Calcium Nitrate Promotes Best Perennial Ryegrass Stand

By Min Liu

Many different sources of N (nitrogen) are used in the turfgrass industry. They are generally classified as quick-release and slow-release sources. Quick release N sources are water soluble and contain N in the NO_3^- (nitrate) or NH_4^+ (ammonia) form. Nitrate-N is immediately available for plant uptake but is also easily leached from the soil. Ammonium nitrate is less prone to leaching but more prone to volatilization.

Nitrification of NH_4^+ to NO_3^- is fairly rapid in most soil conditions, and acidity will be generated during the process. Plant uptake of N in the form of NH_4^+ verses NO_3^- will have consequences on the pH of the surrounding soil solution. Riley and Barber (1969) reported a pH increase of the root-soil interface environment was associated with the supply of NO_3^- in the soil solution.

Different N sources and rates influence turfgrass growth. Hummel (1980), using several N sources, reported that 97 kg of N per hectare provided darker color and more rapid establishment of Kentucky bluegrass than 48 kg of N per hectare. Root growth will increase as N levels increase above zero (Canway, 1984). However, high levels of available N will stimulate shoot production and growth, thus limiting the quantity of stored carbohydrates available for protein synthesis. High available N has been shown to cause a distinct suppression in root growth (Schmidt and Blaser, 1967). The objective of this study is to investigate the effect of N source and rate on perennial ryegrass shoot growth, tissue N concentration, turf quality and sand media pH.

Material and methods

Ammonium sulfate [$(NH_4)_2SO_4$], ammonium chloride (NH_4Cl) and calcium nitrate [$Ca(NO_3)_2$] were the three N sources used. Four rates of each N source were selected: 2.5; 5; 10; 20 grams N per square meter. Treatments with three replications were arranged in a randomized complete block design. USGA-uncoated sand was used as the growth medium. The container was 6-inches tall and 6 inches in diameter with five small holes at the bottom for free air exchange. Calculated quantity of water was added to each pot to bring the water content to the field capacity. The moisture level was maintained approximately at 80 percent field capacity during the whole study period.

Ryegrass seeds were applied at 2.1 grams to each pot for germination. Fertilizer treatments were applied to corresponding pots in liquid form with a hand held boom sprayer four days after seed germination.

Clippings for dry matter production were taken twice during the study, once the dry matter production reached harvestable quantities. The turf quality was recorded each time prior to the harvest. Turfgrass was clipped at about 8 millimeters with hand scissors. Plant tissue was dried at 70 degrees Celsius for a period of 48 hours, ground to 2 mm mesh size. Total N in plant tissue was analyzed.

Soil samples were collected at the end of the study by taking a single core sample (3-centimeter diameter) from each pot. Soil samples were air-dried and screened through a 2-mm sieve. Soil was analyzed for pH (2:1 water to soil ratio). Statistical analysis was performed using SAS for Analysis of Variances (SAS institute, 1987). Single degree of freedom contrasts were used to separate the means based on the general linear model procedure.

Influences of N source and rate

The tissue N concentration increased with the increased N applications from 2.5 grams to 20 grams N per square meter across all three N sources (Figure 1).

The highest tissue concentration was 5.6 percent gained by application of NH_4Cl at rate of 20 grams N per square meter. The contrast procedure in the statistical analysis software revealed that the growth rate and N uptake were significantly influenced by N source with a statistical p value, representing the probability of error, of less than 0.01 (Table 1). The NH_4Cl treated pots gained the lowest growth rate and $Ca(NO_3)_2$ treated pots had the highest growth rate among the three N sources, which may explain the general low tissue N concentrations when subject to $Ca(NO_3)_2$.

Tissue growth rates with application of NH_4Cl fell continually with higher N rates from 2.5 grams to 20 grams N per square meter. This might be due to toxicity of NH_3 volatilized from NH_4^-. Tissue growth rates decreased with $(NH_4)_2SO_4$ rate increased from 5 to 10 grams N per square meter. This observation was against Hummel in 1980, who reported faster establishment of bluegrass with 10 grams N per square meter than 5 grams N per square meter. This was possibly due to water stress after the first harvest in our study.

The first harvest was taken on Friday, and the pots were subject to a very hot weekend. The pots with higher N rates experienced water shortage because of the elevated osmotic water potential in rootzone. Moreover, the higher rate N application led to good top growth but limited root growth before the first harvest. When subject to water stress it was difficult for limited roots to absorb restrained water they needed.

For the treatments with $Ca(NO_3)_2$, growth rate increased with the increased N rates from 2.5 grams to 10 grams N per square meter, but decreased dramatically from 10 grams to 20 grams N per square meter because of elevated salt stress when water was limited. Compared to $(NH_4)_2SO_4$, the detrimental effect of salt stress was relatively mild because $Ca(NO_3)_2$ has much smaller salt index value.

The NH_4Cl treated pots took up an average 1.4 grams N per square meter across all N rates, which was the lowest compared with 1.9 grams and 2.4 grams N per square meter for $(NH_4)_2SO_4$ and $Ca(NO_3)_2$ respectively. Perennial ryegrass N uptake as influenced by N rate was shown in Fig. 3.

Higher N recovery occurred in the clippings with N application of 2.5 grams N per square meter compared with higher rates of N application. Multiple N applications with relatively small amount each time were beneficial for N recovery in plant uptake. For $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, N uptake increased with N rates from 2.5 grams to 10 grams N per square meter and then decreased from 10 grams to 20 grams N per square meter, suggesting that N application gained no growth beyond the rate of 10 grams N per square meter. For NH_4Cl, N uptake decreased continually with N rate increased from 2.5 grams to 20 grams N per square meter, which was possibly resulted from NH_3 toxicity and elevated salt stress in rootzone.

