Nitrous Oxide Emissions and Carbon Sequestration in Turfgrass: Effects of Irrigation and Nitrogen Fertilization

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Nitrous oxide (N_2O) is important greenhouse gas implicated in global climate change. Turfgrass is typically fertilized with nitrogen (N) and irrigated and has the potential to emit N_2O at similar rates as other agricultural soils and thus, play an important role in atmospheric N_2O budgets. The development of management practices such as slow-release N fertilizer and/or deficit irrigation may mitigate N_2O emissions. The objectives were to quantify the magnitude and patterns of N_2O emissions in turfgrass and determine how irrigation and N fertilization may be managed to reduce N_2O emissions.

The study is being conducted under an automated rainout shelter near Manhattan, Kansas (Fig. 1). By shielding rainfall from turfgrass, researchers can control the amount of water applied to plots. Zoysiagrass was sodded June 4, 2013, and maintained at a 1-inch mowing height. During the summer (June-Aug) of 2014 and 2015, two irrigation treatments were applied including medium (80% evapotranspiration [ET] replacement) and medium-low (60% ET replacement) (Fig. 2). Three N-fertilization treatments included urea and polymer-coated N, both at 2 lb/1000 ft^2, and a control with no N applied. Because little drought stress was observed in the 60% ET treatment in 2014, irrigation amounts in both treatments were reduced, specifically from 80 to 75% ET replacement in the medium and 60 to 50% ET replacement in the medium-low treatment in 2015.

Nitrous oxide emissions were measured of with static chambers placed over the turfgrass surface and analyzed with gas chromatography (Fig. 3). Measurements began on October 29, 2014 (DOY 302) and continued weekly-to-monthly until October 5 2015 (DOY 278), concluding the first year (Fig. 4). Carbon sequestration in the upper soil profile (0 to 12 inches) will be measured by sampling soil C at the end of the 3-year study; initial soil C was measured on Aug. 28, 2013. Ancillary measurements included soil moisture, temperature, nitrate and ammonium, visual quality, and percent green cover using digital image analysis.

Cumulative annual emissions of N_2O were significantly greatest in urea and least in untreated (no N) zoysiagrass among treatments. Annual emissions were 1.82, 2.09, 2.77 kg N_2O-N ha^{-1} yr^{-1} for untreated, polymer-coated urea, and urea, respectively (Fig. 5). Annual emissions were similar to those reported in other turfgrass studies, which ranged from 1 to 3.85 kg N_2O-N ha^{-1} yr^{-1} across various turfgrass species and under different fertilization regimes (Bremer, 2006; Kaye et al., 2004; Lewis and Bremer, 2013). The percentage of applied N fertilizer emitted as N_2O in this study was 2.2% from poly and 2.9% from urea fertilizer. The highest fluxes and majority of emissions occurred in the summer because of the fertilization events and, presumably, higher soil temperatures. There were spikes after applications of urea fertilizer, but increases were much smaller with application of controlled release (poly) N fertilizer. Both urea and controlled release N fertilizer treatments resulted in higher turfgrass quality than the control, but all three treatments maintained acceptable turfgrass quality during deficit irrigation treatments (Fig. 6).

Bullet Points:

- Annual N_2O emissions were greatest in urea and least in untreated (no N) among treatments.
- Differences were negligible due to irrigation treatment. Irrigation levels may be decreased further in the final year to induce slight stress on the low irrigation treatment.
- All fertilizer treatments maintained acceptable quality, however the controlled-release fertilizer resulted in more consistent visual quality ratings compared to urea and untreated
- Urea fertilizer had higher peak fluxes after fertilization and overall annual emissions than polymer-coated N-fertilizer.
- Thus, controlled released N fertilizers such as polymer-coated urea in turfgrass systems could potentially help mitigate N_2O emissions.

Figure 1. Automated rainout shelter moving across plots activated by 0.01 inch of rain.

Figure 2. Plots received precise irrigation amounts based on daily ET during summer period.

Figure 3. Close-up of one of twelve static chambers used for sampling N2O.

Figure 4. N2O sampling on July 22, 2015 DOY 174.

