THE LONG-TERM FATE OF NITROGEN APPLIED TO KENTUCKY BLUEGRASS

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Introduction

Extensive research has been conducted in the last 10 years on nitrate-nitrogen (NO_3-N) leaching in turfgrass systems. The majority of research has indicated that turfgrass poses little risk to the environment from nitrate leaching. Research conducted at MSU by Miltner et al. reported that the majority of ^{15}N labeled urea nitrogen applied to Kentucky bluegrass never reached the soil. The majority of applied nitrogen was taken up by the plant, immobilized in the thatch layer, or lost to volatilization. Only 0.23% of the ^{15}N labeled urea was collected in the drainage water of lysimeters 1.2 m (4 ft) below the soil surface over a three-year period following application.

Research has also shown that turfgrass builds organic matter for a period of about 10 years following establishment and then reaches equilibrium where no further net N immobilization occurs. The question under investigation is whether or not after an extended period of time, 10 years, will the amount of NO_3-N leaching from a turfgrass system change. The research is important because it will indicate if the amount of NO_3-N leached from a mature turf occurs at a level where an alteration in fertilizer practices needs to be considered.

Materials and Methods

Between 1989 and 1991 at the Hancock Turfgrass Research Center, Michigan State University, four monolith lysimeters were constructed. In September 1990 the area was sodded with a polystand of Kentucky bluegrass (cv. 'Adelphi', 'Nassau', 'Nugget') for a United States Golf Association sponsored leaching and mass balance nitrogen-fate study conducted by Miltner et al. between 1991-1993. Prior to the construction of the lysimeters the area had been in turfgrass for six years. The lysimeters are constructed of grade 304 stainless steel, 0.05 cm thick. The lysimeters are 1.14 m (3.75 ft) in diameter and 1.2 m (4 ft) deep. The bottom of the lysimeter has a 3% slope to facilitate leachate drainage to a tube on one side. Leachate is collected in 19 L glass jugs. The leachate is collected when the jugs are approximately ½ full. For complete specifications of lysimeter construction, see Miltner et al. (1996).

The lysimeters and surrounding plot area have received continual fertilizer applications and cultural practices to maintain high quality turfgrass since lysimeter construction. This research was initiated in 1998 and will last until at least 2008. The experimental design is relatively simple. Two of the large lysimeters and surrounding turf area were treated annually with 245 kg N ha^{-1} (5 lb. N/1000 $ft.^2$) split over 5 applications. The application dates were May 1, June 1, July 1, September 15, and October 15. The remaining two lysimeters and surrounding turf area were treated annually with 98 kg N ha^{-1} (2 lb. N/1000 $ft.^2$) split over 2 application dates from 1998 through 2000, and 4 application dates for 2001 and 2002. The application dates for 1998 through 2000 were May 1 and October 15. In 2001 and 2002 the application dates were May 1, June 1, July 1, and October 15. Lysimeter percolate was collected periodically, volume measured, and a subsample collected for N analysis. The turf was mowed twice a week at 7.6

cm and clippings returned. Irrigation was used to return 80% potential evapotranspiration weekly.

In the fall of 2000, 90 microplots were installed in the plot area adjacent to the lysimeters. The microplots are constructed of 20-cm diameter polyvinyl chloride (PVC) piping to a depth of 45-cm. The PVC piping was driven into the ground using a tractor and hydraulic cylinder. This process preserved the soil structure within the microplots and the surrounding plot area. On October 17th 2000, ^{15}N labeled urea was applied to the lysimeters and microplots to determine mass nitrogen balance. The microplots were extracted and partitioned into verdure, thatch, roots, and soil on 7 sampling dates. Soil and roots samples were partitioned into depths of 0-5, 5-10, 10-20, and 20-40 cm.

