Examining Turfgrass Species and Management Regimes for Enhanced Carbon Sequestration

Aaron Patton, Jon Trappe, Quincy Law, and Ron Turco

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Objectives:

1. *Measure CO_2 flux for perennial ryegrass, Kentucky bluegrass, tall fescue, bermudagrass and zoysiagrass grown in West Lafayette, IN.*
2. *Contrast the net C accrual rates for tall fescue and Kentucky bluegrass cultivars with varying leaf elongation rates and mowing requirements in order to identify those with reduced mowing requirements and increased C sequestration potential.*
3. *Determine if a one-third rule mowing regime will reduce mowing requirements of golf course rough compared to scheduled weekly mowing.*
4. *Define the effects of clipping removal on soil C and N dynamics.*

To better understand the effect of turfgrass species on greenhouse gas fluxes, a total of five species (common bermudagrass, Kentucky bluegrass, perennial ryegrass, tall fescue, and zoysiagrass) were evaluated for carbon flux on a monthly basis. Each of the species were located in mature (>5 yrs) stands of turf maintained at 2.5 inches at the William H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. Three permanent anchors were established for each species for the duration of the study. Greenhouse gas flux measurements were obtained using a vented flux chamber that was 8 in. in diameter and 6 in. tall (Figure 1). The chambers were installed onto the anchors between 1100 and 1400 hrs and gas samples were collected with a syringe at 0, 15, 30, and 45 minutes after installation. Samples were collected on a monthly interval for a total of 13 sampling dates (30 May, 28 June, 25 July, 24 Aug, 26 Sep, 24 Oct 2013, 31 Mar, 26 April, 25 May, 27 June, 27 July, 28 Aug, and 26 Sep 2014). Gas samples were immediately analyzed for carbon dioxide flux using a gas chromatograph (Figure 2). Nitrous oxide and methane were also measured but this data is still being analyzed.

To understand the influence of tall fescue and Kentucky bluegrass cultivars with varying leaf elongation rates and mowing requirements on CO_2 flux, soil C and N dynamics, we used experimental areas established in April of 2011 with two species and three cultivars of each species. Cultivars were selected for this experiment based upon their growth rate in preliminary trials (data not shown) and their similar appearance and stress tolerance in previous field trials in West Lafayette, IN. A total of four mowing strategies were applied. Two separate mowing frequencies based upon 1) a standard homeowner with plots mown on the same day each week, and 2) the “one-third rule” using daily measurements to determine the appropriate mowing date based upon removing one-third of the leaf tissue. Additionally, for each of the two mowing frequencies described,

Figure 1. Sampling from the greenhouse gas flux chambers.

Figure 2. Gas chromatograph used to sample the greenhouse gases.

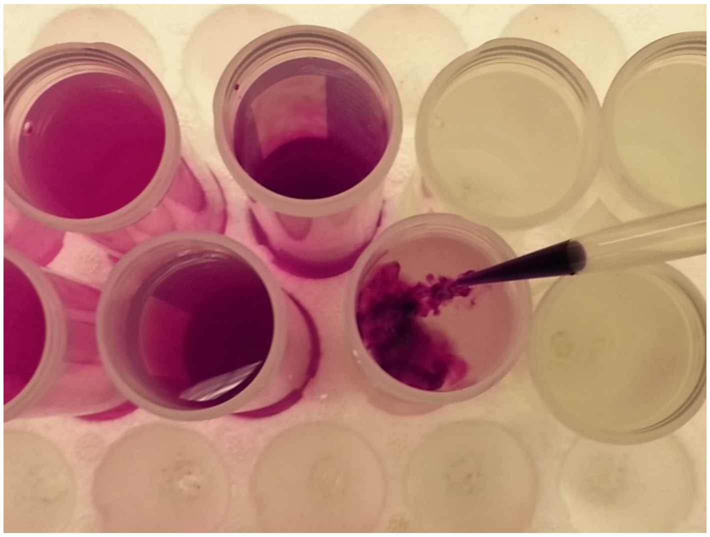

Figure 3. Laboratory measurement of labile soil carbon.

