Effects of N-(nbutyl)thiophoshoric Triamide (NBTP) and Dicyandiamide (DD)on the Efficacy of Urea Applied to Turfgrass

By Douglas J. Soldat

INTRODUCTION

Investigations of the fate of fertilizer N in turfgrass ecosystems have consistently failed to account for 19 to 43% of the N applied (Starr and DeRoo, 1981; Power, 1988; Miltner et al., 1996; Horgan et al., 2000). The 'missing' N is thought to be that lost from the ecosystem via volatilization and denitrification.

Application of urea or urea bearing fertilizers to turfgrass can result in volatilization loss of upto 60% of the N applied (Titko et al., 1987). However, these losses can be reduced to less than 8%by irrigating with 0.4 inch or more of water immediately after fertilizer application (Bowman et al.,1987; Titko et al., 1987). Golf tees, greens, and fairways rarely receive this much water in a single irrigation cycle. Hence, typical N volatilization losses from urea applied in these circumstances are unknown.

Until recently, the only measures of N denitrification losses of N from turf were those of Mancino et al. (1988). They found N denitrification losses of 45 to 93% of the N applied to two soils. The problem is that these losses occurred when the soils were saturated with water, which is an atypical condition in turf. Horgan et al. (2000) have begun to research denitrification losses of N from turf under normal field conditions. Initial indications are that losses range from 5 to 23% of applied N.

Clearly, losses of fertilizer N from turf ecosystems via volatilization and denitrification can be substantial. Reductions in these losses could, therefore, have a significant impact on N use efficiency, perhaps to the point where N use rates could be reduced.

When applied to turfgrass, urea undergoes hydrolysis, a reaction mediated by the ubiquitous enzyme, urease (Torello, 1981). The initial hydrolytic products of urea are NH_4^+ and CO_3=. The latter is quickly hydrolyzed, forming HCO_3- and OH-. Unless there is rapid dissipation or neutralization of the OH-, the pH of the solution at the site of urea hydrolysis rises to and exceeds 7.3, at which point OH- strips protons from NH_4^+ ions to form increasing amounts of NH_3 and volatilization occurs.

A means for reducing volatilization loss of N is to slow the rate of urea hydrolysis, thereby slowing the rate of NH_4^+ production and allowing for more extensive dissipation by rainfall and irrigation water and by nitrification (Titko et al., 1987). The most direct means for slowing urea hydrolysis is to inhibit the action of urease. This is the mode of action of N-(-n- butyl) thiophoshoric triamide (NBTP), which reportedly inhibits the enzyme for up to 2 weeks after urea application (technical literature; Lange Stegmann Co., St. Louis, MO).

