Electronic Supplementary Information

CHAMBER CONSTRUCTION

Chamber components

Custom-built chambers were assembled to determine light response curves on bermudagrass turfgrass grown under field conditions (Figure 1). One chamber was built for each plot utilized in this study for a total of four chambers.

The open system used a 10.2-cm, thin wall, PVC T-coupling as the chamber (Fig. 1A). The top of the PVC chamber was sealed with Lexan clear polycarbonate glass (SABIC Innovative Plastics; Pittsfield, MA) that was cut to fit flush inside the chamber and sealed with Lexal clear caulk (Sashco; Brighton, CO).

The LED light source was mounted on an aluminum heatsink with a 12V, 100W (92 mm×30 mm) cooling fan to dissipate heat from the LEDs (Fig. 1B). The LED light source was fixed above this glass (Fig. 1A) to cast the light directly onto the grass surface. For the pilot study the controlled light source was a 70W 'warm white' (2700-3500k) LED High Power Chip (EPILEDS; Tainan, Taiwan) that was capable of reaching up to 1100 μmol m^{-2} s^{-1}. For the full sun and shaded study, a 100W 'warm white' (2700-3500k) LED that produced over 2000 μmol m^{-2} s^{-1} was used to reach a "full sun" irradiance. The color 'warm white' was chosen based on previous research since it has a primary peak at 578 nm and a secondary peak at 444 nm with 98.5% of its total photon flux falling between 400-700 nm where most plant growth occurs[42].

Electronics (power)

Cooling fans were powered individually using a separate circuit connected to a 12V Deep Cycle Marine battery (O'Reilly Auto Parts; Springfield, MO). A parallel electrical circuit was created to give individual control of the LEDs for each of the chambers during the experiment.

The LED light was powered by a 0-60 volts (V)/0-10 amp (A) switch mode bench power supply (CircuitSpecialists; Tempe, AZ). This system was manipulated using a 6-90 VDC, 15 A, pulse width modulator (PWM) board which allowed the diodes to be controlled using a pulse-width-modulated DC voltage with a duty cycle fully adjustable from 0-100%. Using both the PWM board and the switch-mode bench power supply together gave the ability to easily change the light intensity of the LEDs by controlling the amperage sent to the light source (Fig. 1C).

Corresponding voltage and current were recorded with a multimeter (Southwire, Digital 600-Volt Manual Ranging Multimeter; Carrolton, GA) through an electrical short designed in the series that used two wire connectors (Dual Banana Plug Gold Plated Screw Type Audio Speaker Wire Cable Connectors; L-com, North Andover, MA). As the LED was used it became less efficient and thus dimmer over the course of the growing season. Therefore, the light intensity was consistently controlled by the amperage sent to the diode from the power supply and the photosynthetic photon flux density (PPFD) was measured at each gas exchange measurement to correlate with the output.

For the pilot study the current increments were 0, 0.05, 0.1, 0.2, 0.3, 0.5, 0.7, and 1.0 Amps which resulted in PPFDs ranging from 0 to 1100 μmol m^{-2} s^{-1}. Care was taken not to increase the current higher than this level because these LEDs can only operate at a maximum of 70W before the diode overheats. By the end of the first year we found that the 70W LED's were not allowing us to reach a full sun irradiance, so we decided to start using a 100W LED that was capable of producing 2000 μmol m^{-2} s^{-1}. Not only were we able to reach our goal, it also extended the life of the diode since we could operate it at lower wattages. The full sun and shaded study light level increments were 0, 0.02, 0.04, 0.1, 0.2, 0.5, 0.8, and 1.2 A which resulted in PPFDs ranging from 0 to 2000 μmol m^{-2} s^{-1}. The chamber was connected to the PWM board via 91.4 m of 18-gauge cable power wire to allow the use on distant plots in the field during the experiment.

