

Researching Golf's Carbon Footprint

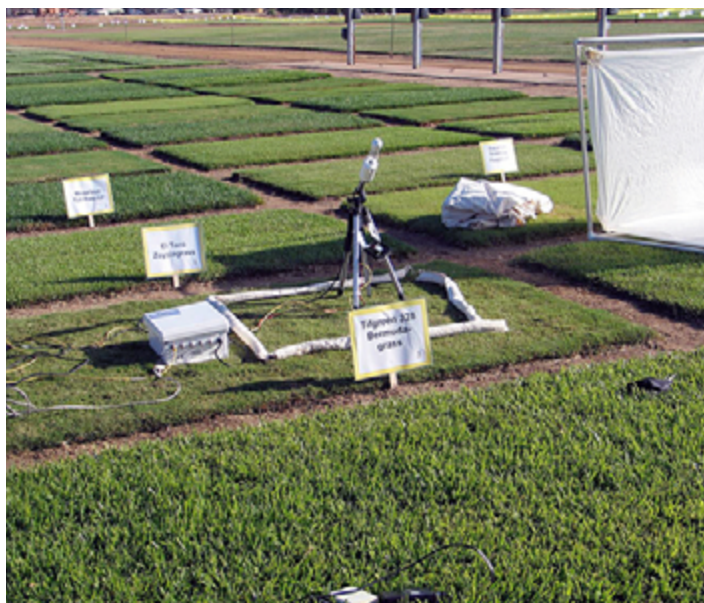
Studies at UC Riverside investigate different turfgrasses used on golf course and their ability to sequester carbon.

BY JAMES H. BAIRD

Scientific research and public debate have brought heightened awareness about global climate change. At the forefront of discussions is carbon dioxide (CO₂), a greenhouse gas with atmospheric concentration on a dramatic rise since the Industrial Revolution. While more than 85% of all energy used in the United States comes from fossil fuels (coal, oil, natural gas, of which CO₂ is a by-product), it's likely that political and environmental influences will shift movement toward energy savings and green energy options. Until that time comes, how can the golf industry better manage CO₂ emissions? One popular strategy being proposed is to increase carbon (C) storage in plant systems, otherwise known as "terrestrial C sequestration." If large amounts of CO₂ are captured from the atmosphere by photosynthesis and then held in stable plant material or soil organic matter, it could help offset CO₂ generated by fossil fuel use.



Carbon comprises nearly 58% of soil organic matter, thus most C is sequestered in this region. Organic matter and soil C can affect turf in several other positive ways, including resiliency and wear tolerance, soil structure and porosity, nutrient and water holding capacities, and binding and degradation of chemicals. However, as your USGA agronomist would be quick to point out, too much thatch can create a spongy, impervious surface that is prone to scalping and poor playability.



Carbon and water fluxes in turfgrass plots are measured using an infrared analyzer, opaque chamber to measure photosynthesis, and cover to measure respiration in absence of light. Measurements were taken near solar noon every two weeks throughout the year.



Dr. Darrel Jenerette, UCR Plant Ecologist, demonstrates a whole ecosystem monitoring sensor system (Eddy Covariance tower) in a large tall fescue turf plot at the UCR Turfgrass Research Facility. The instrument measures several environmental parameters, including real-time water and C fluxes at half-hourly intervals. This sensor system is a next-generation weather station-type system and we are currently examining applications of this technology for uses in locations with turf.

TURFGRASS CARBON FOOTPRINT

Given that turfgrasses comprise more than 40 million acres in the U.S. and represent the largest irrigated agricultural crop, it's no wonder they are the subject of mounting investigations about net import or export of carbon. On one side of the equation we need to consider and predict with greater accuracy C outputs from management of turf facilities, including plant respiration, fuel expenses in maintaining turfgrass, fertilizer and pesticide use, energy for pumping water to irrigate, and the fluxes of other greenhouse gases (mainly N₂O and CH₄) in addition to soil C sequestration.

