Rethinking Acclimation of Growth and Maintenance Respiration of Tomato in Elevated CO_2: Effects of a Sudden Change in Light at Different Temperatures

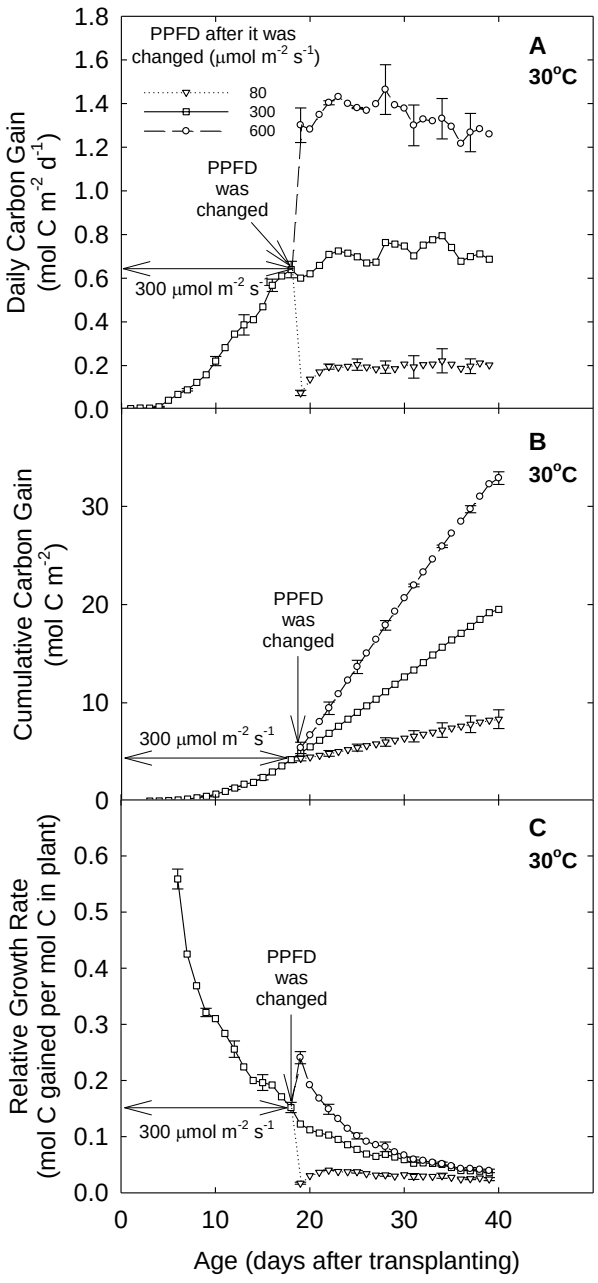
Changes in light and temperature are among he most common and profound environmental changes. The independent effects of light and temperature on photosynthesis and respiration are well studied in single leaves, but are less well studied in whole plants. The short and long term influence of light and temperature on carbon use (i.e. respiration) efficiency is also poorly understood, and is commonly modeled to remain constant over a wide range of conditions. We sough to determine the primary effects of changing light at two growth temperatures on photosynthesis, respiration, and their balance, as defined by carbon use efficiency (CUE).

We separated respiration into growth and maintenance components using whole-canopy gas-exchange in an elevated CO_2 environment in a controlled environment (Figure 1). From the data gathered we calculated daily carbon gain (DCG), CUE, canopy quantum yield (CQY), and both respiration components. Tissues harvested from the plants were analyzed for percent carbon (C), hydrogen (H), and nitrogen (N).

Decreases in light level decreased the carbon efficiency through a reduction in the maintenance coefficient, increased the growth coefficient, and reduced the partitioning of nitrogen into protein. Growth temperature did not significantly affect either maintenance or growth respiration coefficients, suggesting that long-term temperature responses can differ greatly from shot-term observations. These data suggest models over-estimate the rate at which plants acclimate to lower light, regardless of temperature.

Figure 1.The ten chamber gas-exchange system. There are five chambers on each side; each chamber has independent temperature control and a separate hydroponic system. The chambers are housed inside a walk-in growth chamber illuminated by water-filtered high pressure sodium lamps. Reflective Mylar was wrapped around each chamber and raised as the canopy grew to minimize side light.

Figure 2.Daily carbon gain (A), cumulative carbon gain (B), and relative growth rate (C) before and after light treatments were started in the 30 ºC plant group. Light of photosynthetic photon flux density (PPFD) was changed from 300 or 600µmol $m^{-2}s^{-1}$ on day 19. Circles represent 600µmol $m^{-2}s^{-1}$, squares represent 300µmol $m^{-2}s^{-1}$, and inverted triangles represent 80 µmol $m^{-2}s^{-1}$ PPFD treatments. Error bars represent standard deviation.



For more information, contact: Jonathan Frantz, jonathanfrantz319@gmail.com. Dr. Frantz now works for Dupont Pioneer.

Frantz, J.M., N.N. Cometti, M.W. van Iersel, B. Bugbee. 2007. Rethinking acclimation of growth and maintenance respiration of tomato in elevated CO_2: effects of a sudden change in light at different temperatures. J. Plant Ecol. 31:695-710.