Harvest dates for the microplots to date were:

November 1, 2000 (15 **D**ays **A**fter ^{15}N **T**reatment)
December 1, 2000 (45 DAT)
April 19, 2001 (184 DAT)
July 18, 2001 (274 DAT)
October 9, 2001 (357 DAT)
April 20, 2002 (549 DAT)
July 17, 2002 (637 DAT)

In addition, weekly clipping samples were taken to determine the amount of nitrogen from fertilizer being moved to the top-growth of the plant.

The leachate from the lysimeters was monitored for nitrate-nitrogen and $\%^{15}N$ enrichment. In addition, soil, thatch, verdure, roots, and weekly clipping samples were sampled for $\%^{15}N$ enrichment to determine mass nitrogen balance for the system.

Results

From 1998-2002, for the 98 kg N ha^{-1} (2 lb. N/1000 $ft.^2$) rate, NO_3-N concentrations ranged between 1.0-8.0 mg L^{-1}, well below the EPA standard for drinking water of 10 mg L^{-1} (Figure 1). From 1998 through September 1999, for the 245 kg N ha^{-1} (5 lb. N/1000 $ft.^2$) rate, NO_3-N concentrations typically ranged between 2.5-9.0 mg L^{-1}. From October 1, 1999 through 2002, NO_3-N concentrations varied between 10.0 and 20.0 mg L^{-1}. On several sampling dates from 2001 through 2002, NO_3-N concentrations measured from the 245 kg N ha^{-1} rate exceeded 30 mg L^{-1}, triple the EPA drinking water standard. Results of NO_3-N concentrations in leachate for each year from 1998 through 2002 are presented in Figures 2 - 6.

To date, seven sampling dates have been harvested and separated into components for $\%^{15}N$ enrichment analysis. The samples have been ground into a fine powder, weighed, and most have been analyzed for $\%^{15}N$ enrichment via mass spectrometry. Although microplot samples are still being analyzed, initial results indicate total nitrogen recovery in thatch, soil, and verdure components to be on average 75 and 70% of applied nitrogen for the low and high nitrogen rates, respectively.

Many leachate samples have been prepared for analysis by mass spectrometry and results from analysis should be available soon. Complete results from ^{15}N analysis of soil, plant, and water samples should be finished in early 2003.

Future Directions

Recent funding by the USGA has ensured that this research will be continued through 2007. Starting in 2003, the amount of nitrogen applied will be reduced to 49 and 96 kg N ha^{-1} split over two applications (24.5 and 48 kg N ha^{-1} per application). The application dates will be May 1 and September 1. For the first application date of each year from 2003 through 2007, ^{15}N enriched urea will be applied. Phosphorus from triple superphosphate (20% P) will be applied at two rates, 49 and 96 kg P ha^{-1} split over two applications (24.5 and 48 kg N ha^{-1} per application). The phosphorus application dates will coincide with the nitrogen application dates, May 1 and September 1.

The results should shed further light on the dynamics of nitrogen cycling and the fate of phosphorus in turfgrass systems. The research from 1998-2002 has revealed significant increases in NO_3-N leaching and this phase of research should reveal whether reducing nitrogen application rates can lower NO_3-N concentration in leachate to acceptable levels. In addition, the impact of phosphorus applications to a turf grown on soils testing medium for phosphorus level will be quantified in terms of phosphorus levels by soil depth and leachate monitoring.

Literature Cited

Miltner, E.D., B. E. Branham, E.A. Paul, and P.E. Rieke. 1996. Leaching and Mass Balance of 15NLabeled Urea Applied to a Kentucky Bluegrass Turf. Crop Sci.36:1427-33.