Connecting the sensor and operating the chamber

Assimilation rates of CO_2 were measured using an infrared gas analyzer (LI-6400, LI-COR Biosciences; Lincoln, NE) attached to the custom chamber described above. The flow rate was set to 700 μmol s^{-1}, the CO_2 reference mixer was set to 400 μmol, and the area was set to 81 cm^2 (the turf surface area covered by each chamber). Light intensities inside of the chambers were measured at each increment in PAR using a light meter (Extech, LT45 Color LED Light Meter; Wilmington, NC) in which the sensor was fixed to a 10.2 cm PVC cap that fit onto the chamber and would read light at equal distances from the LED. Also fixed the PVC cap was a thermometer (Extech, EA10 EasyView Dual Input Thermometer; Woburn, MA) to read internal temperature of the chamber. After each light intensity increase, the turfgrass was allowed a 15 to 20-minute acclimation period before CO_2 assimilation rates were measured and recorded as net photosynthesis. Due to chamber size, an additional five minutes was also required for sample CO_2 exchange rates to reach a steady state. The gas exchange rates were graphed with the corresponding PAR reading to create a light response curve. The initial slope of this curve was recorded as quantum yield of CO_2 assimilation (ϕCO_2). Assimilation rates were recorded at 0

μmol m^{-2} s^{-1} to obtain the dark respiration rate (R_d) rate.

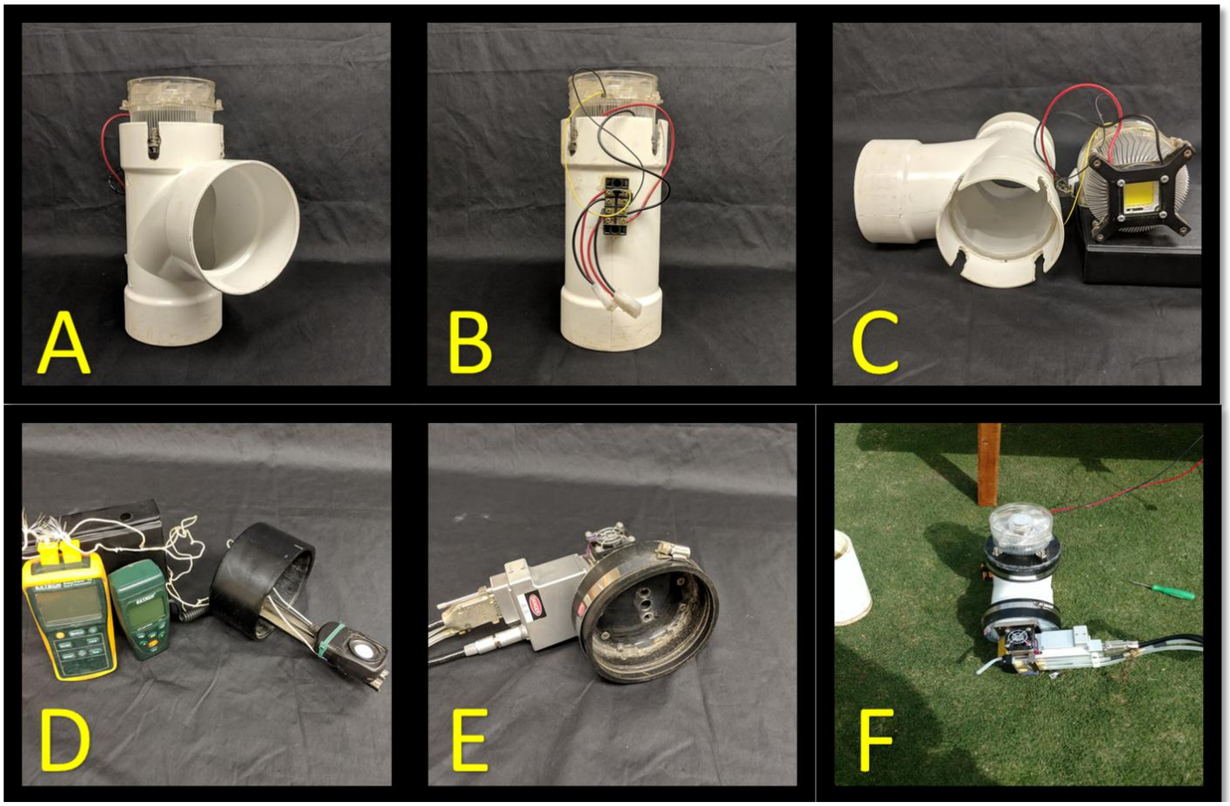

Figure 1. (A) The custom chamber constructed from a 10-cm PVC, T-coupling, (B) the plexi-glass installed at the top of the chamber to create a seal and the 70W LED light fixed to the heat-sink cooling fan, (C) the terminal block fixed to the back of the chamber to connect power the LED light source and heat-sink cooling fan, (D) Extech light meter and Extech EA 10 thermometer with light sensor and probes modified to fit inside of the chamber, (E) modified sensor head of LICOR 6400 customized to fit and seal over T-coupling, (F) simulation of chamber when in use.