Measurement and Partitioning of *in situ* Carbon Fluxes in Turfgrasses

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Introduction:

Field measurements of photosynthesis and respiration are often conducted with surface chambers that cover a small area of the turf's canopy. Consequently, measurements include the various components of ecosystem carbon (C) balance, including photosynthesis, canopy respiration and soil respiration. When used for measuring carbon flux, steady-state portable photosynthesis systems (i.e., Licor 6400) are pressurized. Small changes in pressurization are known to partially suppress soil respiration. Thus, chamber measurements of CO_2 flux from turf may be more related to unintended changes in soil respiration than to changes in photosynthesis. We propose that the chamber can be intentionally pressurized to almost completely suppress soil respiration and obtain independent measurements of gross canopy photosynthesis and canopy respiration.

Objectives:

1. Fabricate and test a chamber connected to a portable photosynthesis system where chamber pressure could be manipulated (Fig 1).
2. Apply increasing pressure until soil respiration was prevented from entering the chamber. The result would be a more accurate indicator of treatment effects on photosynthesis and canopy respiration.
3. Attempt to partition various components in the turf C budget, including net and gross photosynthesis and canopy respiration, in perennial ryegrass, tall fescue, and Kentucky bluegrass.

Theory:

The instantaneous C budget (CO_2 fluxes) in turfgrass can be represented by:

$$NEE = P_g - R_c - R_s$$

where *NEE* is net ecosystem exchange of CO_2, P_g is gross photosynthesis, R_c is canopy respiration, and R_s is soil respiration.

If R_s could be completely suppressed with pressure, then sunlit and shaded measurements on the same area would yield (P_g-R_c) and R_c, respectively. The difference between the two readings would be P_g. However, field testing showed that although R_s could be radically reduced with intentional over pressurization, it could not be completely eliminated. Thus, an alternative procedure was developed that accounted for this small soil flux.

Materials and Methods

- Licor 6400 with modified custom chamber (Fig. 1).
- Measurements collected at Rocky Ford Turfgrass Research Center, Manhattan, KS.
- Soil type: silt loam
- Gravimetric soil water content collected from 0-10 cm.
- Chamber measurements of CO_2 flux were collected from intact turf canopies under full sunlight, shaded (eliminated photosynthesis), and after turf was clipped at ground level (eliminated R_c).

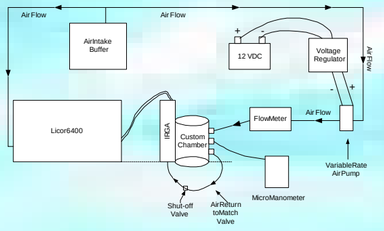

Figure 1. Conceptual diagram (top) and photo (bottom) that illustrate the design of a pressurized chamber system. A variable flow air pump and manometer were used to regulate chamber pressure. A mass flow meter was used to monitor the air flow into the chamber, and results were used to correct fluxes for the effect of dilution.

Results:

Preliminary measurements indicated that:

1. Neutral pressure chamber measurements were extremely difficult to obtain in an open-path system because changes in pressure of ±0.5 Pa were often uncontrollable and caused large differences in R_s (Fig. 2); hence, measurements of *NEE* were not measured in this study.

2. Chamber pressurization prevented most but not all R_s from entering the chamber (Fig. 3). This problem was circumvented by measuring CO_2 flux from a clipped, shaded area near the plots under investigation. This provided an estimate of R_s', the soil flux when the chamber was under pressure.

The following three measurements from fully pressurized chambers provided estimates of the given components of the C budget:

1. Sunlit chamber: P_g-R_c-R_s'
2. Shaded chamber: R_c-R_s'
3. Turf canopy clipped at ground level: R_s'

Therefore, estimates of net photosynthesis (P_{net}), P_g, and R_c could be calculated from the above measurements:

1. P_g = Sunlit chamber – shaded chamber
2. P_{net} = Sunlit chamber – clipped canopy*
3. R_c = Shaded chamber – clipped canopy*

*Measurements collected immediately after turfgrass canopy was clipped.

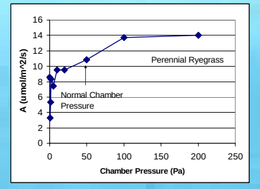

Figure 2. Apparent response of carbon assimilation (A) to changes in chamber pressure (sunlit). The increase in CO_2 "assimilation" with chamber pressure was actually caused by reductions in R_s entering the chamber.

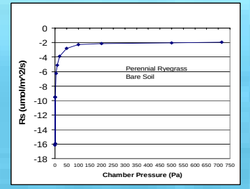

Figure 3. Response of soil respiration (R_s) entering the chamber to changes in chamber pressure (bare soil). Of the total R_s of 16 umol m^{-2} s^{-1}, all but 1.92 umol m^{-2} s^{-1} was excluded by high pressures.

Results (continued):

- Measurements of CO_2 fluxes increased by 6 to 23% when the chamber was pressurized compared to normal chamber operation (Fig. 4).
  - ✓Increase was result of higher pressure restricting R_s from chamber measurements.
- Estimates of P_g, P_{net}, and R_c provided more meaningful quantifications of C fluxes because these components are directly linked to the biophysics of the turf canopy, as opposed to normal operation of the chamber, where the partitioning of C fluxes among P_g, P_{net}, and R_c, is uncertain (Fig. 5).
- Measurements of C fluxes at the beginning and end of a one-week drydown showed a 19 and 11% reduction in P_g, a 21 and 16% reduction in P_{net}, and an 11% reduction and 10% increase in R_c in perennial ryegrass and tall fescue, respectively (Fig. 5).
  - ✓Comparatively, measurements with the unmodified chamber showed a 26 and 21% reduction in C fluxes in perennial ryegrass and tall fescue, respectively.

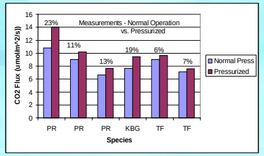

Figure 4. Comparison between measured C fluxes with normal chamber operation (unmodified) and with pressurized chamber (modified) in perennial ryegrass (PR), Kentucky bluegrass (KBG), and tall fescue (TF). PR and TF were measured on multiple dates.

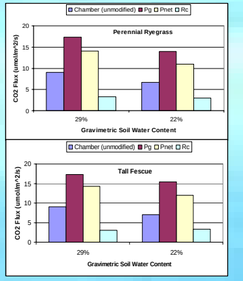

Figure 5. Carbon fluxes measured with normal (unmodified) and modified chamber on perennial ryegrass and tall fescue during a one-week drydown. Variables P_g, P_{net}, and R_c were partitioned by using modified chamber on sunlit, shaded, and clipped turfgrass.

Conclusions:

1. Measuring CO_2 fluxes from turf using an open-chamber system that does not account for pressure yields meaningless results that do not represent NEE or P_g-R_c.
2. C fluxes can be partitioned among P_g, P_{net}, and R_c using a modified, pressurized chamber consecutively on sunlit, shaded, and clipped turfgrass.
3. Partitioning of C fluxes provided more sensitive and meaningful comparisons between treatments than measurements with the unmodified chamber because of the direct relationship of P_g, P_{net}, and R_c to the biophysics of the turfgrass canopy.

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