FATE OF FERTILIZER NITROGEN APPLIED TO TURFGRASS

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INTRODUCTION

Nitrogen is the fertilizer nutrient applied in the greatest quantity in the maintenance of high quality turfgrass. However, plants are not the only sink of applied nitrogen and the movement and transformation of nitrogen within the soil is a complex process. Soil microorganisms are essential in cycling nitrogen among various forms within the soil, and large quantities of nitrogen can be resident in this microbial biomass. Dead plant material entering the soil organic matter can also serve as a large pool of nitrogen. Inorganic forms of N are present in the soil solution and may participate in ion exchange processes. Nitrogen can also be lost from the environment either in gaseous forms through volatilization or denitrification, or in water as runoff or leachate to groundwater. These final two fates are of special importance due to their impacts on environmental quality. This experiment was designed to monitor the various transformations of applied fertilizer nitrogen and ultimately construct a mass balance to account for applied fertilizer N in the various pools in the turfgrass environment.

MATERIALS AND METHODS

Four intact monolith drainage lysimeters were constructed at the Hancock Turfgrass Research Center at Michigan State University for use in this study. These cylindrical stainless steel lysimeters are 1.2 m in diameter and 1.2 m in depth and contain undisturbed cores of a Marlette sandy loam soil. Following construction during 1990 and 1991 they were sodded with a blend of 'Nugget', 'Adelphi', and 'Nassau' Kentucky bluegrass (Poa pratensis L.). Adjacent to the lysimeters 64 microplots constructed of 20 cm diameter PVC were installed to a depth of 60 cm to allow for soil sampling.

Two experimental treatments consisted of annual rates of fertilizer nitrogen of 196 kg/ha (4 lb./M) applied as urea under two different schedules. Each treatment included five equivalent applications of 39 kg N/ha (0.8 lb. N/M) at approximately 36 day intervals. Applications for the 'Spring' treatment commenced in late April and continued through late September. 'Fall' treatment applications were made between early June and early November. This design allowed for comparison of a late fall fertilization with a more traditional early season schedule. Fertilization dates were similar for the years 1991-93. In 1991, the first year of the study, the April and November applications for each respective treatment were made with 25 atom percent excess ^{15}N labelled urea. Use of this stable isotope of nitrogen allows for discrimination of that single nitrogen application from all other N in the environment through mass spectroscopy. With this tool, a mass balance can be constructed at any point in time during the course of the study, indicating the relative distribution of nitrogen from the labelled application in different pools in the environment.

Clippings were collected by hand on approximately a weekly basis from all lysimeters and microplots. Lysimeter percolate was collected approximately every ten days. Soil samples were collected four times during the growing season immediately following ^{15}N application and twice in the second season following application by excavating microplots intact. Following excavation, verdure was removed and the cores were sectioned into depth increments (thatch, 0-5 cm, 5-10 cm, 10-20 cm, 20-40 cm, and 40-60 cm). Clippings, verdure, thatch, and percolate were analyzed for total N and ^{15}N. Soil was analyzed for N and ^{15}N as total N, inorganic N, and microbial biomass N, and organic N was calculated by difference.

RESULTS AND DISCUSSION

For the Spring treatment, total fertilizer nitrogen recovered in green plant tissue (clippings plus verdure) remained essentially constant throughout the course of the study (38 - 40 %), indicating rapid uptake and transport of N into plant shoots followed by upward movement of N over time with growth (Table 1). Thatch was very important in interception and storage of fertilizer N, remaining relatively constant until late in the second year, when the level decreased possibly due to mineralization. The low level of N in the October 1991 thatch sample was due at least in part to sampling variability, and this effect was probably not real. Less than 20% of the applied fertilizer N reached the soil below the thatch layer. Nitrogen present in the soil was largely in an organic form, and therefore immobile but still slowly available to plants through microbial mineralization. Fertilizer nitrogen in leachate was less than 0.01% of applied N. Total recovery for Spring treated turf ranged from 73 to 91%. Unrecovered nitrogen was attributed to loss through volatilization, or potentially some denitrification.

For late fall applied N, uptake and distribution into plant shoots was similar to that for the spring treated turf (36 to 45%). Over 60% of the applied N was recovered in thatch approximately three weeks after treatment. This level did not decline until the following June when soil temperatures warmed, possibly enhancing microbial transformations. Fertilizer N recovered in soil was approximately 10 to 15% of that applied and was primarily in organic forms. Fertilizer N in leachate was again less than 0.01% of that applied. Total recovery was initially greater than 100%. This was due to inherent variability in methodology as opposed to prior presence or synthesis of ^{15}N. Decrease in total recovery over time could be due to losses through volatilization or denitrification.

The highest concentration of nitrate nitrogen in leachate was 4.5 mg/L (ppm) for the Spring treatment and 2.7 mg/L for the Fall treatment. The majority of samples had concentrations below 1 mg/L. These levels are well below the EPA drinking water threshold limit of 10 mg/L.

Table 1. Percent fertilizer ^{15}N recovered in each pool at selected sampling dates for 'Spring' treatment.

Sampling date	Clippings	Verdure	Thatch	Soil nitrogen: Inorganic	Soil nitrogen: Organic	Total recovery
5/14/91	2.4	36.3	30.9	1.1	6.9	77.7
6/21/91	19.9	20.4	31.2	0.3	10.6	82.5
10/16/91	30.3	8.5	18.9	0.6	15.1	73.4
11/26/91	30.8	7.7	31.9	0.6	16.6	87.6
5/20/92	32.4	3.9	34.9	2.3	18	91.5
11/30/92	36.8	2.5	21.4		16.7[1]	77.4

1 Value represents total of inorganic and organic nitrogen.

Table 2. Percent fertilizer ^{15}N recovered in each pool at selected sampling dates for 'Fall' treatment.

Sampling date	Clippings	Verdure	Thatch	Soil nitrogen: Inorganic	Soil nitrogen: Organic	Total Recovery
11/26/91	0	36.1	62.5	1.2	11.1	110.9
5/20/92	21.8	22.9	56.5	2.1	7.6	110.9
6/26/92	27.0	19.5	35.7	1.6	5.5	89.4
11/30/92	36.5	4.5	25.6		15.9[2]	82.4

2 Value represents total of inorganic and organic nitrogen.

The insignificant amount of fertilizer nitrogen recovered in leachate is good news for turfgrass managers. Only a minor portion of the applied N reached the soil, and when it did it was quickly converted to organic forms, rendering it immobile. The thatch played an important role in intercepting and storing fertilizer N. Forty to forty five percent of applied nitrogen was accounted for in green plant tissue during the first growing season. Approximately 10 to 20% of the spring applied N was not recovered, and was probably lost through ammonia volatility. There may have been some gaseous losses (denitrification) of fall applied N over time as well.