TURFGRASS CULTURAL PRACTICES THAT MAXIMIZE SOIL CARBON SEQUESTRATION

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INTRODUCTION

Turfgrass is often overlooked as a potential sink for soil carbon (C) sequestration. Recent studies, however, have suggested that areas managed in turfgrasses may have a relatively high potential for soil C sequestration (Qian and Follett, 2002; Bandaranayake et al., 2003; Milesi et al., 2005; Huh et al., 2008; Qian et al., 2010; Morgan et al., 2010; Selhorst and Lal, 2011; Selhorst and Lal, 2013).

Too often, turfgrass is viewed negatively with respect to environmental quality. Showing that soil C sequestration can be important in turfgrass areas will be a positive attribute for advocating for, or defending, turfgrass systems from ill-informed regulations or decisions that are anti-turfgrass in principle. Secondly, turfgrass soil C sequestration may be a potential income generator for turf managers and land owners. With respect to strategies in reducing carbon dioxide (CO_2) emissions, there is a general movement globally to institute C cap-and-trading. Under this model, generators of CO_2 are given limits or goals to meet each year. If they cannot obtain those preset limits, then they can buy credits from other sources that are C sinks to meet their goals. These may be forested areas, cropland, or perennial grassland systems (i.e., prairies, savannahs, native grasslands), or other industries or land areas that are C neutral or C negative with respect to CO_2 emissions. With more information about turfgrass systems, it is not inconceivable that turfgrass areas could be used as a C-trading sink target since turfgrasses are a perennial grass system.

Climate change, and the consequences of it, is considered by many to be one of the greatest challenges humans will face this century. Soil sequestration of C, and maximizing its potential, is a goal within the environmental and scientific community, and governmental agencies as a means to lessen or delay the negative outcomes of climate change. Turfgrass areas have the potential to contribute to this goal.

The objective of this research was to determine which turfgrass cultural practices maximize soil C sequestration.

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MATERIALS & METHODS

This study was initiated in the fall of 2012. Six years prior to the start of the experiment, the existing vegetation of the area was a mixed cool-season grass sward. The experiment was set out in a split-split plot design with three replications on a Paxton fine-sandy loam soil. Main plots were species (Kentucky bluegrass [*Poa pratensis*], perennial ryegrass [*Lolium perenne*], tall fescue [*Festuca arundinacea*], and creeping red fescue [*Festuca rubra rubra*]); subplots were a combination of mowing heights (2, 3, and 4 inches) and clipping management (mulched or bagged); and subsubplots were N rates (0, 0.2, 0.4, 0.6, and 0.8 lbs N per 1000ft^2 per month, May through November).

Prior to treatment application, the experimental area was delineated into the respective plots and soil samples, to a depth of 0 to 4 inches, and 4 to 8 inches, were collected from each plot using a 18-mm dia. probe. Four samples were collected from each plot and combined into a single sample, separated by depth. After soil sample collection, plots were seeded to the species in August 2012. Full treatments commenced in May 2013, and were repeated through the 2014, 2015, and 2016 growing seasons. In November 2016, soils samples were collected from each plot at depths of 0 to 4 inches, and 4 to 8 inches as described above.

Soil samples from the 2012 and 2016 0 to 4-inch depths were analyzed for concentrations of total C using a LECO TruMac CN Macro Determinator (LECO Corp., St. Joseph, MI). (note: samples for the 4 to 8-inch depth are still being analyzed at the time of this report).

Total C concentrations were used to calculate the total mass of C (tons per acre at 0 to 4-inche depth) by using an average bulk density of 1.3 g per cm^3 for all plots. Treatment differences in C sequestration rate per year were determined by subtracting the 2012 total C mass from the 2016 total C mass for each plot, then dividing by 4 years.

Carbon sequestration rate differences were analyzed for treatment differences by using analysis of variance with Fisher's LSD for mean separation in the MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC).

RESULTS & DISCUSSION

Initial mean total C mass in the experimental area prior to treatment imposition was very high: 122.4 tons/acre in the 0 to 4-inch sampling depth. Since the Paxton fine-sandy loam soil has low carbonate concentrations, the starting C contents were primarily derived from organic sources. These soils at our research farm are historically high in organic matter (5 to 8%) for a mineral soil. Since soil samples were collected from each plot prior to treatment imposition in 2012, we were able to calculate the C sequestration rate across the 4 years of the study.

Surprisingly, there were no interaction effects with the treatments, except for the 4-way Species × Mowing Height × Clipping Management × N rate effect. However, investigation of that interaction did not reveal any logical trends within the data. Therefore, only main effects will be presented.

Overall C sequestration rates at the 0 to 4-inch depth were different ($P < 0.001$) for species, with the greatest rate associated with tall fescue and the lowest rate for creeping red fescue (Fig. 1). Carbon sequestration rates at the 0 to 4-inch depth were not different between Kentucky bluegrass and perennial ryegrass.

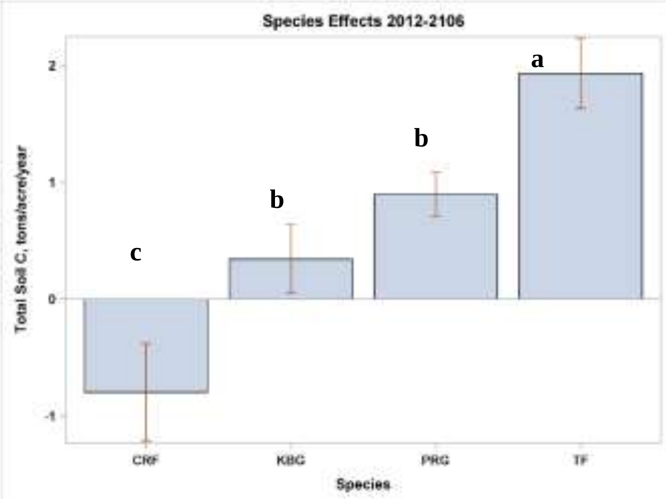

Fig. 1. Carbon sequestration rate differences among species; CRF = creeping red fescue. KBG = Kentucky bluegrass, PRG = perennial ryegrass, and TF = tall fescue. Means with the same letters are not significantly different according to Fisher's LSD. Error bars are standard errors.

