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Chlorophyll Fluorescence Imaging: Monitoring Growth, Morphology, and Physiology of Hydroponic Lettuce in Response to Photosynthetic Photon Flux Densities Under Sole-Source Lighting

P. Palsha[1], M. van Iersel[1](*in memoriam*), R. Ferrarezi[1].

[1] Department of Horticulture, University of Georgia, Athens, GA, USA
*plpalsha@uga.edu

Abstract

The electricity costs to provide lighting in controlled environment agriculture (CEA) can cost growers anywhere from 10 to 50% of their entire operating costs. Efficient use of light is critical for profitable crop production. Crop growth is strongly affected by the amount of light captured by the canopy and light use efficiency (LUE). To increase the amount of light captured by the plants, rapid leaf expansion is crucial. Increased leaf expansion coupled with optimum PPFD rates from supplemental lighting can maximize biomass production. Increased leaf area can increase the amount of light captured by the canopy thus increasing the overall crop growth which shortens the production period important in decreasing electricity costs in CEA. The effect of different photosynthetic photon flux densities (PPFD) on lettuce growth, morphology, light capture, and light use efficiency is not well understood. The objective of this study was to document the physiological and morphological effects of lettuce grown hydroponically at different photosynthetic photon flux densities under sole-source lighting in controlled environments. Using chlorophyll fluorescence imaging (CFI) to calculate projected canopy size throughout the growing cycle, we are able to calculate total incident light. The goal of this experiment was to identify the optimal photosynthetic photon flux densities to achieve maximum crop growth in lettuce, thus decreasing electricity costs in greenhouse environments. We predicted that by increasing photosynthetic photon flux density, growth will increase due to increased incident light, despite a decrease in light use efficiency (LUE). Our findings show that plant morphology under low photosynthetic photon flux density will change to increase light capture by increasing SLA and projected canopy size. Ultimately, LUE was not an important factor in determining growth. Growth and total incident light are strongly and positively correlated.

Keywords: Projected Canopy Size, Total Incident Light, LUE