Photosynthetic Capacity of *Illicium parviflorum* and *I. floridanum* Exposed to High Irradiance

Jason J. Griffin[1] and Thomas G. Ranney[2]
[1]John C. Pair Horticultural Center, Kansas State University
1901 E. 95th Street South, Wichita, KS 67233
[2]Mountain Horticultural Crops Research and Extension Center
North Carolina State University
455 Research Drive, Fletcher, NC 28732

Index Words: A/Ci Curve, Light Response Curve, Environmental Stress, Photoinhibition, Photosynthesis

Nature of Work: Excessive irradiance can be detrimental to many landscape plants. In particular, those that are not well adapted or have not been properly acclimated to high-light can be especially sensitive. Plants that are adapted to high-light typically have a greater light-saturated photosynthetic capacity (A_{max}) and increased capacity to dissipate excess absorbed light energy, potentially limiting the formation of reactive oxygen species (1,3). A high A_{max} enables a large percent of absorbed energy to be used in photosynthesis, reduces the need for alternative dissipating mechanisms, and minimizes the risk of photodamage (4). However, when acclimated to high but not excessive light intensities, most plants can up-regulate their protective mechanisms, as well as their A_{max}. The extent of this acclimation can mean the difference between survival and death of the plant.

Many taxa of *Illicium* L. experience some level of photoinhibition when grown in full sunlight (2). *Illicium floridanum* Ellis. was one taxa where assimilation and dark-adapted maximum quantum efficiency (Fv/Fm) were severely inhibited by high-light growing conditions. Another species, *I. parviflorum* Michx. ex Vent, and the cultivar *I. parviflorum* 'Forest Green', however, experienced no decrease in assimilation or Fv/Fm, suggesting no photoinhibition had occurred. These two species are both native to the southeastern US, and are becoming popular landscape plants. However, data suggests they are not interchangeable with regard to exposure in the landscape. The purpose of this study was to examine the physiological response of photosynthesis in these two species when exposed to full sunlight.

Plants were grown as described previously (2) and placed in either sun or shade until new leaves had acclimated to the growing environment. Light response curves were generated on a block-by-block basis for each plant using a CIRAS-1 (PP Systems, Haverhill, MA) infrared gas analyzer. A recently matured leaf was placed in a dark cuvette at 30 °C (86 °F) with 350 µL•L^{-1} CO_2 and given 15 min to stabilize. Dark respiration was then recorded and the irradiance was increased to 2000 µmol•m^{-2}•s^{-1} PAR in nine increments (50, 100, 150, 200, 500, 800, 1000, 1500, and 2000 µmol•m^{-2}•s^{-1}). Assimilation was recorded at each light level following a 10 min acclimation period. The following day, A/Ci curves were generated on the same plants. A different recently matured leaf was placed in the cuvette at a temperature of 30 °C (86 °F), 1000 µmol•m^{-2}•sec^{-1} PAR, and 370 µL•L^{-1} CO_2. The air within the cuvette was maintained at approximately 70% relative humidity to guard against stomatal heterogeneity. Following a 15 min acclimation period, assimilation was recorded and the CO_2 concentration was reduced to 50 µL•L^{-1} where another reading was taken. A gradual increase in ambient CO_2 to a final concentration of 2000 µL•L^{-1} in 10 increments occurred with a reading taken at each increment following a 10 min acclimation period.

The experimental design was a randomized complete block with a split-split-plot arrangement of treatments. Two light regimes (100% and 50% incident irradiance) represented whole plots, species the first split-plot, and irradiance or CO_2 concentration the final split-plot. The treatments were replicated six times. Data were analyzed using ANOVA and models were fit with PROC NLIN in SAS.

Results and Discussion: The light response curves revealed no statistical difference in photosynthesis between plants grown in full sun or under shade, so only the main effect of species were presented. The data clearly revealed a fundamental difference between these two species (Fig. 1). *Illicium parviflorum* was able to dissipate a greater portion of energy from incident irradiance through carbon fixation than *I. floridanum*. Calculated A_{max} of *I. parviflorum* and *I. floridanum* was 23 and 7 µmol CO_2•m^{-2}•s^{-1}, respectively. Surprisingly, no differences between the two species were detected for quantum efficiency, light compensation point, or the rate of respiration. However, the estimated light saturation point was nearly six fold greater for *I. parviflorum* than *I. floridanum* (1170 and 200 µmol•m^{-2}•s^{-1} PAR, respectively). The data suggest that when grown under high-irradiance or partial shade, *I. parviflorum* is able to dissipate a greater portion of energy into carbon assimilation if exposed to high-light.

The data from the A/Ci curves suggests that the difference in A_{max} between the two species may not be a simple affect of stomatal aperture. Saturating internal CO_2 concentrations (Fig. 2) were achieved in both species and *I. parviflorum* had a calculated potential photosynthetic capacity (PPC) of 56 µmol•m^{-2}•s^{-1} compared to 24 µmol•m^{-2}•s^{-1} for *I. floridanum*. Although the relative difference between the PPC of these two species is not as great as the light response data, it still suggests that *I. parviflorum* is simply capable of fixing more CO_2 given the same internal CO_2 concentration.