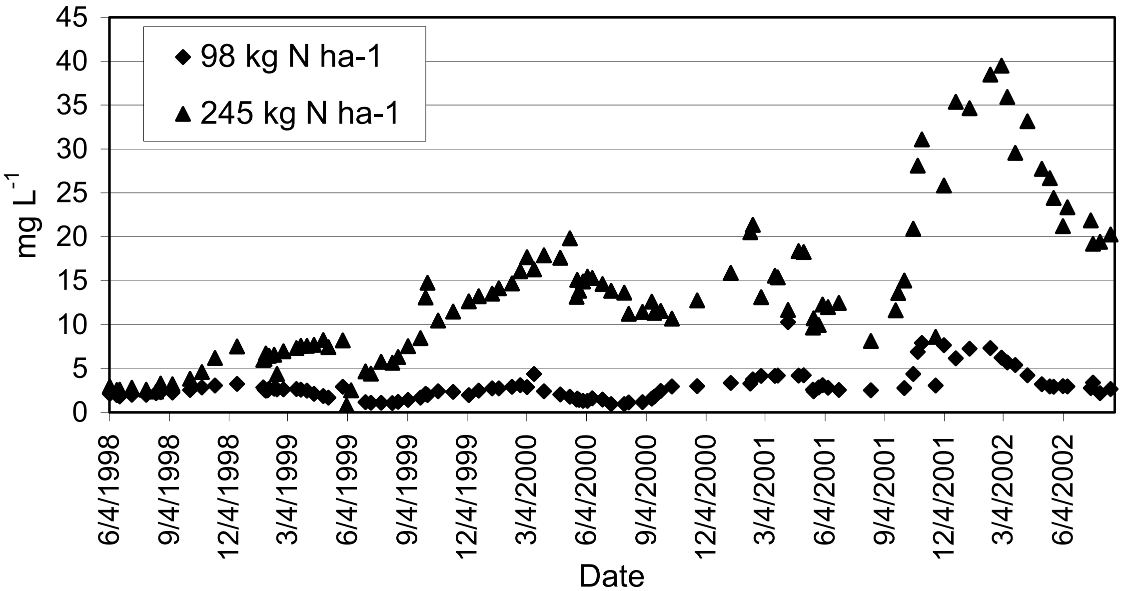

Figure 1. Nitrate-nitrogen concentration in leachate from 1998 – 2002.

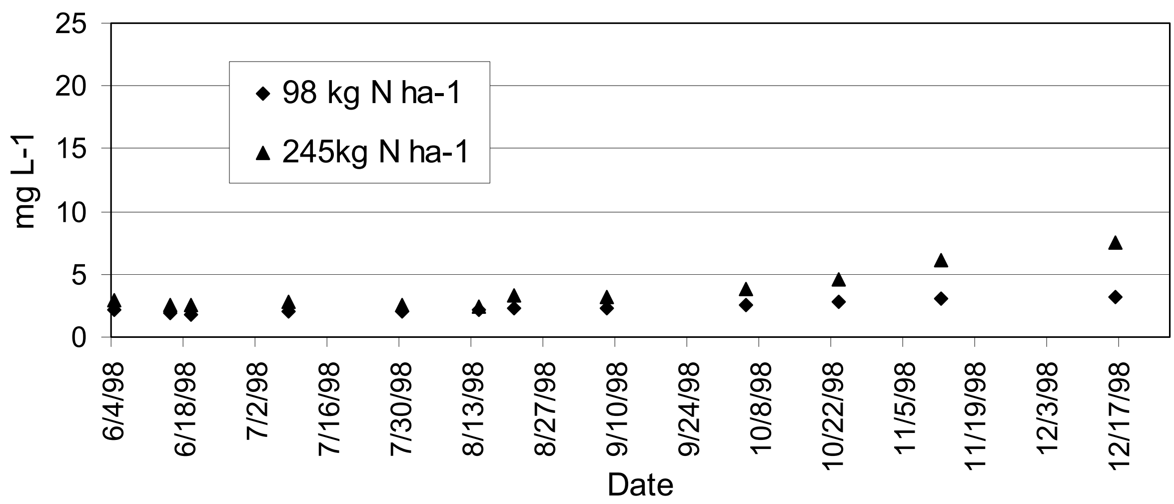

Figure 2. Nitrate-nitrogen concentration in leachate in 1998.

