Carbon Footprint and Agronomy Practices to Reduce Carbon Footprint of Golf Courses

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Objectives:

1. *Evaluate fuel and electricity uses associated with golf course maintenance activities (electricity used for irrigation, fuel and energy used for mowing, spraying, and aeration, vehicle and golf cart uses); and b) fuel and electricity use associated with clubhouse operations.*
2. *Determine the carbon sequestration rates for golf course native areas, roughs, fairways, and greens by computer modeling.*
3. *Measure trace gas fluxes on golf course fairways, roughs, native areas, and putting greens.*
4. *Evaluate the impact of different types of fertilizers on trace gas fluxes.*
5. *Identify agronomic practices that will increase carbon sequestration, reduce carbon foot print, and minimize greenhouse gas emissions using calibrated and validated CENTURY and DAYCENT models as a management support system.*

Golf course industry is interested in evaluating golf course carbon budget and assessing and controlling greenhouse gas (GHG) emissions. To determine the impact of turfgrass on the GHG budget on golf courses, several components need to be considered: 1) carbon cost associated with golf course operations, such as golf cart use, mowing, fertilizing, and irrigation, 2) soil C sequestration, and 3) turf-atmosphere trace gas fluxes, especially nitrous oxide (N_2O) emission. Nitrous oxide is a trace greenhouse gas with 298 times greater global warming potential (GWP) than CO_2 on per molecular basis.

Research was initiated collaboratively by Colorado State University and the GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network) program of USDA-ARS to evaluate golf course carbon footprint. A survey was conducted to evaluate fuel, electricity, and natural gas uses associated with golf course operations in Colorado. We are in progress of analyzing survey data.

In 2012, research has been conducted to address Objectives 3 and 4. To determine N_2O flux on golf course fairways, roughs, native areas, and putting greens, we selected Harmony Golf Club in Fort Collins as the study site. The turf-atmosphere exchange of N_2O has been measured by using specialized chambers (Figure 1). Fifty-six vented chambers were built and 56 PVC anchors were installed on putting greens (creeping bentgrass), fairways (perennial ryegrass), rough (Kentucky bluegrass), and native areas (a mix of smooth bromegrass, western wheatgrass, blue grama, and bufflograss) (Figure 2). For gas sampling, the vented chambers were installed onto the PVC anchors (Figure 3). Gas samples from inside the chambers were removed with polypropylene syringes fitted with nylon stopcocks, at 0, 15, and 30 minutes after the chambers were installed. Samples were analyzed by gas chromatography within 12 hours after collection. Flux measurements were made once per week throughout the growing season and twice per month during winter. Soil sensors were installed on the study sites on the

Figure 1. The modified trace gas measurement chamber.

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Figure 2. PVC anchors were installed on a fairway with little disturbance to daily management and play.

Figure 3. For trace gas sampling, the vented chambers were installed onto the PVC anchors. Air samples were removed from each chamber.

putting green, fairway, rough, and native area to concurrently measure soil water content and soil temperature.

To evaluate the impact of different types of fertilizers on trace gas fluxes, 12 plots were used on a fairway and a rough, respectively, to accommodate 4 fertilization treatments (BCMU, UMAXX, POLYON, and a control with zero N fertilization input). Fertilizer treatments were applied 3 times per year at 50 kg N ha−1. Two trace gas flux chambers were used on each plot. Trace gas fluxes were measured as described above.

Our results to date indicate that soil water content and soil temperature play a large role in N_2O emissions. N_2O fluxes increase when field conditions exceed field capacity. N_2O fluxes Increase with increasing soil temperature. The spring fertilization resulted in the least amount of N_2O emission, likely due to the cool soil temperatures in the spring. A very high N_2O emission was observed a few days following the summer N fertilization due to environmental conditions conducive to nitrification and denitrification activities, including high soil water content and soil temperature. Our data suggest that summer N fertilizer application should be avoided in Colorado. When compared to summer fertilization, fall N fertilization in September resulted in a moderate level of N_2O emission a few days following the fertilization event, suggesting scheduling fall fertilizer application to as late as the end of October for cool−season grasses may further reduce N_2O emissions.

Analysis of variance test indicated that accumulative N_2O emission from the fairway site was significantly higher than the rough site. Accumulative N_2O emission from rough was significantly higher than N_2O emissions from the putting green and native sites. It is interesting the N_2O emission from the putting green was only about 10% of the emissions from the fairway, although the N input to the putting green was greater than the fairway.

Among the fertilizers tested, POLYON had the lowest loss of N_2O. POLYON is considered as an enhanced efficiency fertilizer that has reduced N_2O emissions.

Summary Points

- Trace gas measurement chamber was successfully modified to measure N_2O flux on golf course settings with minimal disturbance.
- Soil water content and soil temperature played a large role in N_2O emissions. N_2O flux increased when field conditions exceeded field capacity. N_2O flux increased exponentially with increasing soil temperature.
- Accumulative annual N_2O emission from the fairway site was significantly higher than the rough site. N_2O emission from the putting green and native sites was only about 10% of the emissions from fairways.
- Compared with BCMU and UMAXX fertilizers, POLYON had the lowest loss of N_2O. POLYON is considered as an enhanced efficiency fertilizer that has reduced N_2O emissions.