Measurement of Photosynthesis and Respiration in Turfgrass with Large and Small Surface Chambers

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Introduction

Field measurements of photosynthesis in turfgrass are often conducted with surface chambers that cover a small area of the canopy (Fig. 1). Measurements may not be representative of overall photosynthesis where spatial variability is high (e.g., in green leaf area index, soil moisture). Furthermore, measurements with many portable photosynthesis systems may take up to four minutes, during which time the conditions that affect photosynthesis (e.g., air temperature) may change significantly inside the chamber. We fabricated a large turfgrass chamber (Fig. 2) similar to the design of Murphy (2007) that measured photosynthesis more quickly than a typical small chamber used in turfgrass; the chamber covered 34-times greater surface area than the smaller chamber. The benefits of these larger chambers potentially include: 1) measurements that cover greater surface areas and thus, may reduce variability in photosynthesis measurements; and 2) faster measurements of photosynthesis, which may reduce undesirable temperature effects that may develop when chambers cover plots for longer measurement periods.

Objectives

- Fabricate a large surface chamber for measuring canopy-level CO_2 fluxes in turfgrass (Figs. 3 and 4)
- Compare measurements of photosynthesis and respiration among the new surface chamber, the large chamber of Murphy (2007), both closed-flow systems, and a smaller surface chamber attached to a Licor 6400, which uses an open-flow system
- Measure and compare net photosynthesis, respiration, and estimate gross photosynthesis in two cool-season turfgrasses with the three chambers

Figure 1. Small custom surface chamber attached to a portable photosynthesis system (Licor 6400). Chamber covers a surface area of 7.09 x 10^{-3} m^2.

Figure 2. Large chambers cover surface areas of 7.23 x 10^{-1} m^2 (large chamber at left, Murphy, 2007), and 2.4 x 10^{-1} m^2 (mid-sized chamber at right). Small chamber with Licor 6400 is in center.

Theory of Operation

The instantaneous gross photosynthesis (Pg) can be calculated as:

- Pg = Pnet + (Rc+Rs)

Where Pnet (net photosynthesis) is measured with sunlit chambers, Pnet = Pg – (Rc + Rs)

The sum of Rc (canopy respiration) and Rs (soil respiration) is measured with shaded chambers

The small chamber, which is an open-flow design, is partially pressurized and therefore blocks a portion of Rs from entering the chamber (Bremer and Ham, 2005)

The pressure inside the two large chambers is approximately equal to ambient atmospheric pressure and therefore, chamber measurements include all soil respiration

Calculations of Pg cancel influence of Rc and Rs on photosynthesis measurements and thus, also remove any bias of pressurization in the chamber on gross estimates of photosynthesis

Materials and Methods

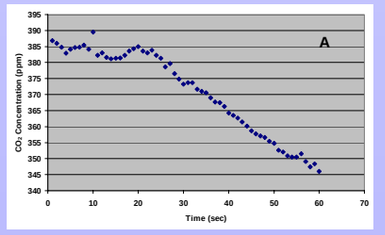
- Chamber sides constructed with clear Plexiglass; top covered with heat-stretched Propafilm-C
- Chamber measurements were collected from tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) at the Rocky Ford Turfgrass Research Center, Manhattan, Kansas
- Fluxes of CO_2 were measured with all three chambers on October 24, 2007
- Measurements were collected with each chamber simultaneously under full sunlight and shaded conditions, respectively
- Large chamber measurements were replicated four times each in tall fescue and Kentucky bluegrass
- Measurements were collected from the exact same locations with both large chambers
- Measurements with the small chamber were collected at 3 locations within the footprint of the large chambers, for a total of 12 times in each turfgrass species
- An infrared thermometer mounted inside the chamber allowed for estimates of canopy conductance

Figure 3. Large chamber fabricated to measure CO_2 fluxes in turfgrass. The system was connected to and controlled by a datalogger in the red cooler.

Figure 4. The chamber console included a closed-path infrared gas analyzer (Licor 840) and a pressure differential transducer.

Results

- Net photosynthesis rates were calculated with data from sunlit chambers between approximately 25 to 45 sec during measurements (Fig. 5A), according to models that best fit the data (linear or quadratic)
- Respiration (canopy + soil) rates were calculated with data from shaded chambers, between approximately 30 to 55 sec (Fig. 5B), according to models that best fit the data (linear or quadratic)
- Respiration was generally lower when measured with the small chamber than with the larger chambers, probably because the small, partially pressurized chamber blocked some Rs during measurements (Fig. 6)
- Canopy conductance was 1.41 cm s^{-1} in tall fescue and 1.23 cm s^{-1} in Kentucky bluegrass
- Air temperature inside the midsized chamber increased from about 0.94 to 1.26 °C during measurements compared with increases of 1.03 to 1.48°C in the smaller chamber; increases were generally similar among chambers (data not shown)
- Estimates of Pg among chambers were 6-18% greater in Kentucky bluegrass than tall fescue (Fig. 6)



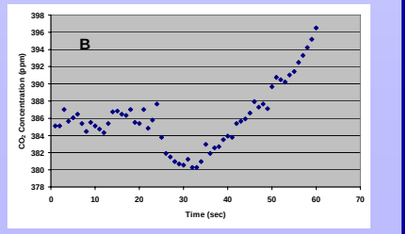


Figure 5. Changes in CO_2 concentration during the 60 sec of flux measurements in the sunlit (A) and shaded (B) mid-sized chamber in Kentucky bluegrass.

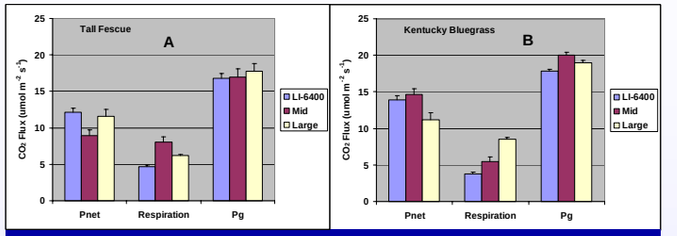


Figure 6. Estimates of net photosynthesis (Pnet), respiration (canopy and soil), and gross photosynthesis (Pg) in tall fescue (A) and in Kentucky bluegrass (B).

Summary

- Equilibrium rates of CO_2 decrease (sunlit chambers) and increase (shaded chambers) were reached rapidly, so that measurements of photosynthesis and respiration required only about 30 to 40 sec after the system was placed on the plot (Fig. 5)
- There was excellent agreement among the three chambers (±12%) in the determination of Pg despite measured differences in Pnet and Respiration. This suggests that errors caused by a chamber's impact on soil respiration tended to cancel when Pg was calculated
- In plot studies of turfgrass, evaluating treatment effects on Pg (using a combination of sunlit and shaded measurements) may have a distinct advantage over isolated measurements of Pnet or Respiration

Literature Cited

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