PAPER I. THE RESPONSE OF KENTUCKY BLUEGRASS TURF TO
PHENYLPHOSPHORODIAMIDATE (PPD) AND MAGNESIUM (Mg++) APPLIED
IN COMBINATION WITH UREA
The Response of Kentucky Bluegrass Turf to Phenylphosphorodiamidate (PPD) and Magnesium (Mg++) Applied in Combination with Urea

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ABSTRACT

Surface-applied urea involves the risk of considerable nitrogen (N) loss to the atmosphere as gaseous ammonia (NH₃). Among the methods that have been proposed to reduce this N loss are the application of urea with urease inhibitors or the combinations of urea with cationic materials. The objectives of this field test were to observe the effects of the urease inhibitor Phenylphosphorodiamidate (PPD) and the effects of magnesium chloride (MgCl₂) on foliar burn, turf quality, and clipping yield of Kentucky bluegrass turf treated with surface-applied urea. In the heat of July, the Mg⁺⁺ treatment resulted in significant foliar burn, but it reduced burn in the relatively cool temperatures of September. The fresh weight of clippings after treatment with 2% PPD was observed to increase 20 to 31%. This result indicates that 2% PPD can have an effect on the N-use efficiency of surface-applied urea on Kentucky bluegrass turf. Magnesium (Mg⁺⁺) produced a 13% to 25% increase of clipping yield at the rate of 1 lb N/1000 ft² in August and September, but a 20% decrease at the rate of 2 lb N/1000 ft² in August. This result indicates that the cation Mg⁺⁺ may have a positive effect on the reduction of ammonia volatilization and increase urea nitrogen efficiency with low concentration under cool-temperature conditions. However, Mg⁺⁺ may increase phytotoxicity of fertilizer solutions at high concentrations in times of environmental stress.

Additional index words: Urease inhibitors, Cationic material,
Ammonia volatilization, Phenylphosphorodiamidate, Magnesium chloride, Foliar burn, Turfgrass.
INTRODUCTION

The use of urea on turfgrass areas has increased during the past 20 years, and it is now a major source of nitrogen (N) for fertilization programs used on golf courses, home lawns, and athletic fields. Urea can be applied in dry and/or liquid forms. Because of its versatility, liquid fertilization is rapidly becoming the most popular method of applying urea to turfgrasses.

Many researchers, however, have reported that the surface application of urea involves the risk of considerable N loss to the atmosphere as gaseous ammonia (NH$_3$), and field studies have shown urea to be less efficient than other N sources when surface-applied on grass sod (Volk, 1959; Gasser, 1964; Tomlinson, 1970). Laboratory studies have been conducted to investigate NH$_3$ volatilization from urea and the factors which affect it. Among these factors are the urease activity of the soil, pH, temperature, water content, NH$_3$ sorbing capacity of the soil, and rate and method of urea application (Ernst and Massey, 1960; Gasser, 1964; Overrein and Moe, 1967; Tomlinson, 1970; Hargrove and Kissel, 1979; Mulvaney and Bremner, 1981).

In 1983, Torello and Wehner (1983) demonstrated that urease activity within a turf thatch layer and urease activity associated with turfgrass tissue were very high compared with activities in underlying soil. Their findings suggest that, when urea is applied to turf, the high urease levels in thatch could result in greater NH$_3$ volatilization than is normally observed in other types of crop production.
Various compounds capable of reducing gaseous loss of NH$_3$ by retardation of urea hydrolysis in soils have been studied, and many compounds have been patented as urease inhibitors (Bremner and Douglas, 1971b; Mulvaney and Bremner, 1981). Researchers at Iowa State University and the Tennessee Valley Authority have studied the effect of urease inhibitors on transformations of urea N in soils. They found that Phenylphosphorodiamidate (PPD) was the most effective urease inhibitor and have reported that it reduces ammonia volatilization and urea hydrolysis under various environmental conditions (Bremner and Douglas, 1971a, 1971b; Bremner and Mulvaney, 1978; Mulvaney and Bremner, 1981; Marten and Bremner, 1982; Hauck, 1983). East German researchers have demonstrated that PPD improves the urea efficiency in pot experiments with oats, ryegrass, and wheat (Heber et al., 1979; Matzel et al., 1979). In 1983, workers in the Syracuse Research Laboratory studied the role of urease inhibitors in increasing efficiency of surface-applied urea and in increasing corn yield in the field. They demonstrated the greater potential for NH$_3$ losses from reduced-tillage systems and proposed the use of urease inhibitors in keeping these losses to a minimum (Hendrickson et al., 1983; O'Connor et al., 1983; Omholt and Hendrickson, 1983).