FIGURE 1

Ryegrass tissue N concentration as influenced by N source and rate

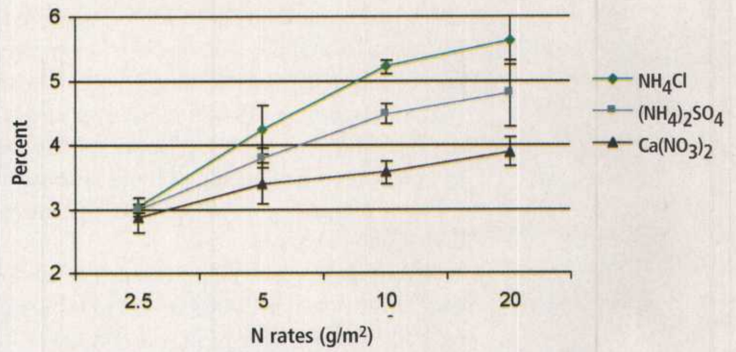


FIGURE 2

Turf quality as influenced by N source and rate

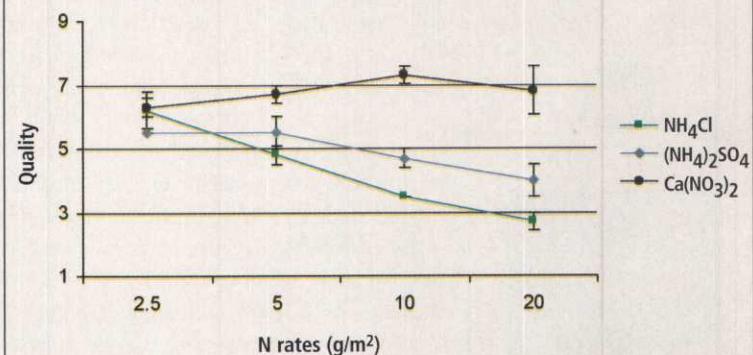
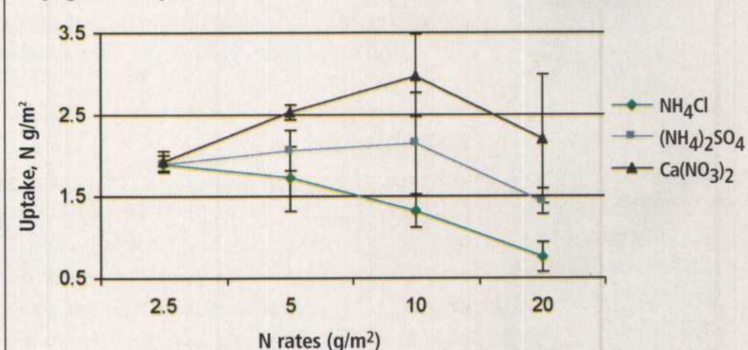


FIGURE 3

Ryegrass N uptake as influenced by N source and rate



Turf quality and media pH

Analysis of variance revealed that the turf quality was significantly influenced by N source and rate at probability level of 0.001. Application of $Ca(NO_3)_2$ gained the best turf quality on average with value of 6.8, compared $(NH_4)_2SO_4$ 4.9 and NH_4Cl 3.4, respectively (Figure 2).

The best turf quality on individual treatment was 7.3 attained by application of $Ca(NO_3)_2$ at rate of 10 grams N per square meter. Use of $(NH_4)_2SO_4$ and NH_4Cl in this study generally led to nonsatisfactory turf quality, particularly

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when high rates were applied. This observation was possibly due to higher salt index values for $(NH_4)_2SO_4$ and NH_4Cl and toxicity of NH_3 volatilized from NH_4^-. Therefore, when subject to water shortage and salt stress, N sources with high salt index values like NH_4Cl should be avoided. High rate of NH_4-N applications were not recommended in high pH soils because of NH_3 volatilization, which could be concentrated enough to be toxic.

Analysis of variance revealed that at the probability level of 0.0001 media pH was significantly affected by N source and rate.

The pH of USGA sand was 6.5. At the end of the study, media pH treated with NH_4Cl and $(NH_4)_2SO_4$ dropped to 6.0, while media pH treated with $Ca(NO_3)_2$ rose to 6.8. The media pH dropped with NH_4Cl and $(NH_4)_2SO_4$ application. This was expected because of nitrification process, in which H^+ ions were generated.

Furthermore, plants would exude the H^+ ion when the NH_4^+ ion was taken up. The media pH increased with $Ca(NO_3)_2$ application, which was also reasonable because plant roots would exude OH^- for NO_3^- uptake. For $Ca(NO_3)_2$ treatments, pH slightly increased with N rate increasing from 2.5 grams to 5 grams N per square meter, stayed unchanged to 10 grams N per square meter, and then dropped dramatically after 10 grams N per square meter. This pH changing pattern matched quite well with the corresponding uptake pattern, which suggests the reason for pH change was root OH^- exudation from NO_3^- uptake.

Conclusions

Among the three selected N sources, $Ca(NO_3)_2$ application gave the best turf quality, greatest growth rate and N uptake, which suggests it is a good N choice for perennial ryegrass subject to salt stress and limited water conditions. High N rate of 20 grams N per square meter was detrimental to turf growth.

High rates of NH_4Cl application were not recommended in any circumstance. N source of $(NH_4)_2SO_4$ might be good, but problems in situations with salt stress and water shortage should be anticipated.

Higher N recovery occurred in the clippings with N application rate of 2.5 grams N per square meter compared with higher N rates, suggesting multiple N applications with relatively small quantity each time were recommended for the best N management practice.

Min Liu is a graduating Ph.D. student in the Soil and Water Science Department at the University of Florida, which supported this research. Liu's interests include soil fertility and turfgrass nutrition.

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