Executive Summary: Gaseous Losses and Long-Term Fate of Nitrogen Applied to Kentucky Bluegrass Turf

Bruce Branham, Principal Investigator
Richard Mulvaney, Co-Principal Investigator
University of Illinois
Department of Natural Resources and Environmental Sciences
Urbana, Il
and
Jim Baird, Co-Principal Investigator
Eldor Paul, Co-Principal Investigator
Michigan State University
Department of Crop and Soil Sciences
E. Lansing, MI 48824

The objectives of this project is to determine how nitrogen is lost from fertilized turf stands, which is being conducted at the University of Illinois; and to determine the long-term fate of nitrogen at Michigan State University. The project at MSU includes the development of long-term turfgrass plots that will be treated the same every year for an indefinite period. We envision these plots as a kind of "Morrow" plots for turf. The Morrow plots are an experimental field at the University of Illinois that has continually produced corn since 1868. The plots at MSU will be continually under turf management for the indefinite future at the same, known level of management inputs. These plots will be an invaluable resource for future researchers long after this study is over. The project at MSU consists of establishing the long-term plots on a site that contains four large lysimeters that will be monitored for nitrogen leaching under two fertility regimes. The high maintenance plots receive 5 lbs nitrogen per 1000 square feet per year while the low maintenance plots receive 2 lbs nitrogen per 1000 square feet per year. The lysimeters will be monitored continuously for nitrate leaching under these two fertility programs. Beginning in the 2000, a study will be initiated to monitor the fate of labeled fertilizer nitrogen in these plots.

The results from monitoring the leachate of the two nitrogen regimes in 1998 indicate slight increases in nitrogen leaching compared to the baseline levels established in these same plots during a study conducted from 1991-1993. Average N losses ranged from 1.83 to 2.85 mg N L^{-1} for the 2 lbs N/M/Yr treatment and 2.37 to 4.61 mg N L^{-1} for the 5 lbs N/M/Yr treatment. While these values are well below the drinking water standard of 10 mg N L^{-1}, they are above the levels detected by Miltner et al. (1996) in a similar study. Values detected by Miltner et al. were generally below 1 mg N L^{-1} with a maximum detection of 3.8 mg N L^{-1}.

Research at the University of Illinois is focused on gaseous losses of N from fertilized turf stands. Turfgrasses are fertilized yearly but seem to lose insignificant amounts of N to leaching. Yet, turfgrass systems must be losing N or fertilization could be stopped without any loss in turfgrass growth or quality. Since N leaching appears negligible, the only other avenue for loss of N from the turf is through N volatilization. Nitrogen volatilization losses can occur by two different pathways. Ammonia volatilization and denitrification will both be studied in these experiments.

Most of our time in 1998 was devoted to developing the systems needed to study N volatilization under field conditions. In particular, denitrification is very difficult to study under field conditions. One of the most vexing problems encountered was a method to measure the volume of the lysimeters to be used in the field measurements. The lysimeters, plastic tubes inserted into the turf, must protrude above the turf surface so that a cover can be placed over the lysimeter and a sample of the air inside the lysimeter taken to determine gaseous N loss. Determining the head space volume inside the lysimeter is critical to getting an accurate estimation of the total N gasses volatilized. While many easy approaches were considered, known of them provided acceptable results. The method developed introduces a known volume of neon gas into the lysimeter prior to sampling, after equilibration, a sample is withdrawn and the concentration of neon gas is determined by mass spectroscopy. The dilution of the neon gas can be used to accurately determine the head space volume of the lysimeters.

Our field system has been tested and is ready for our first field studies which will begin in May of 1999. These trials should be sufficiently sensitive to determine nitrogen volatilization losses from fertilized turf stands.

Annual Report: Gaseous Losses and Long-Term Fate of Nitrogen Applied to Kentucky Bluegrass Turf

Bruce Branham, Principal Investigator
Jim Baird, Co-Principal Investigator
University of Illinois
Department of Natural Resources and Environmental Sciences
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and
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Department of Crop and Soil Sciences
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Research initiated in 1998

Brian Horgan is a PhD student who began the project at the University of Illinois. He has spent the last 10 months preparing for the experiment on the gaseous fate of nitrogen applied to turf. This has included the following challenges: development of an air-tight lysimeter system for the fate studies in the field; development of a gas sampling system to permit 8 hour sampling of lysimeters in the field; learning to operate the mass spectrometer used to differentiate $^{28}N_2$, $^{29}N_2$, and $^{30}N_2$; and the development of a technique to determine the volume of head space plus pore space in the field-installed lysimeters.

