthetic recovery from drought was 90% complete 2 days following re-watering across all species and treatments. Our results suggest that *E. saligna* (faster-growing) seedlings are more susceptible to drought than *E. sideroxylon* (slower-growing) seedlings. The greater susceptibility to drought of *E. saligna* reflected faster drawdown of soil moisture, associated with more leaf area and leaf area ratio, and the ability of *E. sideroxylon* to maintain higher g_s at a given soil moisture. Inclusion of a pre-industrial [CO_2] treatment allowed us to conclude that susceptibility of these species to short-term drought under past and future climates may be regulated by the same mechanisms. Further, the beneficial effects of rising [CO_2] and deleterious effects of elevated temperature on seedling response to drought were generally offsetting, suggesting susceptibility of seedlings of these species to short-term drought in future climates that is similar to pre-industrial and current climate conditions.

Keywords: drought, elevated [CO_2], photosynthesis, pre-industrial [CO_2], stomatal conductance, temperature.

Introduction

Atmospheric [CO_2] has increased over the past 150 years from ca. 280 ppm to 395 ppm at present. This 40% increase is similar in magnitude to the increase in [CO_2] projected for the 21st century. The projected increase in [CO_2] is expected to be accompanied by a 0.3–3.4 °C rise in mean air temperature for Australia (Hennessy et al. 2007). Although tree responses to elevated [CO_2] have been well documented (Ceulemans and