Examining Turfgrass Species and Management Regimes for Enhanced Carbon Sequestration

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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. *Quantify total and labile soil carbon in varying aged stands of Kentucky bluegrass, tall fescue, and zoysiagrass located in Indiana.*
3. *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.*
4. *Determine if a one-third rule mowing regime will reduce mowing requirements of golf course rough compared to scheduled weekly mowings.*
5. *Define the effects of clipping removal on CO_2 flux, soil labile C, and N dynamics.*

Experiment 1: 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 years) 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 measurements were obtained using a vented flux chamber that is 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 six sampling dates (30 May, 28 June, 25 July, 24 Aug, 26 Sep, and 24 Oct 2013). Gas samples were immediately analyzed for carbon dioxide flux using a gas chromatograph. Nitrous oxide was also measured but this data is still being analyzed.

Figure 1. Location of species and mowing regime plots in West Lafayette, IN at the William H. Daniel Turfgrass Research and Diagnostic Center. The photo shows the greenhouse gas flux chambers on the plots during a sampling event.

Experiment 2: To understand the includes of tall fescue and Kentucky bluegrass cultivars with varying leaf elongation rates and mowing requirements on CO_2 flux, soil labile C, and N dynamics we used experimental areas established in

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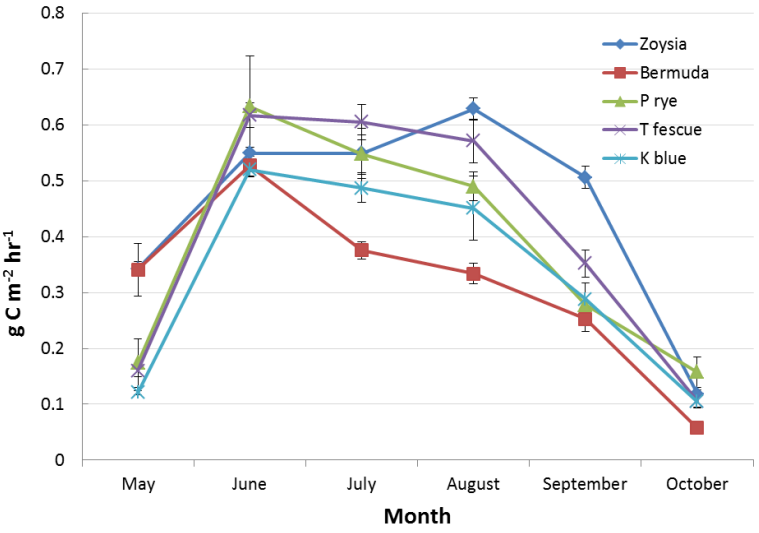

Figure 4. Carbon flux by turfgrass species across six sampling dates in W. Lafayette, IN in 2013. Standard errors bars are shown around means for each species on each sampling date.

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, 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. Additionally, greenhouse gases were measured similarly to the description above.

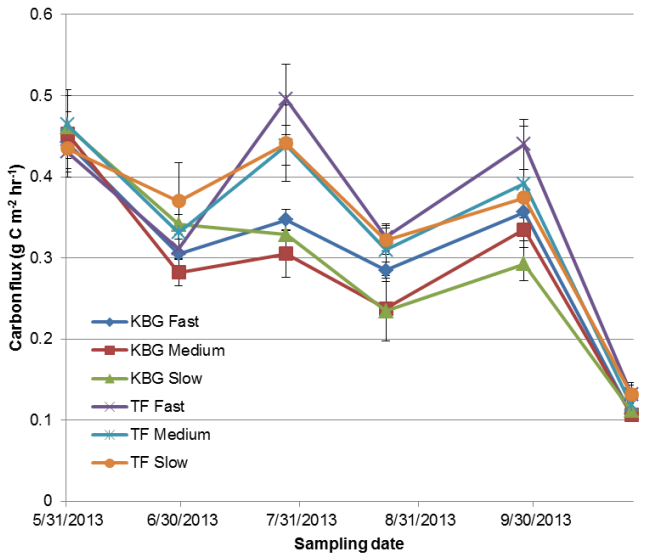

Figure 5. Carbon flux by turfgrass species and cultivars (clippings returned) across six sampling dates in W. Lafayette, IN in 2013. Standard errors bars are shown around means for each species on each sampling date. Slow TF = Gazelle II tall fescue, Med. TF = Tar Heel II tall fescue, Fast TF = Endeavor tall fescue, Slow KBG = Prosperity Kentucky bluegrass, Med. KBG = Moonshine Kentucky bluegrass, and Fast KBG = Thermal blue Kentucky bluegrass.