On the other side, turfgrasses are perennial crops with dense root production and are managed without significant disturbance of the soil, ideal traits for C sequestration. Qian and Follett (2002) conducted an initial study to assess soil C sequestration in golf course fairways and putting greens using historic soil testing data in Colorado and Wyoming. They found that a rapid soil organic carbon (SOC) accumulation occurred during the first 25 years after turfgrass establishment, with average rates approaching 1.0 Mg C ha⁻¹ yr⁻¹ (0.45 ton C A⁻¹yr⁻¹). These rates are comparable to those reported for Conservation Reserve Program (CRP) land and grassland prairies. In

general, C sequestration increases under well-irrigated (Qian et al., 2010) and well-fertilized (Qian and Follett, 2002; Lopez-Bellido et al., 2010) conditions, and when clippings are returned (Qian et al., 2003). Overall, soil C sequestration and organic C decomposition rates are different for different turfgrasses and different management regimes, thus further research is warranted.

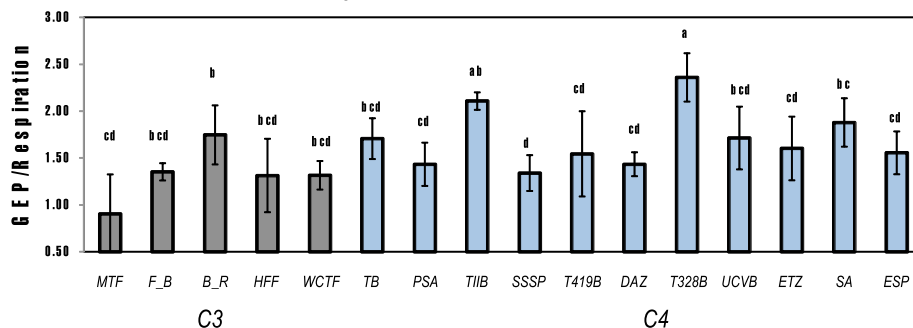
RESEARCH AT THE UNIVERSITY OF CALIFORNIA, RIVERSIDE (UCR)

At UCR, ongoing research is aimed at studying the C and water dynamics of the major warm- and cool-season

turfgrass species and cultivars. A LI-COR 7500 (Lincoln, Nebr.) open path infrared CO₂ and water analyzer attached to a tripod is placed on each turfgrass plot. A transparent chamber is used to cover the instrument during gas exchange measurements. A small fan attached to the tripod helps mix the air within the chamber. For each turfgrass plot, two measurements are taken. The first is net ecosystem exchange (NEE), which is gas exchange during photosynthesis and respiration in sunlight. After the measurement is taken, the chamber is removed and vented. The second measurement is ecosystem respiration. The chamber is placed back over the tripod and covered by a shade cloth that prevents light from penetrating the chamber. Measurements of NEE and respiration per plot determine gross ecosystem productivity (GEP) or how much carbon dioxide is being exchanged between the plant and the atmosphere per unit area and time. Data are logged on a computer using the LI-COR software. Additional measurements taken are turf canopy temperature, soil temperature, and soil water content. Water use efficiency (WUE), or the amount of CO₂ taken up by a plant (GEP) per unit of water lost, is also determined for each plot using the LI-COR instrument. A turf with high WUE takes up more CO₂ while transpiring less water, which may increase its ability to withstand deficit irrigation or drought.

From March 2009 to March 2010, biweekly measurements were taken on 16 turfgrass species and cultivars established from sod or plugs in 2008 and maintained under non-limiting irrigation and fertility in replicated plots at the UCR Turfgrass Research Facility. Tifgreen 328 and Tifway II exhibited among the highest C fixation potentials or GEP of the warm-season species, while a Kentucky bluegrass and perennial ryegrass mixture was highest of the cool-season species (Figure 1). In terms of WUE, the warm-season species generally were superior compared to the cool-season species, as was expected due to their differences in physiology and anatomy, which contribute to superior drought and heat

Figure 1. Carbon Fixation Potential



MTF = Medallion Tall Fescue

F_B = Elite Plus Tall Fescue/Ky Bluegrass

B_R = Bayside Blend (80% KB/20% PR)