Significance to Industry: This study indicated that these two species of *Illicium*, vary considerably in their capacity to utilize high-light intensities for photosynthesis. *I. floridanum* did not have a high photosynthetic capacity and was therefore unable to dissipate light energy through photosynthesis to the extent that *I. parviflorum* could. In a nursery or landscape situation, these two species cannot be treated equally. Only *I. parviflorum* can be successfully grown in full sun, whereas both species can be grown in shade.

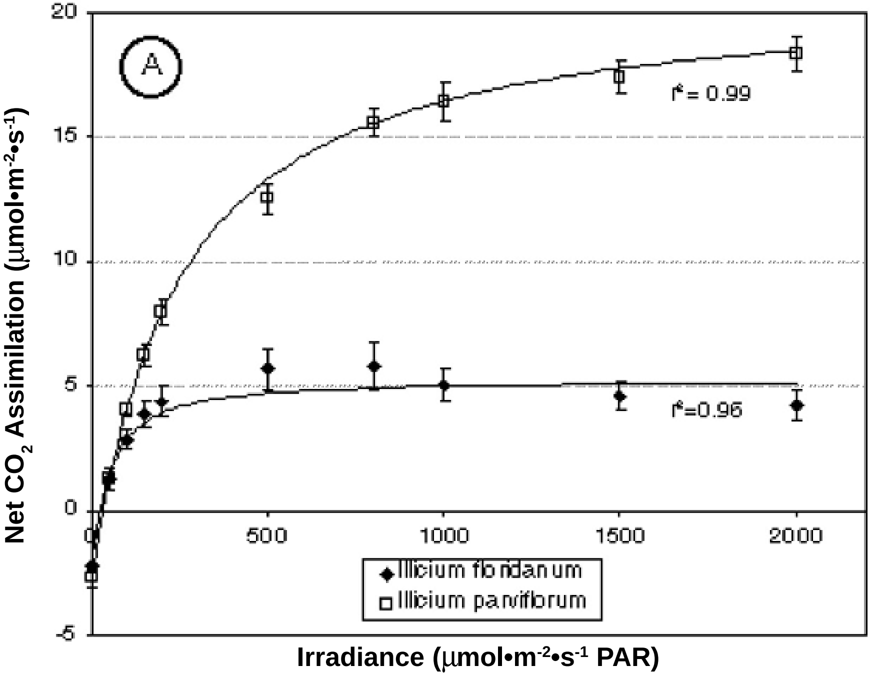
Literature Cited

1. Demmig-Adams, B., W. W. Adams, and S. C. Grace. 1997. Physiology of light tolerance in plants. Hort. Rev. 18:215-246.

2. Griffin, J.J. and T.G. Ranney. 2001. Comparative light tolerance among taxa of *Illicium*. Proc. South. Nurs. Assn. Res. Conf. 46:525-527.

3. Lambers, H., F. S. Chapin III, and T. L. Pons. 1998. Plant physiological ecology. Springer-Verlag New York Inc. NY.

4. Niyogi, K. K. 1999. Photoprotection revisited: genetic and molecular approaches. Annu. Rev. Plant Physiol. Plant Mol. Biol. 50:333-359.



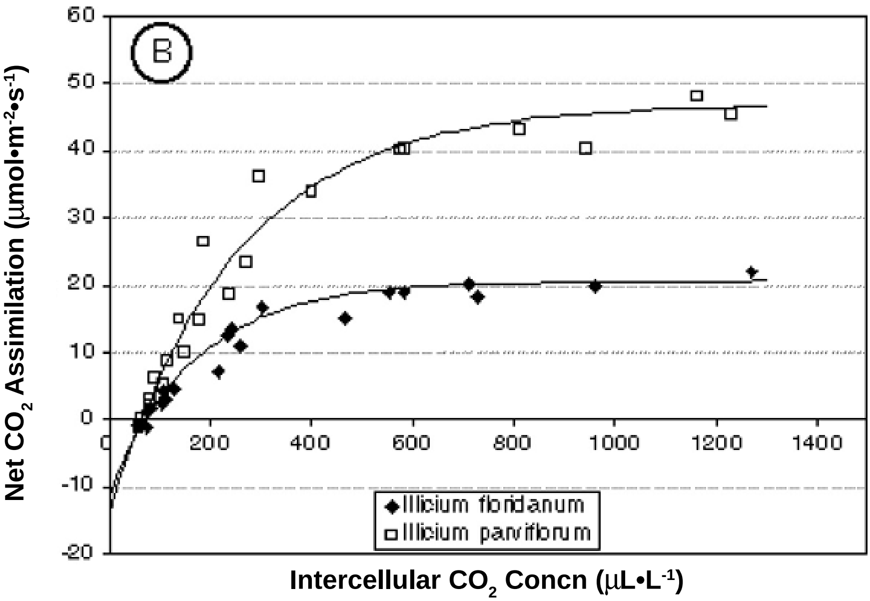


Fig. 1. Effect of increasing irradiance (A), and CO_2 concentration (B), on photosynthesis in species of *Illicium*. Growth irradiance did not significantly affect the response within a species, therefore sun and shade measurements for a species were averaged. Error bars in A are ±1 standard error of the mean for all observation at that irradiance; n = 12.