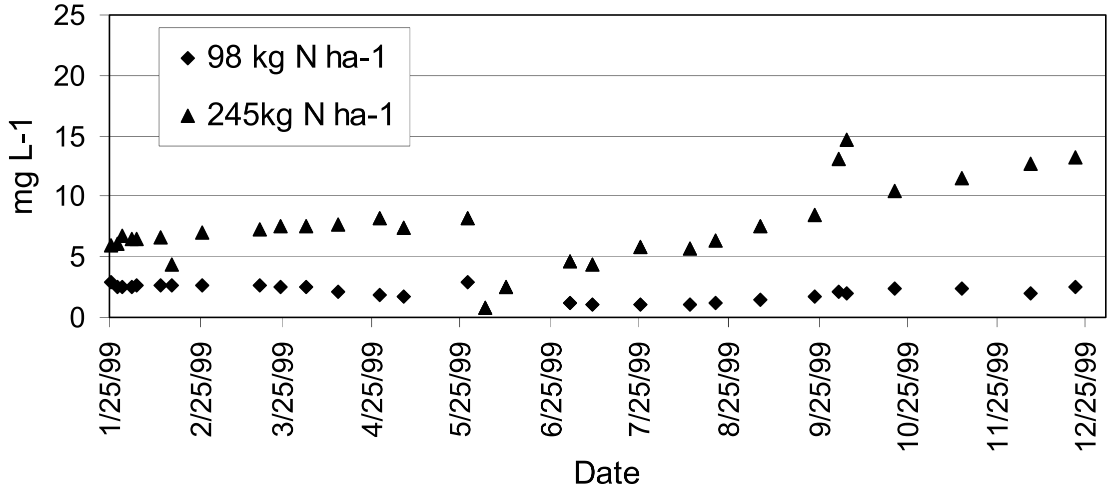

Figure 3. Nitrate-nitrogen concentration in leachate in 1999.

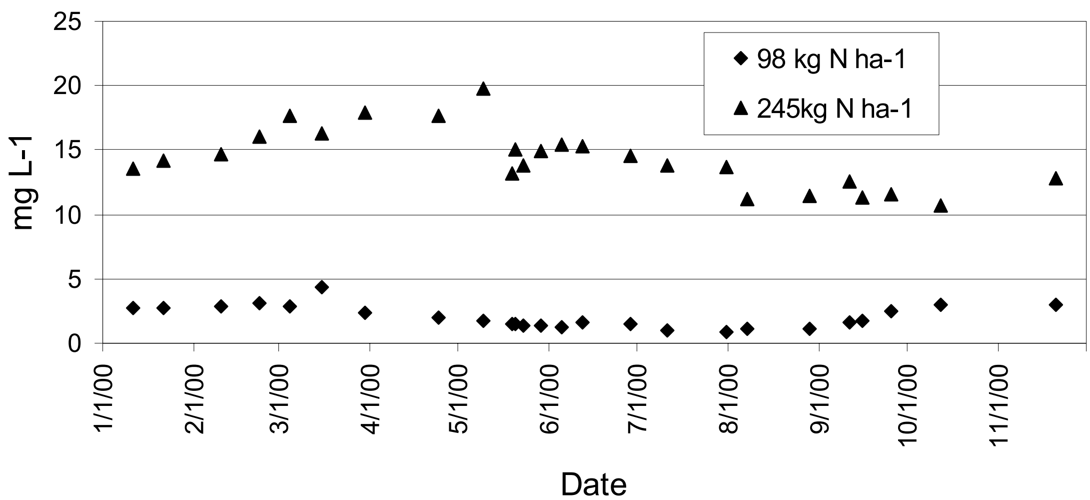

Figure 4. Nitrate-nitrogen concentration in leachate in 2000.