Another concept concerning the reduction of NH$_3$ loss from surface-applied urea was presented by Fenn (Fenn et al., 1981, 1982a, 1982b). They have studied the use of Ca$^{++}$, NH$_3$, K$^+$, and Mg$^{++}$ to reduce NH$_3$ volatilization. In the absence of cations, all urea on the soil surface is reported to be converted to other forms of nitrogen in two to three
days. The extremely rapid conversion of urea to ammonium carbonate is believed to be responsible for the high ammonia losses. However, cations in combination with urea are believed to reduce the rate at which urea decomposes. Large quantities of urea in the presence of cations may persist on the soil surface for two or more weeks. The urea combined with cations on the soil surface is thought to be in equilibrium with water and will be immediately released into the soil during a rainfall or irrigation.

The objectives of this initial field test were to observe the effects of the urease inhibitor PPD and the effects of magnesium chloride on foliar burn, turf quality, and clipping yield of Kentucky bluegrass turf treated with surface-applied urea.
MATERIALS AND METHODS

This study was conducted in 1984 at the Iowa State University Turf Research Plots north of Ames, Iowa. The turf used in the study had been established in 1981 on a 'Nicollet' Aquic Hapludoll fine loamy mixed mesic soil with a pH of 7.5, 10 ppm P, 90 ppm K, and 2.3% O.M. with a blend of 25% by weight each of 'Parade', 'Adelphi', 'Glade', and 'Rugby' Kentucky bluegrass (Poa pratensis L.). The turf was watered as needed to prevent drought stress throughout the study.

The investigation was designed in a split-plot with repeated treatments and measurements on the same plot areas in four replications. The main plots included liquid urea applied at 0, 1, and 2 lb N/1000 ft$^2$. The subplots included a control, PPD at 1 and 2% of the weight of N, and Mg$^{++}$, in the form of MgCl$_2$·6H$_2$O at 25% of the weight of N. The treatments were applied monthly in June through September. Each plot measured 25 ft$^2$, and each treatment was applied in the equivalent of 3 gal H$_2$O/1000 ft$^2$ with a CO$_2$ backpack sprayer operated in four different directions to assure uniform application. The degree of damage to turfgrass foliage was estimated visually three days after each application. The rating scale used ranged from 1 to 9; 9 = no visual burn, and 1 = dead turf. Data of visual quality ratings based primarily on color, uniformity, and density were collected on a weekly basis and rated on a scale of 1 - 9; 9 = best quality, 6 = acceptable, and 1 = poorest. Clipping weights were collected weekly for five weeks after each treatment at a 2-inch mowing height from two strips through the
center of the plots measuring 20 inches X 5 feet each. After data were collected, all plot areas were mowed at the 2-inch mowing height and clippings were removed.
RESULTS AND DISCUSSION

The effects of the ammonia volatilization inhibitors on fertilizer burn varied with nitrogen rate and time of application (Table 1). In the heat of July, the MgCl₂ treatment resulted in greater foliar burn in the plots with 2 lb N/1000 ft², but it reduced burn in the treatments with 1 and 2 lb N/1000 ft² in the relatively wet conditions and cool temperatures of September. The PPD reduced burn significantly at 1 lb N/1000 ft² in September, but those effects were not consistent across all application dates (Table 1, Figure 1).