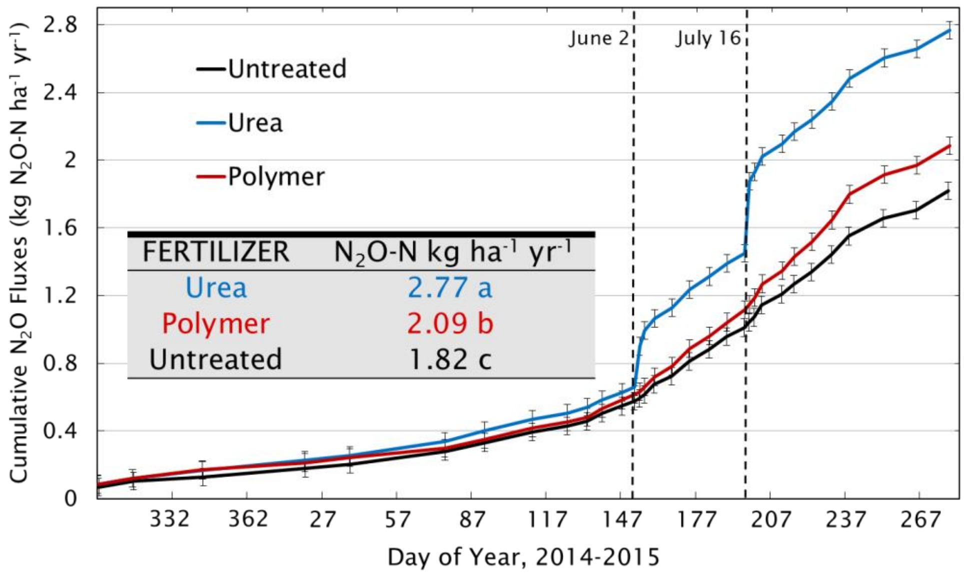

Figure 5. Cumulative fluxes of N_2O-N from plots treated with urea, polymer-coated urea, and untreated. Vertical dashed lines represent fertilization dates.

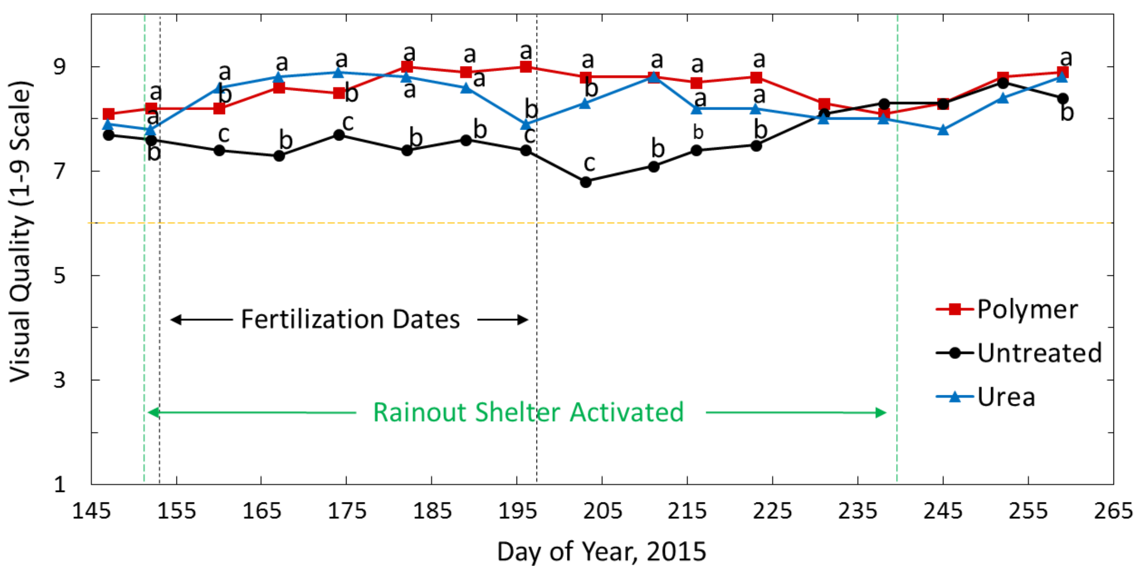

Figure 6. Visual quality ratings (9 = best quality) of Meyer zoysiagrass prior to and following the summer period under the automated rainout shelter. Plots were fertilized with Urea and Poly on DOY 153 and only Urea fertilizer again on DOY 197. Any points below yellow horizontal dashed line at rating of 6 would be below acceptable quality. Means followed by the same letter on a date are not significantly different according to Fisher's protected least significant difference test ($P \leq 0.05$).