Fig. 4. Soils air drying prior to analysis.

clippings were either 1) collected with a rear collection bag attachment, or 2) mulched by the mower and returned. All plots were mown at 7 cm with a walk-behind push mower. To collect annual yield data, the grass clippings from the weekly-mown treatments with clippings removed were collected, dried, and weighed.

To better understand the effect of turfgrass species on soil C and N dynamics over time, labile soil C, total soil C, and total soil N were analyzed for soil samples collected to a 5 cm depth on 19 Nov. 2013. Permanganate oxidizable carbon describes a relatively new method developed to measure a soil carbon pool that is sensitive to management practices. It is possible to measure the amount of labile soil C by using the reaction of potassium permanganate and soil because the amount of labile C (from soil) oxidized is a function of the quantity of potassium permanganate reduced. Total soil C and N were analyzed via combustion.

Progress Update and Results:

For all results, data should be considered preliminary. Refereed journal articles will be submitted at the conclusion of the study. The preliminary carbon flux results by species demonstrate trending differences in carbon flux for the 13 sampling dates (Figure 5). Carbon flux data across species closely tracked soil temperature data for each of the six sampling dates (data not shown). Based on standard error, Perennial ryegrass and tall fescue were among species with the highest carbon flux

Table 1. Labile soil carbon, total soil carbon, and total soil nitrogen values from soil samples collected to a 2 in (5 cm) depth on 19 November 2013. Turfgrasses were sown from seed in April of 2011 and grass clipping management practices were implemented in March of 2012. Labile carbon, total carbon, and total nitrogen means were separated using Tukey's test for significant differences.

Cultivar	Species	Growth rate†	Labile carbon (mg kg^{-1})		Total carbon (g kg^{-1})		Total nitrogen (g kg^{-1})	
			Collected	Returned	Collected	Returned	Collected	Returned
Gazelle II	Tall fescue	Slow	839	841	24.94	25.85	2.29	2.36
Tar Heel II	Tall fescue	Medium	847	851	23.8	24.58	2.15	2.25
Endeavor	Tall fescue	Fast	839	892	24.9	24.94	2.22	2.26
Prosperity	Kentucky bluegrass	Slow	765	799	23.46	25.33	2.15	2.34
Moonshine	Kentucky bluegrass	Medium	738	790	22.98	23.56	2.14	2.22
Thermal blue	Kentucky bluegrass	Fast	771	783	23.14	24.01	2.11	2.24
Mean			800 B[1]‡	826 A[1]	23.87 B[3]	24.71 A[3]	2.18 B[5]	2.28 A[5]
Tall fescue mean			851 A[2]		24.83 A[4]		2.26	
Kentucky bluegrass mean			774 B[2]		23.75 B[4]		2.20	

† Cultivars were selected for this experiment based upon their growth rate in preliminary trials (data not shown) and their similar appearance and stress tolerance in previous field trials in West Lafayette, IN.

‡ Means followed by different letters and identical superscripted number are significantly different at P = 0.0021, 0.0012, 0.0124, 0.0439, and 0.0006 for the 1, 2, 3, 4, and 5 numbered superscripts, respectively.