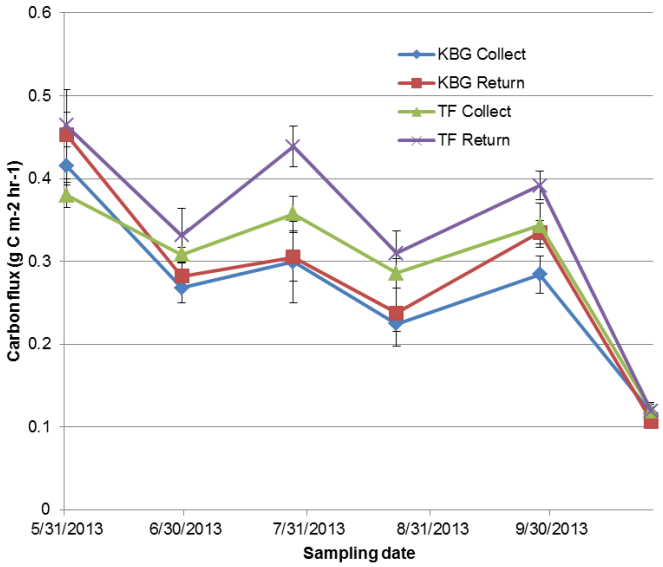

Figure 6. Carbon flux by turfgrass species and cultivars (clippings returned) across six sampling dates in W. Lafayette, IN in 2013. Standard errors bars are shown around means for each species on each sampling date. KGB Collect = the medium growing Kentucky bluegrass cultivar with clippings collected weekly at each mowing, KGB Return = the medium growing Kentucky bluegrass cultivar with clippings returned weekly at each mowing, TF Collect = the medium growing tall fescue cultivar with clippings collected weekly at each mowing, and TF Return = the medium growing tall fescue cultivar with clippings returned weekly at each mowing.

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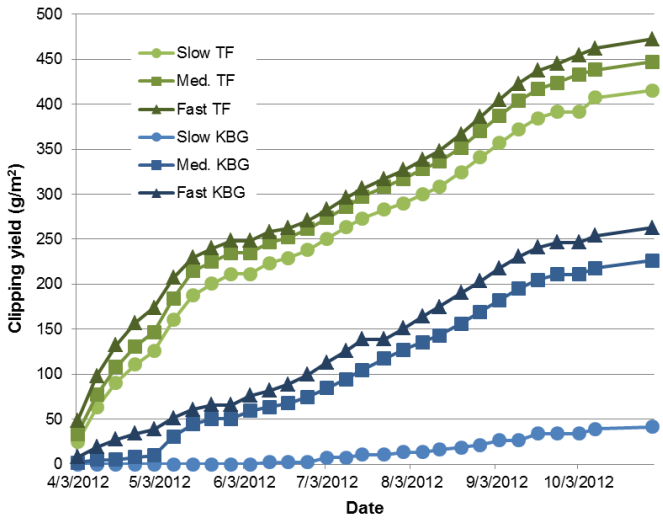

Figure 7. Cumulative clipping yield of tall fescue and Kentucky bluegrass cultivars in W. Lafayette, IN in 2012. Slow TF = Gazelle II tall fescue, Med. TF = Tar Heel II tall fescue, Fast TF = Endeavor tall fescue, Slow KBG = Prosperity Kentucky bluegrass, Med. KBG = Moonshine Kentucky bluegrass, and Fast KBG = Thermal blue Kentucky bluegrass.

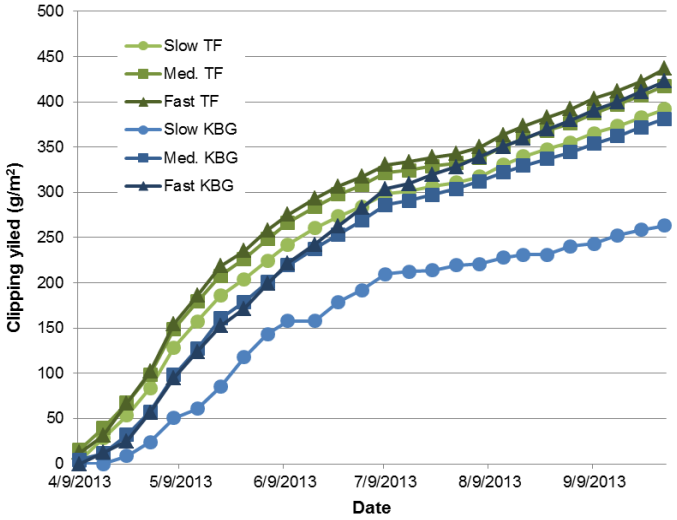

Figure 8. Cumulative clipping yield of tall fescue and Kentucky bluegrass cultivars in W. Lafayette, IN in 2013. This data only include collections until 30 September 2013 and does not include October and November collections. Slow TF = Gazelle II tall fescue, Med. TF = Tar Heel II tall fescue, Fast TF = Endeavor tall fescue, Slow KBG = Prosperity Kentucky bluegrass, Med. KBG = Moonshine Kentucky bluegrass, and Fast KBG = Thermal blue Kentucky bluegrass.