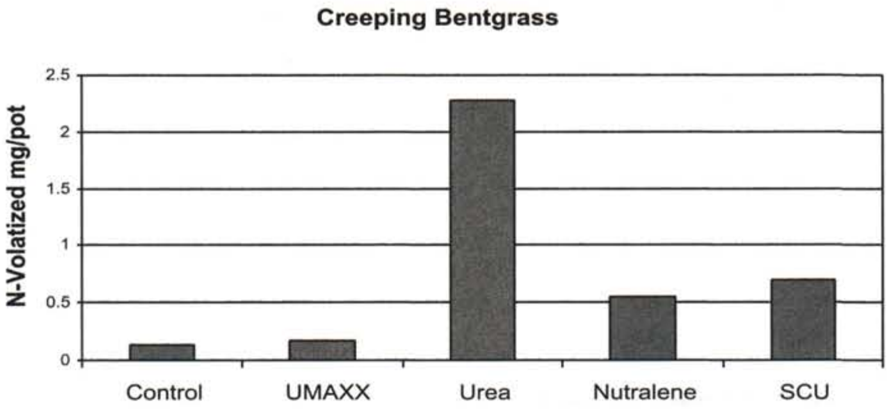


Figure 1

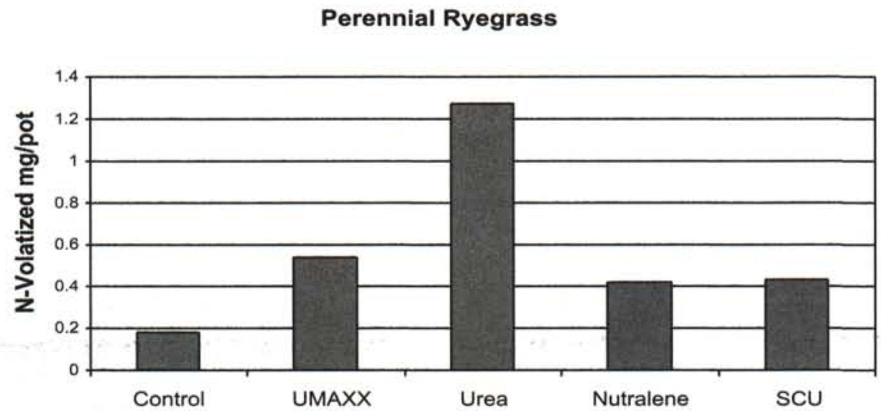


Figure 2

In a warm, moist environment, NH_4^+ is quickly microbiologically oxidized to NO_3-(Schmidt, 1982), rendering the N in a form subject to denitrification. While some denitrification may be a chemical process, the most common pathway is microorganism use of NO_3- as an e- acceptor within O_2-deficient soil microsites (Firestone, 1982). The dominant products resulting are the gases N_2O and N_2. The obvious means for reduction of denitrification is inhibition of the microorganisms responsible for oxidation of NH_4^+. Several such chemical inhibitors have been identified, one of which is dicyandiamide (DD) (Mengel and Kirkby, 1987).

The purpose of the research was to determine how and to what degree impregnation of urea with NBTP and DD alters the efficacy of urea as a turfgrass fertilizer. To achieve this purpose a greenhouse study was conducted where the extent of which NBTP and DD influence volatilization and denitrification losses of urea-N were documented. The objectives of the study were:

1. To obtain evidence that NBTP reduces ammonia volatilization from urea applied on turfgrass;
2. To obtain evidence that DD reduces denitrification loss of N from turf;
3. To observe the comparative effects of NBTP and DD treatment of urea on turfgrass color, clipping nutrient content, and root mass.

METHODS

The experimental units consisted of Penncross creeping bentgrass and Manhattan III perennial ryegrass grown in silt loam soil maintained at field moisture capacity by the weighing method. The bentgrass and ryegrass were clipped weekly at 0.5 inch and 2.0 inches, respectively. The fertilizers tested in the experiment were urea, UMAXX (urea treated with NBTP and DD), Nutralene, and SCU. A control (no N) treatment was also included. The treatments were replicated four times. The fertilizers were applied at the rate of 1.0 lb N/M.

Twenty-four hours after applying the N, sorption pads containing a glycerol and phosphoric acid solution were suspended over the pots to trap any NH_3 that was volatilized. The pads remained in place for 24 hours. The nitrogen trapped in the pads was extracted and quantified.

Three weeks into the experiment, nitrification data were collected by measuring the amount of soil NO_3- and NH_4^+ before and 2 days after over-watering the pots (125% field capacity) to create conditions favorable to nitrification.

Each week color ratings were made, and clippings were collected, weighed, and analyzed for %N. At the end of the study, roots from each treatment were weighed.

RESULTS

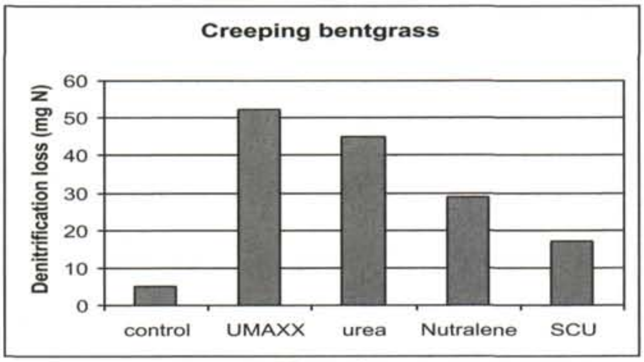
Ammonia Volatilization Loss

UMAXX showed significantly lower N volatilization rates than Nutralene, SCU and Urea on creeping bentgrass (Fig. 1) and was not significantly different from the control treatment (no N applied). On perennial ryegrass UMAXX showed significantly lower volatilization rates than the urea treatments (Fig. 2).

