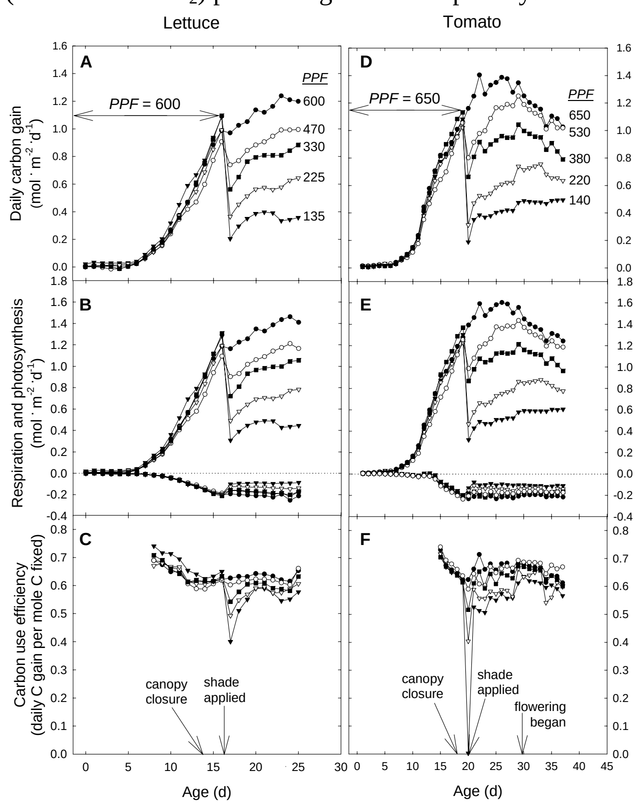
Acclimation of Plant Populations to Shade: Photosynthesis, Respiration, and Carbon Use Efficiency

Cloudy days cause an abrupt reduction in daily photosynthetic photon flux (*PPF*), but we have a poor understanding of how plants acclimate to this change. We continuously measured daily photosynthesis and night respiration of populations of a tomato and lettuce over 42 days. We integrated photosynthesis and respiration measurements separately to determine daily net carbon gain and carbon use efficiency (CUE) as the ratio of daily net C gain to total day-time C fixed over the 42-d period. After 16 to 20 days of growth in constant *PPF*, plants in some chambers were subjected to an abrupt *PPF* reduction to simulate shade or a series of cloudy days.

The immediate effect and the long term acclimation rate were assessed from canopy quantum yield and carbon use efficiency. The effect of shade on carbon use efficiency and acclimation was much slower than predicted by widely used growth models. It took 12 days for tomato populations to recover their original CUE and lettuce CUE never completely acclimated.

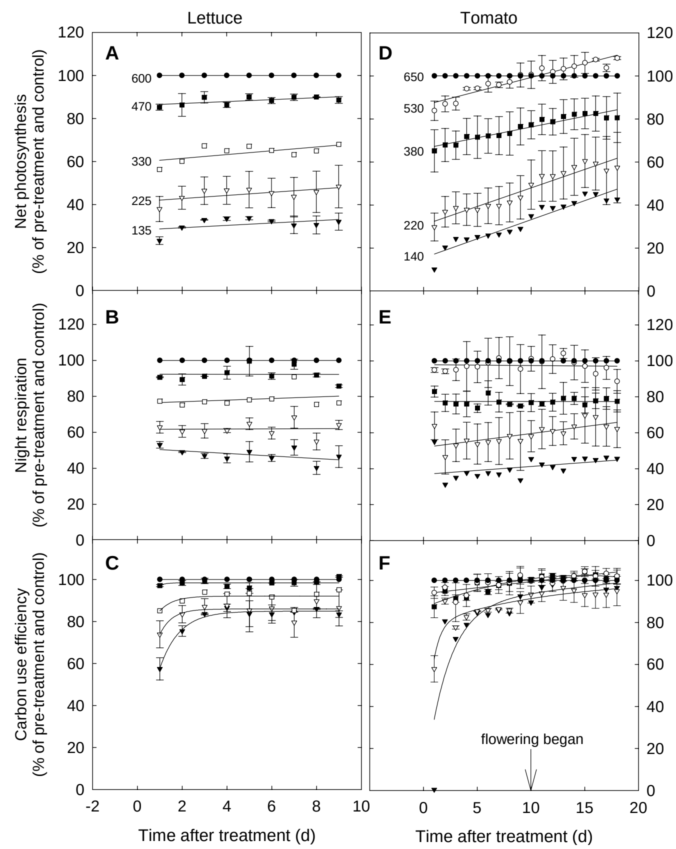
Tomatoes acclimated to low light more rapidly than lettuce (Figs 1 and 2). Plant growth models should be modified to include the photosynthesis/respiration imbalance and resulting inefficiency of carbon gain associated with changing *PPF* conditions.

Figure 1. Daily carbon gain of lettuce (A) and tomato (B), daily respiration (below zero) and photosynthesis of lettuce (C), and tomato (D), and carbon use efficiency of lettuce (E) and tomato (F). Data are expressed as moles of C (measured as CO_2) per m^2 of ground area per day.



Supply and demand of substrates may be a good working model in which to view respiration responses to different light environments, but a better understanding of the carbohydrate demand that determines growth and maintenance requirements is needed. Additionally, these data show that current models that have an instantaneous acclimation of respiration and carbon retention (CUE) in response to reduced *PPF* overestimate the rate at which acclimation occurs in plants and the extent to which acclimation occurs in some species.

Figure 2. Recovery of net photosynthesis for lettuce (A) and tomato (B), night respiration of lettuce (C) and tomato (D), and carbon use efficiency of lettuce (E) and tomato (F) after shading expressed as a percent of pre-treatment and control level. Numbers before the lines indicate the *PPF* at which that treatment
was grown.



For more information, contact: Jonathan Frantz, jonathan.frantz@utoledo.edu USDA-ARS-ATRU, Greenhouse Production Research Group, University of Toledo, Mail Stop 604, 2801 W. Bancroft, Toledo, OH 43606