To better understand the effect of turfgrass species on soil carbon dynamics over time, labile soil carbon was quantified. 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 C (from soil) oxidized is a function of the quantity of potassium permanganate reduced.

Progress Update

- For all results, data is preliminary with full statistical analyses pending.
- Preliminary results of carbon flux by turfgrass species (Figure 4), cultivar by species (Figure 5), and species by clipping management (Figure 6) are shown. Error bars are included for each treatment across the six sampling dates.
- The preliminary carbon flux results by species demonstrate trending differences in carbon flux for the six sampling dates (Figure 4). Carbon flux data across species closely tracked soil temperature data for each of the six sampling dates (data not shown). Based on standard error, zoysiagrass was among the species having the highest flux on 24 August and 26 September sampling dates. Bermudagrass was consistently among the species with the lowest carbon flux across four rating dates. The three cool-season species, Kentucky bluegrass, perennial ryegrass, and tall fescue followed similar trends in carbon flux across all rating dates.
- Cumulative clipping yield varied by species and cultivar across both years (Figures 7 and 8). Species and cultivars were more variable in 2012 than 2013. Tall fescue had higher mean clipping yields in 2012 than Kentucky bluegrass, but in 2013 tall fescue cultivars had similar clipping yields to the fast growing Kentucky bluegrass. Temperature varied between years and could account for species differences. The mean temperature from 1 April to 30 September in 2012 was 19.5 °C in comparison to a mean temperature of 18.7 °C during the same time period in 2013. Plots were irrigated and not allowed to enter summer dormancy although more rainfall was received in 2013 than 2012 would favored Kentucky bluegrass early summer growth in 2013.
- Carbon flux data across species and cultivars of varying growth rates showed differences between species – with tall fescue cultivars having higher carbon flux on some rating dates – but few differences in cultivar within species (Figure 5). Within cultivar and within species, plots where clippings were returned showed elevated carbon flux on some rating dates compared to plots where clippings were collected (Figure 6).

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- Soil labile carbon fractions from 5 May 2012 – 1 year after planting – were similar between treatments and clipping regimes (Table 1). Fall 2012 and Fall 2013 soil samples are currently being analyzed to determine how soil labile carbon fractions are influenced by species, cultivar, and management practices.
- The number of total annual mowing events required varied by species and cultivar in 2012 (Table 2). Tall fescue cultivars required more annual mowings than Kentucky bluegrass. Cultivar impacted the number of annual mowings, especially when measured by the one–third rule with slow–growing cultivars requiring less annual mowings. Returning clippings increased the number of annual mowing event by about 2 compared to plots where clippings were collected.
- Several data points still need collected and analyzed before more substantial conclusions can be made regarding the influence of turfgrass species and management on soil carbon dynamics.

Table 1. Soil labile carbon values from 5 May 2012 sampling after a year–long grow–in period and five mowing events where clipping treatments were initiated.

Cultivar	Species	Growth rate	POXC (mg/kg)	
			Clippings collected	Clippings returned
Gazelle II	Tall fescue	Slow	647.1 (33.2)	673.1 (43.0)
Tar Heel II	Tall fescue	Medium	742.6 (77.8)	724.3 (86.1)
Endeavor	Tall fescue	Fast	709.0 (67.5)	705.5 (40.6)
Prosperity	Kentucky bluegrass	Slow	690.1 (54.6)	686.9 (71.9)
Moonshine	Kentucky bluegrass	Medium	687.2 (35.7)	671.4 (63.4)
Thermal blue	Kentucky bluegrass	Fast	658.8 (33.5)	698.8 (38.4)

* Standard error of the mean given in parenthesis.

Table 2. The number of recorded mowing events for each treatment in 2012.

Cultivar	Species	Growth rate	Number of Mowing Events /plot			
			Weekly		One–third rule	
			Collected	Returned	Collected	Returned
Gazelle II	Tall fescue	Slow	29	29	19	21
Tar Heel II	Tall fescue	Moderate	30	30	20.75	22.5
Endeavor	Tall fescue	Fast	30	30	23.25	25
Prosperity	Kentucky bluegrass	Slow	9	9	6	6
Moonshine	Kentucky bluegrass	Moderate	26	26	14.75	16.75
Thermal blue	Kentucky bluegrass	Fast	27	27	19.5	21.75

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