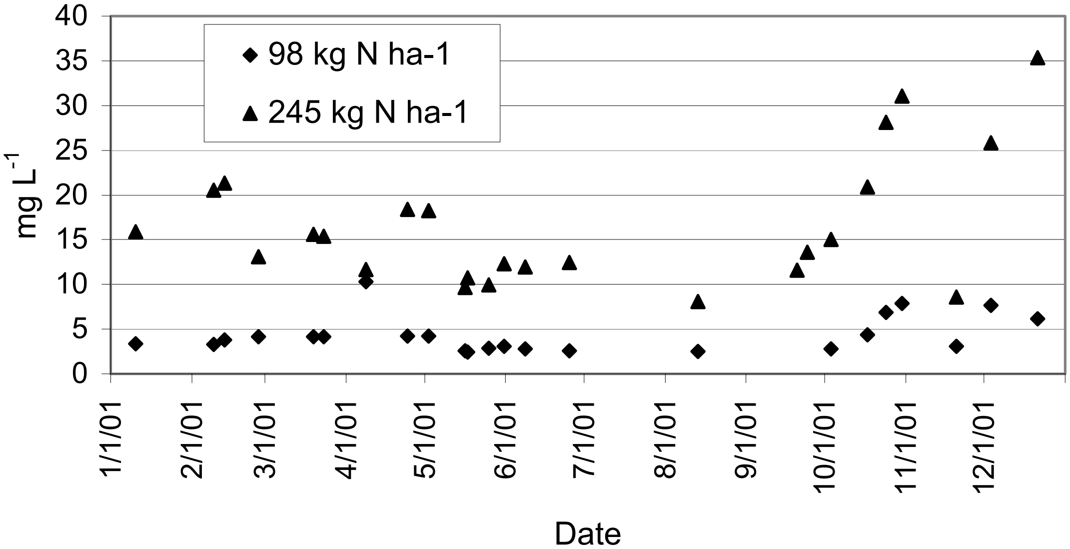

Figure 5. Nitrate-nitrogen concentration in leachate in 2001.

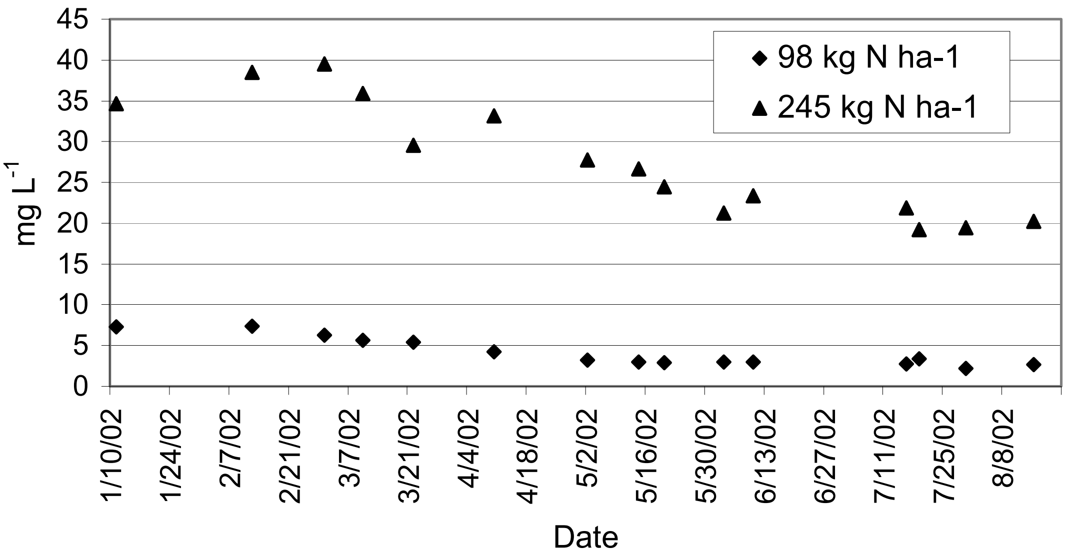

Figure 6. Nitrate-nitrogen concentration in leachate in 2002.