Denitrification Loss of Nitrogen

The denitrification data were somewhat sporadic. Creeping bentgrass fertilized with the NBTP and DD impregnated UMAXX had three times more N denitrified than did the SCU treatment. The UMAXX treatment, however, was found to be not statistically different than the urea treatments in regard to denitrification losses (Fig. 3).

When applied to ryegrass, the UMAXX treatment showed 36% less N denitrification than SCU, and the N loss was not statistically different from the urea treatment (Fig. 4). Among the four fertilizers, denitrification loss of N was least for the Nutralene treatment, suggesting that much of the N in the Nutralene was still in the form of methylene urea.



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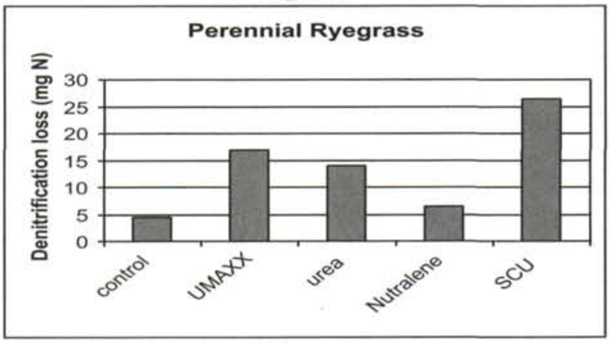


Figure 4

Effects on Turfgrass Color

UMAXX showed color ratings very similar to the other fertilizer treatments on both bentgrass (Fig. 5) and ryegrass (Fig. 6) over the 8-week study. Very little variation was found between treatments.

Effects on Fertilizer N Uptake

At the time this report was prepared, fertilizer N uptake data were available only for the first 4 weeks of the study. On bentgrass, fertilizer N uptake was significantly higher from UMAXX than the urea and SCU treatments during week 1 (Fig. 7). During week 2, UMAXX showed significantly higher N uptake from fertilizer than SCU. During weeks 3 and 4, UMAXX showed significantly higher N uptake from fertilizer than urea.

On ryegrass, fertilizer N uptake was significantly higher from UMAXX than the SCU treatment during week 1 (Fig.8). During week 2, the UMAXX treatment had significantly higher fertilizer N uptake than from urea or Nutralene. UMAXX was not significantly different from the urea, SCU, or Nutralene treatments during week 3. Fertilizer N uptake from UMAXX was significantly higher than from Nutralene during week 4.

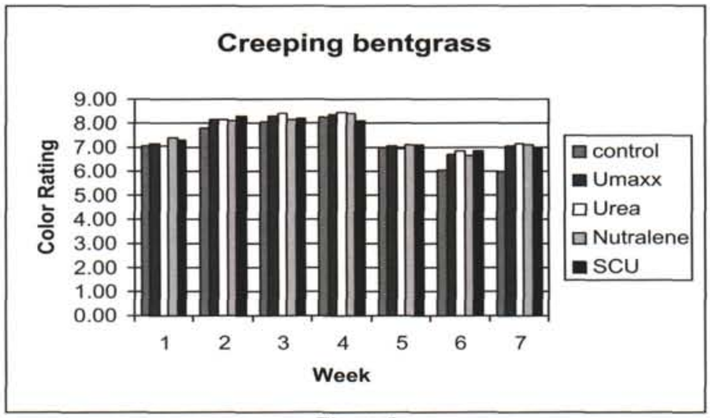
Effects on Root Mass

The root mass of the UMAXX treatment was not significantly different from the urea and SCU treatments for either bentgrass (Fig. 9) or ryegrass (Fig. 10). As expected, the control pots had the highest root mass per pot. This is because nitrogen stimulates shoot growth at the expense of root growth.