Visual turf quality increased with increasing N rate, however, the effect varied with month of application (Table 1, Figure 2). Plots treated with PPD at 2% of the weight of N had higher quality ratings than plots receiving other inhibitor treatments (Table 1). This effect was most evident in September, although even that effect was quite small (Figure 2).

Clipping yield increased with increasing rates of N, although the response varied with month of application (Table 1, Figure 3). Where no urea was applied, there was no effect of PPD or Mg⁺⁺ on clipping yield and quality of Kentucky bluegrass (Figure 2, Figure 3). The average fresh weight of clippings over a five-week period in plots treated with 2% PPD increased 28% at 1 lb N/1000 ft² in August, 31% at 1 lb N/1000 ft² and 20% at 2 lb N/1000 ft² in September (Figure 3). This result indicates that 2% PPD can have an effect on the nitrogen efficiency of surface-applied urea on Kentucky bluegrass turf. Magnesium chloride
treatments showed a 13% to 25% increase of the fresh clipping yield at 1 lb N/1000 ft$^2$ in August and September, but a 20% decrease at 2 lb N/1000 ft$^2$ in August. These results indicate that the cation Mg$^{++}$ may have a positive effect on urea nitrogen efficiency with low concentrations under cool temperature conditions. However, Mg$^{++}$ may increase phytotoxicity of fertilizer solutions at high concentrations in times of environmental stress.
CONCLUSIONS

The results of this study do not prove that NH$_3$ volatilization was decreased by any of the inhibitor treatments; however, the positive effects of the 2% PPD and the Mg$^{++}$ treatments on the clipping yield and turf quality would indicate that, under some conditions, a reduction of N loss and an increase in N-use efficiency are possible when these materials are combined with liquid urea applications on Kentucky bluegrass turf.

More detailed studies are under way to further measure the effects of these treatments on turfgrass growth and quality and to measure the quantity of NH$_3$ volatilized from turfgrass areas treated with these materials.


Table 1. The analysis of variance for burn rating, turf quality, and clipping yield as affected by nitrogen levels, inhibitors (PPD, Mg^{++}) and month treated

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>df</th>
<th>Mean Squares</th>
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</thead>
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<td></td>
<td></td>
<td>Burn rating</td>
</tr>
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<tr>
<td>Inhibitors</td>
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</tr>
<tr>
<td>Control vs. Mg^{++}</td>
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</tr>
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<td>Control vs. PPD 1%</td>
<td>(1)</td>
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<tr>
<td>Control vs. PPD 2%</td>
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<td>0.13</td>
</tr>
<tr>
<td>Nitrogen X inhibitors</td>
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<td>0.34</td>
</tr>
<tr>
<td>Month treated</td>
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<tr>
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<tr>
<td>Month X N X inhibitor</td>
<td>18</td>
<td>4.42 *</td>
</tr>
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</table>

*, **Significant at the 0.05 and 0.01 probability levels, respectively.
Figure 1. The effects of inhibitors on foliar burn of Kentucky bluegrass turf treated with surface-applied urea

Liquid urea was applied at 0 (NO), 1 lb N/1000 ft² (N1), and 2 lb N/1000 ft² (N2).

The rating scale used ranged from 1 to 9; 9 = no visual burn, and 1 = dead.
Figure 2. The effects of inhibitors on turf quality of Kentucky bluegrass turf treated with surface-applied urea

Liquid urea was applied at 0 (NO), 1 lb N/1000 ft$^2$ (N1), and 2 lb N/1000 ft$^2$ (N2).

The rating scale used ranged from 1 to 9; 9 = best quality, 6 = acceptable, and 1 = poorest.
Figure 3. The effects of inhibitors on clipping yield of Kentucky bluegrass turf treated with surface-applied urea

Liquid urea was applied at 0 (NO), 1 lb N/1000 ft$^2$ (N1), and 2 lb N/1000 ft$^2$ (N2).

Clipping yields are based on fresh weight from the area of 16.7 ft$^2$ (1.5 m$^2$).