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Research paper

Higher growth temperatures decreased net carbon assimilation and biomass accumulation of northern red oak seedlings near the southern limit of the species range

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If an increase in temperature will limit the growth of a species, it will be in the warmest portion of the species distribution. Therefore, in this study we examined the effects of elevated temperature on net carbon assimilation and biomass production of northern red oak (*Quercus rubra* L.) seedlings grown near the southern limit of the species distribution. Seedlings were grown in chambers in elevated CO_2 (700 μmol mol^{-1}) at three temperature conditions, ambient (tracking diurnal and seasonal variation in outdoor temperature), ambient +3 °C and ambient +6 °C, which produced mean growing season temperatures of 23, 26 and 29 °C, respectively. A group of seedlings was also grown in ambient [CO_2] and ambient temperature as a check of the growth response to elevated [CO_2]. Net photosynthesis and leaf respiration, photosynthetic capacity (V_{cmax}, J_{max} and triose phosphate utilization (TPU)) and chlorophyll fluorescence, as well as seedling height, diameter and biomass, were measured during one growing season. Higher growth temperatures reduced net photosynthesis, increased respiration and reduced height, diameter and biomass production. Maximum net photosynthesis at saturating [CO_2] and maximum rate of electron transport (J_{max}) were lowest throughout the growing season in seedlings grown in the highest temperature regime. These parameters were also lower in June, but not in July or September, in seedlings grown at +3 °C above ambient, compared with those grown in ambient temperature, indicating no impairment of photosynthetic capacity with a moderate increase in air temperature. An unusual and potentially important observation was that foliar respiration did not acclimate to growth temperature, resulting in substantially higher leaf respiration at the higher growth temperatures. Lower net carbon assimilation was correlated with lower growth at higher temperatures. Total biomass at the end of the growing season decreased in direct proportion to the increase in growth temperature, declining by 6% per 1 °C increase in mean growing season temperature. Our observations suggest that increases in air temperature above current ambient conditions will be detrimental to *Q. rubra* seedlings growing near the southern limit of the species range.

Keywords: photosynthesis, *Quercus rubra*, respiration, temperature acclimation.

Introduction

Almost all studies of the effects of elevated temperature on the growth of deciduous tree species have reported that warming enhances growth (Way and Oren 2010). For example, in both ambient and elevated [CO_2], saplings of *Fagus sylvatica* had increased stem diameter, biomass and leaf area when grown at +2 and +4 °C above the current ambient temperature (Overdieck et al. 2007). A similar response was observed in *Quercus myrsinaefolia* saplings when grown at temperatures of +3 and +5 °C above ambient (Usami et al. 2001). Positive growth responses can be substantial: in elevated [CO_2], elevated air temperatures increased the annual biomass increment by 11–12% per 1 °C (Usami et al. 2001, Overdieck et al. 2007). In cold temperate regions, in elevated [CO_2], the