Data on turfgrass clipping concentrations of nutrients other than N were not available at the time of preparation of this report.

CONCLUSIONS

The denitrification data failed to show anything that would lead me to believe that DD significantly inhibited nitrification. The failure of DD to be an effective nitrification



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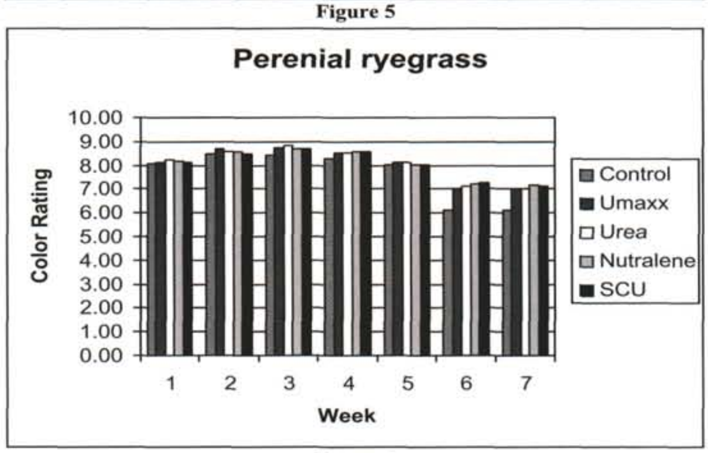

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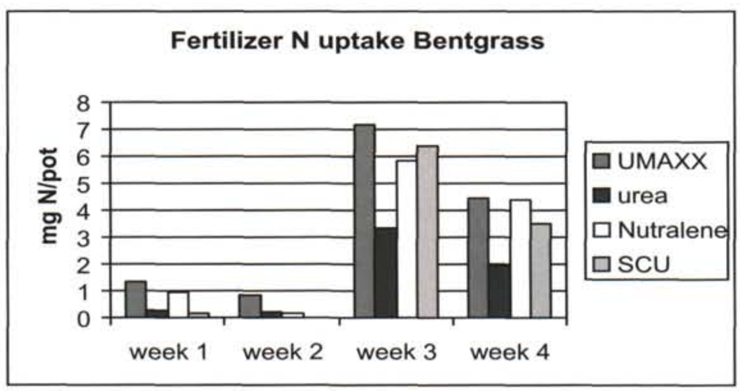

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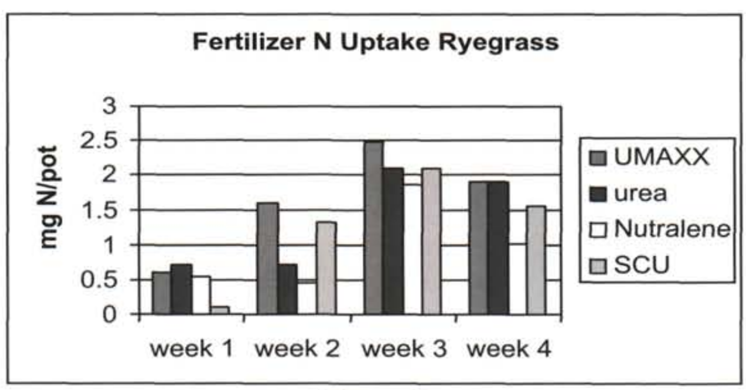

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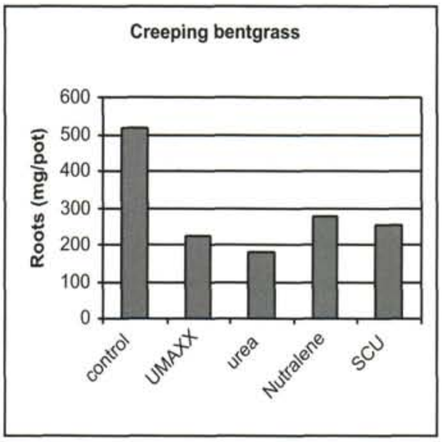