Progress and Results

The sampling procedure we will employ in these experiments consists of covering a lysimeter with a brass plate equipped with sampling valves that permit withdrawing air samples of the headspace. Because the air within the headspace will be "stirred" to get good mixing and accurate sampling, it is imperative that the system be air tight. Second, since the lysimeters will be covered, the microenvironment within the lysimeter will change the longer the lysimeters are covered. To avoid the problems associated with covering the lysimeters too long, we will sample one replicate for two hours and then sample other replicates for 2 hour periods until we have 8 hours of sampling. These 4 samples will then be mixed and the resulting mix analyzed by a mass spectrometer to detect ^{15}N. This will permit us to sample an entire day without having to make assumptions based on very short sample periods. However, the glassware needed for this kind of mixing and sampling apparatus turned out to be non-trivial.

In order to sample the head space in the field-installed lysimeters for denitrification and ammonia volatilization losses, the plastic lysimeters must be fitted with an air-tight cover that will allow these gases to build-up in the lysimeter and then permit a sample of the head space gas to be withdrawn for later analysis. While this may sound simple, it actually took considerable effort to develop this technology during the spring and early summer of 1998.

A critical factor in the analysis of the head space gas is a measurement of the volume of the head-space. While this can be estimated by measuring the distance from the top of the lysimeter to the soil surface, it does not take into account the loss of volume associated with the turf. Further it assumes no contribution from the soil air. We tried two procedures to estimate the volume of the head space. With the first method, an evacuated cylinder was connected to the lysimeter with cover in place. After equilibration, the pressure in the whole system was measured. By knowing the volume and pressure of the evacuated cylinder and the pressure of the cylinder plus head space, we should have been able to determine the volume of the head space. This procedure did not work, probably because of the contribution of the soil and the possibility of outgassing from the soil water. A second technique involved sweeping the chamber with 100% CO_2 in order to saturate the head space with CO_2, and then bubbling the head space gas through a sodium hydroxide solution to trap CO_2. The CO_2 concentration was then determined gravimetrically. This procedure also did not work, presumably because CO_2 is soluble in water and some dissolved in the soil water, only to be released when the atmospheric concentration of CO_2 returned to normal levels.

A final approach to this problem gave excellent results. This approach is also valuable in that it can be used at each sampling date to estimate chamber volume. This procedure introduces a known quantity of neon gas, a non-reactive noble gas, into the covered lysimeter. The neon is diluted as it mixes with the head space volume. When a gas sample is collected at the end of the two hour sampling period, the concentration of neon in the sample can be used to determine the head space volume. This relationship is shown in figure 1 and will be the basis of paper to be submitted the Soil Science Society of America Journal as a technique for determining soil volumes.

Proposed Research 1999

In June of 1999, we will begin our first set of experiments on nitrogen fate and gaseous losses of N from turf. There will only be two treatments each with 4 replications. One treatment will receive 5 gm/m^2 of 99% enriched ^{15}N labeled urea on June 1, 1999 and the other treatment will receive 5 gm/m^2 of enriched urea on September 1, 1999. At the June 1 application date, 100 kg/ha of KBr will be applied to each lysimeter. The Br^- will serve as a benchmark for movement of a non-adsorbed species in soil.

Gas phase sampling will begin immediately following application and will continue for 21 days after application. After that time period, sampling will be intermittent based upon soil moisture and rainfall levels. Clippings will be collected during the course of the study and the lysimeters will be excavated approximately 12 months after application to determine the overall mass balance of applied nitrogen. This study will be repeated in the year 2000 since climate is extremely important in determining the amount of denitrification that occurs.

Figure 1. Relationship of Head Space Volume to Neon Concentration, expressed as mass spectrometer voltage.