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The temperature optima for tree seedling photosynthesis and growth depend on water inputs

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Abstract

Understanding how tree growth is affected by rising temperature is a key to predicting the fate of forests in future warmer climates. Increasing temperature has direct effects on plant physiology, but there are also indirect effects of increased water limitation because evaporative demand increases with temperature in many systems. In this study, we experimentally resolved the direct and indirect effects of temperature on the response of growth and photosynthesis of the widely distributed species *Eucalyptus tereticornis*. We grew *E. tereticornis* in an array of six growth temperatures from 18 to 35.5°C, spanning the climatic distribution of the species, with two watering treatments: (a) water inputs increasing with temperature to match plant demand at all temperatures (W_{incr}), isolating the direct effect of temperature; and (b) water inputs constant for all temperatures, matching demand for coolest grown plants (W_{const}), such that water limitation increased with growth temperature. We found that constant water inputs resulted in a reduction of temperature optima for both photosynthesis and growth by ~3°C compared to increasing water inputs. Water limitation particularly reduced the total amount of leaf area displayed at T_{opt} and intermediate growth temperatures. The reduction in photosynthesis could be attributed to lower leaf water potential and consequent stomatal closure. The reduction in growth was a result of decreased photosynthesis, reduced total leaf area display and a reduction in specific leaf area. Water availability had no effect on the response of stem and root respiration to warming, but we observed lower leaf respiration rates under constant water inputs compared to increasing water inputs at higher growth temperatures. Overall, this study demonstrates that the indirect effect of increasing water limitation strongly modifies the potential response of tree growth to rising global temperatures.

KEYWORDS

biomass, *Eucalyptus tereticornis*, forests, global warming, photosynthesis, rainfall, stem and root respiration, temperature

1 | INTRODUCTION

Projections of the future terrestrial carbon cycle depend strongly on how global forests are assumed to respond to rising temperature (Mercado et al., 2018; Rogers et al., 2017). Empirical research has reported spatially divergent growth responses to warming, whereby trees in cold, wet sites typically show an increase in growth, in contrast to trees in warm, dry sites where growth typically declines