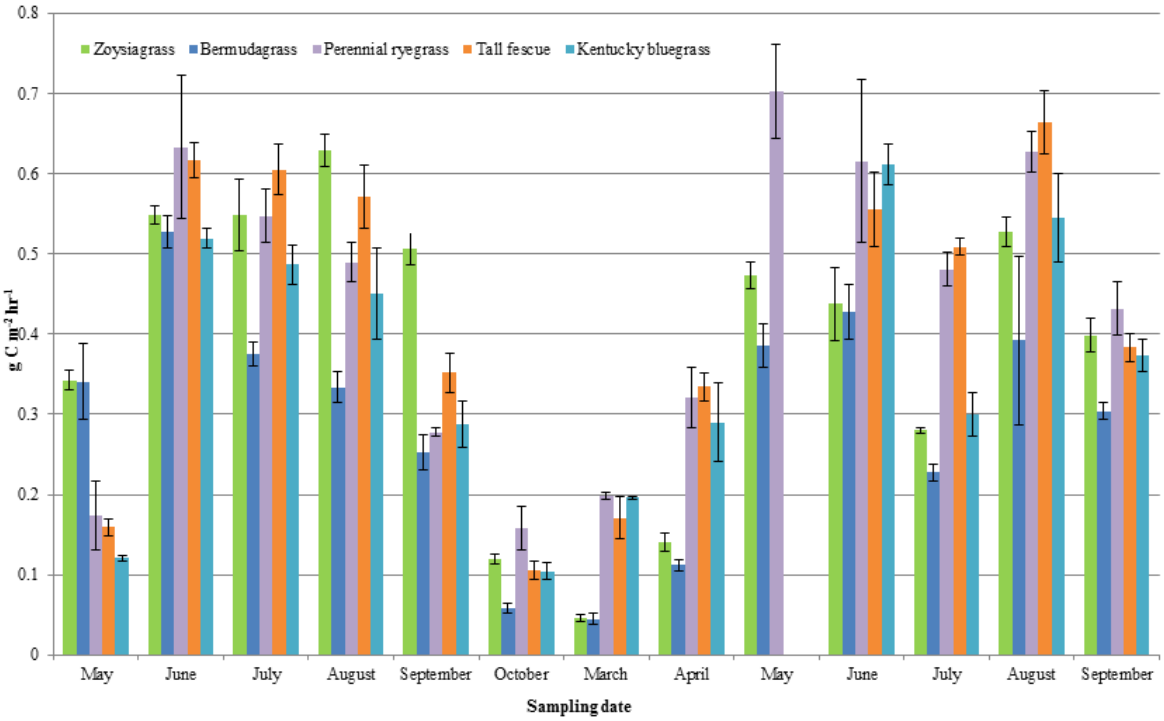

Figure 5. Carbon flux by turfgrass species across 13 sampling dates in W. Lafayette, IN in 2013 and 2014. Standard errors bars are shown around means for each species on each sampling date.

on 10 and 9 dates, respectively, out of the total 13 sampling dates. Bermudagrass was consistently among the species with the lowest carbon flux across 11 rating dates. The three cool-season species, Kentucky bluegrass, perennial ryegrass, and tall fescue followed similar trends in carbon flux across most rating dates.

Differences in labile and total soil C were realized between turfgrass species after 3 years of growth post planting, with tall fescue having 9.9% more labile soil C and 4.5% more total soil C than Kentucky bluegrass (Table 1). After 2 years under different mowing practices, plots where grass clippings were returned had 3.3% more labile soil C, 3.5% more total soil C, and 4.6% more total soil N than those where clippings were collected.

The number of total annual mowing events required varied by species and cultivar in 2013 (Table 2). Tall fescue cultivars required more annual mowing than Kentucky bluegrass. Cultivar impacted the number of annual mowing, especially when measured by the one-third rule with slow-growing cultivars requiring less annual mowing. Returning clippings increased the number of annual mowing event by about 2 compared to plots where clippings were collected.

This project is continuing in 2015 to gain an additional understanding of the influence of turfgrass species on soil C and N dynamics so that the turf science community can continue to learn and better understand how turf management influences soil carbon sequestration.

Table 2. The number of recorded mowing events for each treatment in 2013.

Cultivar	Species	Growth rate†	Number of mowing events			
			Weekly		One-third rule	
			Collected	Returned	Collected	Returned
Gazelle II	Tall fescue	Slow	28.25	29	16	17.75
Tar Heel II	Tall fescue	Medium	29	29.25	17.25	21
Endeavor	Tall fescue	Fast	28.75	29.5	21	24.75
Prosperity	Kentucky bluegrass	Slow	19.75	24	12.25	14.25
Moonshine	Kentucky bluegrass	Medium	27.5	28	15.5	17.5
Thermal blue	Kentucky bluegrass	Fast	27.75	28	20	22.5

† Cultivars were selected for this experiment based upon their growth rate in preliminary trials (data not shown) and their similar appearance and stress tolerance in previous field trials in West Lafayette, IN.