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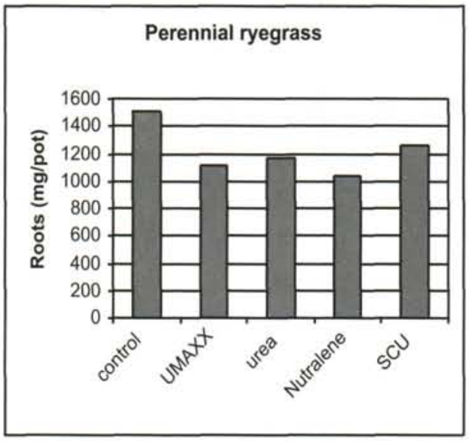

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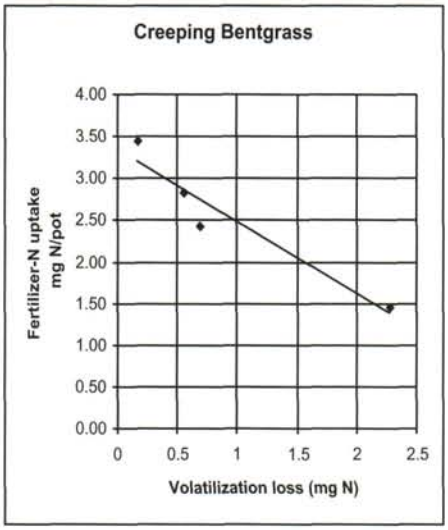

Figure 11

inhibitor is not surprising. Spangenberger et al. (1986) evaluated a 3.2% DD + $(NH_4)_2SO_4$ combination and a 4.6% DD + urea combination, and compared them to $(NH_4)_2SO_4$ and urea alone. While some color and yield differences were observed, they concluded that there was little advantage to including DD in the formulation. Mosdell et al. (1986) made similar comparisons with the same conclusions.

NBTP proved to be effective at reducing N loss due to ammonia volatilization. Volatilization N losses of N from urea applied to bentgrass and ryegrass were over 2 to 13 times greater than the volatilization N loss from UMAXX . The increase in N volatilization of the UMAXX treatment from the bentgrass as compared to the ryegrass could be attributed to particle size differences between the two treatments. The UMAXX applied to the bentgrass had a SGN of 150, while that applied to the ryegrass had a SGN of 237.

There was a strong correlation between N volatilization and fertilizer-N uptake (Fig. 11). This was especially evident in the bentgrass treatments, where UMAXX showed the lowest volatilization loss. The treatments with the highest N volatilization had the lowest fertilizer-N uptake. By reducing N volatilization through the action of NBPT, the efficiency of UMAXX was increased, perhaps to the extent that its rate of application could be less than urea but produce the same level of turfgrass response.

Treatment of urea with DD and NBTP did not seem to have any significant effects on turfgrass color or root mass as compared with the other treatments. This may have been the result of application of the fertilizers at the rate of 1.0 lb N/M. A lower rate of N application would likely have resulted in greater differences among the fertilizer treatments.

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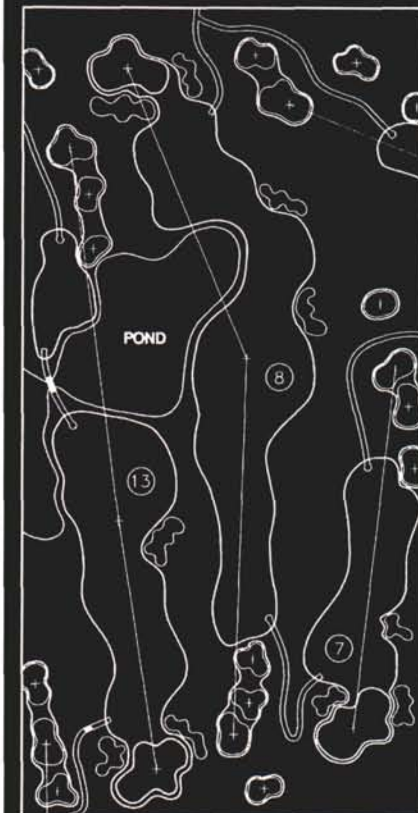

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