Mowing height differences (*P* = 0.05) indicated that the 4-inch height of cut resulted in the greatest C sequestration rate for the 0 to 4-inch sampling depth (Fig. 2). There were no differences between the 2- and 3-inch mowing heights.

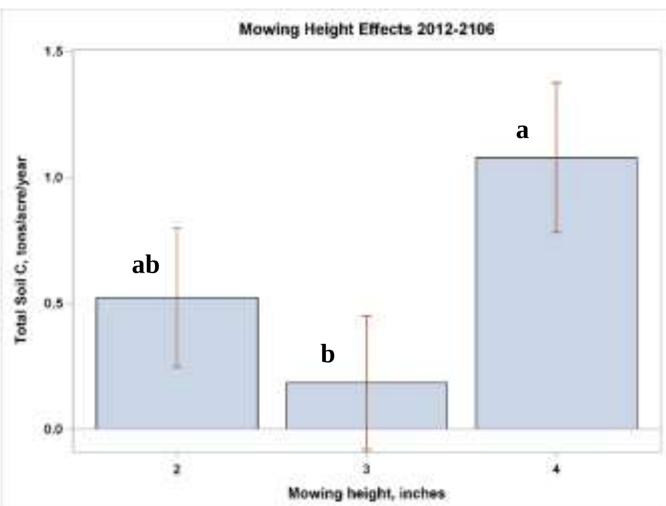

Fig. 2. Carbon sequestration rate differences among mowing heightsMeans with the same letters are not significantly different according to Fisher's LSD. Error bars are standard errors.

Clippings management had a significant (P < 0.10) effect on C sequestration rates in the 0 to 4-inch sampling depth. Returning clippings back to the turf surface increased soil C sequestration rates by a factor of about 1.5 (Fig. 3).

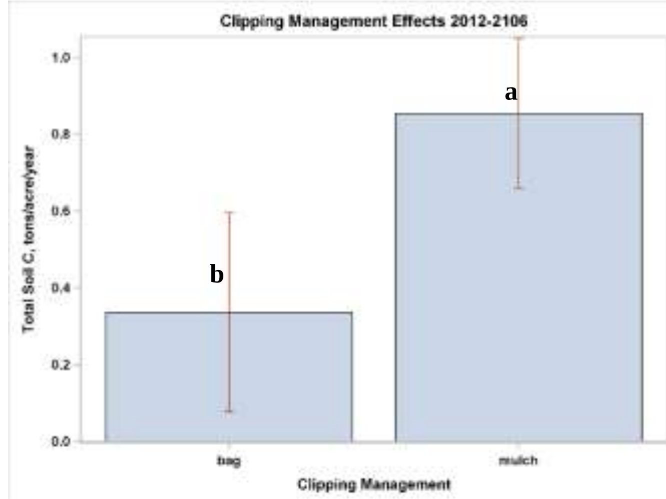

Fig. 3. Carbon sequestration rate differences between clipping management practices. Means with the same letters are not significantly different according to Fisher's LSD. Error bars are standard errors.

The most variable results were observed with N rate effects. In general, greater C sequestration rates were obtained when some N was applied (0.2 to 0.8 lbs N per 1000ft^2 per month, May through November) versus no N (*P* = 0.11) (Fig. 4).

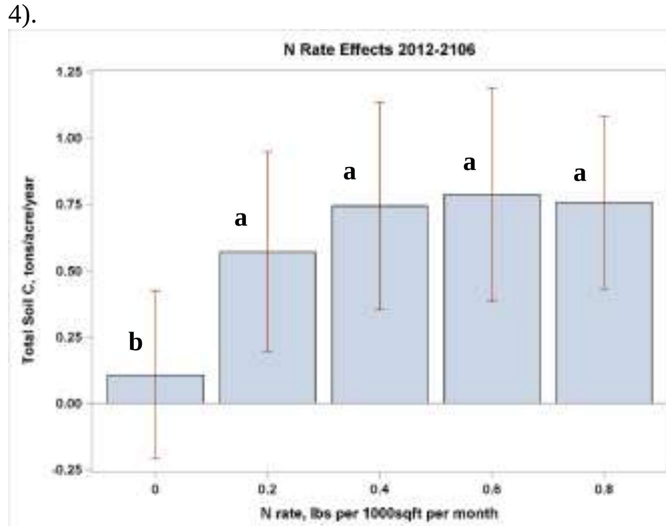

Fig. 4. Carbon sequestration rate differences among N rates. Means with the same letters are not significantly different according to Fisher's LSD. Error bars are standard errors.

SUMMARY

The results of this study indicate that turfgrass areas do have the potential to sequester C in the soil in the 0 to 4-inch sampling depth. Overall, higher potentials were obtained with tall fescue, returning clippings, higher height-of-cut, and N fertilization between 0.2 and 0.8 lbs N per 1000ft^2 per month.

We anticipate that these results may change somewhat when the 4 to 8-inch depth sample analyses for total C are completed and added to the totals from the 0 to 4-inch depth.

If Carbon Cap-and Trade policies become implemented at some future date, turfgrass areas could become a viable option as a C sink, and therefore generate revenue.

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