Nitrogen 'Best Management Practices' for Turfgrass

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The ultimate goal of best management practice (BMP's) is to establish and maintain high quality turf at reasonable cost without detriment to the environment. In the case of nitrogen, the focus is on loss of the nutrient from turf. Reducing N loss accomplishes three things: (1) The percentage of fertilizer N recovered by the turfgrass is increased; (2) The percentage of fertilizer N that can enter surface and groundwater is reduced; and (3) With more efficient use of the fertilizer N, high quality turf can be achieved at reduced cost and with lower N rates. This, in turn, further reduces the amounts of N that may escape to the environment.

Avenues for Nitrogen Loss from Turf

Understanding how nitrogen applied to turf escapes to the environment is basic to the development of BMP's. But, these considerations arise only when the nitrogen is, in fact, applied to the turf. The moment that nitrogen fertilizer is inadvertently applied to and left on paved surfaces constitutes pollution of the environment. There should be absolutely no tolerance for such an irresponsible act.

The nitrogen loss mechanisms of concern here are (1) volatilization, (2) denitrification, (3) leaching, and (4) runoff (Fig. 1). The first two mechanisms pose no threat to the environment. Rather, such losses reduce fertilizer N effectiveness. Leaching, on the other hand, leads to groundwater pollution, and runoff loss contaminates streams and lakes.

Under extreme conditions, any one of the above avenues can result in loss of as much as one-half the N applied to turf (Table 1). However, all of these losses can be reduced to insignificant amounts through adoption of BMP's.

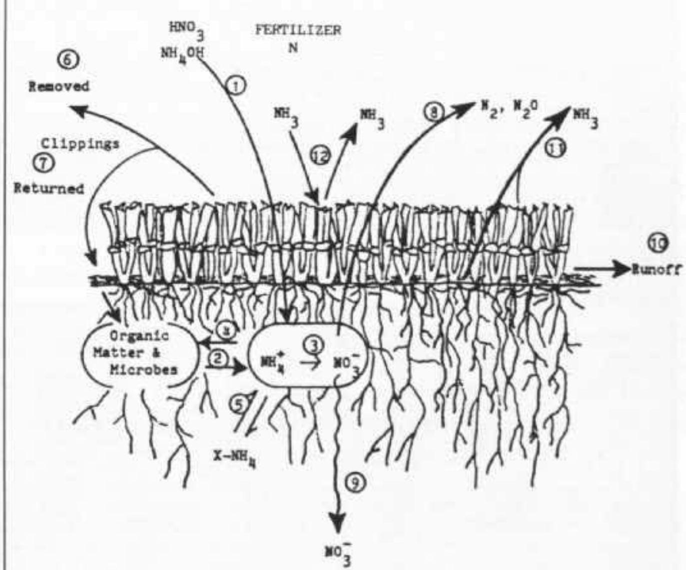
TABLE 1.
RANGES IN NITROGEN LOSS FROM TURF

Type of Loss and the Process	Percent Fertilizer N Lost
Permanent	
Volatilization	1-50
Denitrification	1-40
Leaching	1-40
Runoff	1-20
Temporary Immobilization	20-40

Reducing Fertilizer N Losses

A reasonable goal for nitrogen BMP's is to reduce fertilizer N losses to 2 to 3 percent or less. Zero loss is not a reasonable goal simply because N loss measurements are confounded by background N levels. Runoff water or leachate from turf always contains some N regardless of whether the turf has been fertilized or not. The N detected in these situations is that released through microbial decomposition of organic matter — clippings, thatch, dead roots and other microorganisms.

Figure 1.
Nitrogen Inputs, Transformations and Loss in Turf



1. Inputs from Rain and Fertilizer
2. Mineralization
3. Nitrification
4. Immobilization
5. Cation Exchange
6. Clipping Removal
7. Clipping Return
8. Denitrification Loss
9. Leaching Loss
10. Runoff Loss
11. Volatilization
12. Ammonia Exchange

In talking about fertilizer N losses, no one should assume or imply that if losses are reduced to 2 to 3 percent of the amount applied, turfgrass recovery of the applied N will increase to 90 percent or more. In actual fact, turfgrass recoveries of fertilizer N rarely exceed 60 percent (Table 2). Does this mean that the remaining 40 percent has been lost, either to the atmosphere or to the environment? Not at all. Fertilizer N recovery values consider only the N removed in clippings. The "missing" 40 percent or so resides in residual N in SRN granules, grass stems, stolons or roots and the microbial population of the turf. This is what is known as immobilized N (Fig. 1). It cycles through the turfgrass-soil system on a continuous basis. It does not represent lost N nor does it pose a threat to the environment.

Reducing fertilizer N loss is not difficult. It involves proper choice of fertilizer, appropriate methods of application and, in some instances, precautionary measures prior to turf establishment. *(Continued on page 9)*

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TABLE 2. FERTILIZER N RECOVERY BY TURFGRASS	
Nitrogen Source	N Recovered
	%
Urea-Liquid	49-60
Urea-Prills	44-52
SCU	46-52
RCU (Resin Coated Urea)	48-54
UF/Methylene Urea	22-60
Milorganite	27-35
IBDU	40-47

Volatilization loss: Losses of this type are significant only when urea or urea-containing fertilizers are used. Losses of N are greatest when urea is left on warm, moist turfgrass and soil surfaces for periods of 24 hours or more. The presence of a substantial thatch layer significantly increases the amount of nitrogen lost. Volatilization N losses can be reduced to 2 percent or less by doing one of two things. One is to irrigate in the urea shortly after application (Table 3). The amount of water required varies from as little as ¼-inch to ¾-inch or more. The deeper the thatch layer, the greater the amount of water required.