HFF = Hillside Fine Fescue

WCTF = West Coaster Tall Fescue

TB = TifSport Bermudagrass

PSA = Palmetto St. Augustinegrass

TIIB = Tifway II Bermudagrass

SSSP = Sea Spray Seashore Paspalum

T419B = Tifway 419 Bermudagrass

DAZ = De Anza Zoysiagrass

T328B = Tifgreen 328 Bermudagrass

UCVB = UC Verde Buffalograss

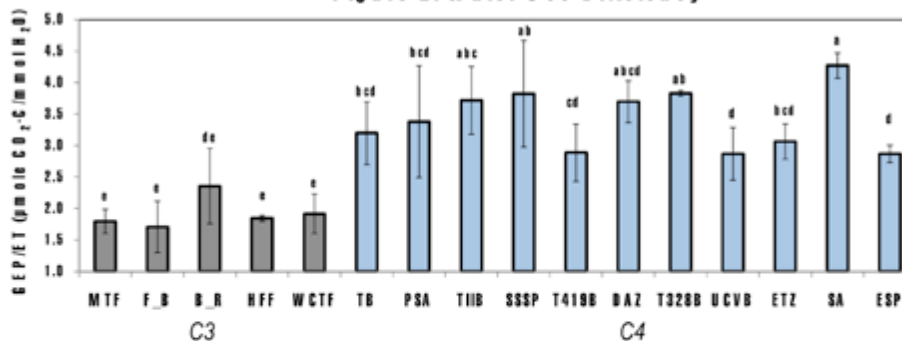
ETZ = El Toro Zoysiagrass

SA = Common St. Augustinegrass

ESP = Excalibre Seashore Paspalum

Average C fixation potential of 16 cool- (blue bars) and warm-season (grey bars) turfgrasses from March 2009 to 2010. Riverside, Calif.

Figure 2. Water Use Efficiency



MTF = Medallion Tall Fescue

F_B = Elite Plus Tall Fescue/Ky Bluegrass

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Mean water use efficiency of 16 cool- (blue bars) and warm-season (grey bars) turfgrasses from March 2009 to 2010. Riverside, Calif.

tolerance (Figure 2). Interestingly, these data further demonstrated that drought tolerance does not necessarily equate to greater WUE or the ability to sequester more C, as evidenced by tall fescue and buffalograss, two species with exceptional drought tolerance or avoidance among the cool- and warm-season turfgrasses, respectively.

Thanks in part to a research grant from the USGA, we began a new phase of research in May 2011 to determine C sequestration potential and WUE of the same species and cultivars, including new additions such as Whittet Kikuyugrass, A-4 creeping bentgrass, Tifdwarf bermudagrass, and a blend of perennial ryegrasses

TEN WAYS TO SAVE ENERGY AND IMPROVE THE CARBON FOOTPRINT ON YOUR GOLF COURSE

From Andrew J. Staples, President, The Golf Resource Group, Inc.).

1. Increase irrigation pump efficiency.
2. Maximize efficiency of irrigation central control (e.g., reduce flow rates).
3. Take irrigation pumps off-line during certain times of year.
4. Manage and adjust the times when electric golf carts are being charged to take advantage of off-peak energy rates.
5. Reduce water use and energy on turf and landscape plants.
6. Become efficient in using low-cost energy-saving devices first before exploring more expensive renewable energy options.
7. Vanpool or "cart pool" employees at the facility, where practical.
8. Maximize efficiency of maintained areas on the golf course.
9. Use technology such as soil water sensors and weather data to monitor turfgrass and landscape irrigation needs.
10. Turn off equipment when not in use.

under deficit irrigation. Baseline measurements of gas exchange and soil properties will be taken under non-limiting irrigation. The turfgrasses will then be hand-watered at a deficit fraction of irrigation replacement based on weather station ET and irrigation requirements (warm- vs. cool-season). Ultimately, our research strives to identify turfgrass species and cultivars that are best capable of sequestering C with minimal cultural inputs, namely irrigation and fertilization, and minimal evolution of other greenhouse gases

such as nitrous oxide (N₂O) and methane (CH₄).

SUMMARY

Once again, golf is assuming a leadership role in environmental stewardship. Much like the vast USGA-sponsored research has demonstrated regarding the environmental fate of chemicals and fertilizer applied to golf courses and turf in general, golf courses can be net C sinks or at least C neutral in the effort to mitigate CO₂ and other greenhouse gas emissions. That is, if we

manage both turf and energy responsibly.

LITERATURE CITED

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Although warm-season turfgrasses possess greater water use efficiency and drought- and heat-tolerance compared to cool-season grasses, winter dormancy has prevented their widespread use in warmer regions of California. Ongoing research at UCR is aimed at making warm-season grasses greener during the winter and keeping cool-season grasses greener during the summer with less water.