TABLE 3. IRRIGATION EFFECTS ON UREA-N VOLATILIZATION LOSS	
Amount of Irrigation	Fertilizer N Volatilized
Inches	%
0	14.1
0.2	4.5
0.4	2.2
0.8	0.8

The second way to minimize volatilization loss of nitrogen is to apply an N source other than urea (Table 4). Even sulfur-coated urea (SCU) seldom has volatilization N losses greater than 3 percent. Organic N sources, methylene ureas, IBDU, etc., typically lose no more than 1 or 2 percent of their nitrogen through volatilization.

TABLE 4. N VOLATILIZATION LOSS FROM DIFFERENT FERTILIZERS	
N Fertilizer	Fertilizer N Volatilized
	%
Urea-Liquid	4.6
Urea-Prills	10.3
Formolene	3.2
Fluf	4.5
UF	3.0
SCU	1.7
IBDU	1.9

Denitrification loss: This type of loss results when soil microorganisms convert nitrate-nitrogen to gaseous forms (Fig. 1). Denitrification occurs only when the microorganisms lack oxygen. This situation arises from excessive water in soil, or conversely, from inadequate drainage. Even then, the amount of nitrogen lost via denitrification depends on how much nitrogen exists in the form of nitrate when oxygen deficiencies develop.

The most obvious way of minimizing denitrification loss of nitrogen is by improving soil drainage or providing for adequate drainage before establishing the turf. In situations where it is impractical to achieve high water infiltration rates and rapid drainage (on clay soils, for example), then irrigation practices become very important. Water application rates have to be such that saturation of the soil does not occur.

The third means of reducing denitrification loss of fertilizer N is to avoid accumulation of high concentrations of nitrate in soil. When applying soluble N sources, this can be achieved through frequent, low rates of application. The alternative to light frequent applications is application of slow-release N fertilizers.

Leaching loss: As in the case of denitrification loss, the culprit is nitrate-nitrogen (Fig. 1). This form of nitrogen is contained entirely in soil water and moves with that water. Virtually any time nitrate moves downward in soil more than a few inches beyond the turfgrass rooting zone, that nitrate eventually winds up in the groundwater. The keys to minimizing leaching loss of nitrogen are keeping nitrate concentrations low in soil water and not irrigating to the extent that water moves beyond the rooting zone of the turfgrass.

Light, frequent applications of soluble N sources or less frequent applications of slow-release N sources are equally effective in keeping soil water concentrations of nitrate at low levels. Either of these approaches to fertilizer application, used in conjunction with irrigation regimes that do not lead to application of water in excess of that lost by way of evapotranspiration (Table 5) are the keys to reducing fertilizer N leaching losses to 2 percent or less.

TABLE 5. EFFECT OF IRRIGATION REGIME ON N LEACHING LOSS FROM A GOLF GREEN	
Irrigation Regime	Fertilizer N Leached
	%
0.4 inches/day	39.2
As Needed	5.1

Logically, leaching losses of nitrogen are greatest on very sandy soils during periods of heavy rainfall. In Wisconsin, rainfall in excess of turfgrass evapotranspiration rates most commonly occurs in spring and fall. Thus, it is rather important that when fertilizer N is applied at these times on sandy soils, it contain a slow-release form of nitrogen.

Runoff loss: Runoff loss of nitrogen happens only if fertilizer is on the soil surface when rainfall or irrigation exceeds the infiltration rate of soil. Research has shown that runoff from a good, dense turf with some thatch is a rather rare event. For example, in studies conducted in Rhode Island and Pennsylvania, runoff from turf was recorded on only two occasions at each site over 2 or 3 year periods and the amounts of runoff water collected were extremely low.

There are, however, situations where fertilizer N runoff loss from turf need be of concern. The problem is most prevalent around buildings where, during construction, heavy equipment has caused extensive soil compaction. The ef-

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fects of such compaction on water infiltration rates of home lawns and commercial grounds are shown in Table 6. Failure to alleviate this compaction prior to turf establishment leaves sloping areas prone to frequent rainfall runoff. Under these circumstances, it does not take an unusually intense storm to result in substantial runoff. It behooves all landscapers to bear this in mind when establishing turf around homes and commercial buildings.

TABLE 6.
VARIABILITY IN WATER INFILTRATION RATES AROUND BUILDINGS

Type of Site	Infiltration Rate
	Inches/Hour
Home Lawns	0.1 -8.8
Commercial Grounds	0.05-5.0

Where the potential for runoff loss of nitrogen is high, the proper approach is to apply the nitrogen only when the soil is fairly dry, apply a soluble form of nitrogen and make sure that application of the nitrogen is immediately followed by slow application of ½-inch water or more. This reduces nitrogen runoff loss during an ensuing 5-inch simulated rainstorm from 10 or 15 percent to less than 2 percent (Table 7).

TABLE 7.
EFFECTS OF SOIL INFILTRATION RATES AND POST-APPLICATION IRRIGATION ON RUNOFF LOSS OF N FROM A 5-INCH SIMULATED RAIN

Water Infiltration Rate	Post-Application Irrigation	Fertilizer N Loss
Inches/Hour		%
1.73	No	6.1
	Yes	0.3
0.96	No	15.2
	Yes	1.2

Summary

Nitrogen BMP's make good sense. In fact, they are basically nothing more than good common sense.

Failure of the turfgrass industry as a whole to conscientiously put forth the effort needed to minimize fertilizer N entry into surface and groundwater will only result in government regulations that inevitably complicate turfgrass management and escalate everyone's costs. If everyone will voluntarily adopt the nitrogen BMP's outlined above, then, and only then, will the industry be in the position of being able to legitimately claim that application of nitrogen to turfgrass is not a significant contributor to surface and groundwater pollution.