Temporal Variation of Amino Sugar Nitrogen in Turfgrass Soils

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Abstract

Nitrogen (N) fertilization of turfgrass continues to be scrutinized due to environmental concerns. Practices that reduce fertilizer inputs without sacrificing turfgrass quality are needed. However, a reliable test of N status in turfgrass is not currently available. The Illinois soil N test has been developed to predict crop response to applied N by measuring the amount of amino sugar N in the soil. Amino sugar N does not fluctuate as rapidly as other forms of N in agricultural soils. The objectives of this study were to determine the temporal variation of soil amino nitrogen in managed turfgrass systems and the contribution of thatch to amino sugar N levels. Studies were established in 2004 and 2008 to examine both the contribution of thatch and seasonal fluctuation of amino N in a Kentucky bluegrass soil profile. Replicate soil cores were tested weekly for 52 weeks during each study. There was no net change in the amino N concentration of the soil during the study period. No significant differences (P=0.05) in amino N concentration were detected due to fertilizer application on any of the weekly sampling dates either in 2004. Thatch accounted for 9% of the total amino N in the top 15 cm of soil. Our results indicate that the Illinois Soil N Test may have value for identifying sites that will be either unresponsive to added fertilizer nitrogen, or, at increased risk for nitrate leaching due to added fertilizer N.

Introduction

- The fertilizer practices of the turfgrass industry continue to be scrutinized and regulated due to environmental concerns and public perception.
- The current practice when growing turfgrass is to apply nitrogen fertilizer based either on a predetermined schedule, regardless of actual need, or, on a visual assessment of turfgrass quality. Neither soil nor plant tissue testing is routinely used to evaluate N fertilizer needs because most forms of nitrogen are too dynamic in a plant-soil system to be accurate and reliable predictors of available nitrogen.
- Turfgrass management practices that could reduce fertilizer inputs without sacrificing turfgrass quality would demonstrate environmental stewardship and the added benefit of reducing maintenance expenditures.
- The Illinois Soil Nitrogen Test was developed to identify sites in production agriculture that are non-responsive to nitrogen fertilizer inputs. The test measures the fraction of nitrogen in the soil that is in amino sugar forms. This fraction is thought to not fluctuate as rapidly in the soil as nitrate or ammonia nitrogen, thus making it a better predictor of season-long nitrogen fertility requirements.
- Our long term goal is to determine if the Illinois soil N test can be used to predict how much nitrogen is potentially available to the turf from organic nitrogen associated with thatch and to determine if this can be correlated to turfgrass response to N fertilizer and thus reduce unnecessary N inputs on unresponsive sites.

Objective

To determine the short and long term temporal variation of soil amino sugar nitrogen in managed turfgrass systems.

Materials and Methods

Temporal Variability Study

- A study was established in April, 2004 as a randomized complete block with unfertilized plots or plots that were fertilized in Apr, May, Aug, and Nov with 48.8 kg N ha^{-1} with urea/sulfur-coated urea (40%/60%, 20-4-12). Two cores were collected from each 3 m^2 plot once per week and stored for analysis.
- A study was established in July 2008 as a randomized complete block with unfertilized plots, Two cores were collected from each 3 m^2 plot once per week and stored for analysis.

Long Term Variability - Michigan State University Study

- In 1998, microplot lysimeters constructed of 20 cm diam. schedule 40 PVC were installed using a hydraulic press
- From July 1998 through 2002, lysimeters were treated annually with urea at a low N rate 98 kg N ha^{-1} (24.5 kg N ha^{-1} $application^{-1}$) and a high N rate of 245 kg N ha^{-1} (49 kg N ha^{-1} $application^{-1}$). In 2003 the N rate was reduced to 196 kg N ha^{-1} for the high N rate while the low N rate remained at 98 kg N ha^{-1}.
- Lysimeters were removed from the low and high N treatment areas periodically. The PVC cylinder was removed with a saw and the soil core was sectioned into 4 depths: 0-5, 5-10, 10-20, and 20-40 cm. The 0-5 cm soil samples were not available for this analysis.

Laboratory Analysis

- Each core was dried for 48 hr at 40°C. The thatch was separated from the soil and each fraction was then weighed and ground with a Willey Mill to pass through a 2 mm sieve. The dried samples were then stored for analysis.
- Each soil or thatch sample was analyzed using the methods of Kahn et al. (2001) (Fig. 1).
- Proc GLM was used to analyze the weekly differences between fertilized and unfertilized plots.

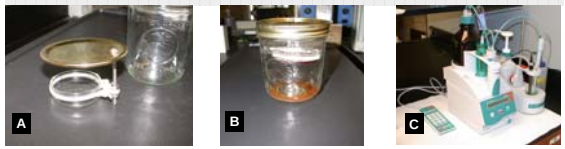

Figure 1. (A) Diffusion unit used to measure soil amino nitrogen content using the methods of Kahn et al. (2001). One g of soil is added to the mason jar with 10 mL of 2 N sodium hydroxide. (B) A petri dish suspended from the jar lid contains 5 mL of boric acid (4% w/v). The unit is placed on a hot plate at 50° C for 5 hours. (C) After heating, the petri dish is removed, 5 mL of distilled water is added, then the solution is titrated with 0.02 N H_2SO_4. Amino N content is calculated as S x T = amino N PPM, where S is the volume of H_2SO_4 and T is the titer (280 µg mL^{-1} for 0.02 N H_2SO_4).

Results

Temporal Variability Study - 2004

- There was a net 6% decrease in the amino sugar N concentration of the soil during the study period (Fig. 2).
- The mean weekly fluctuation of amino sugar nitrogen was 9%. The maximum difference was a 27% increase observed between 8 Dec and 15 Dec 2004. However, the weekly difference was less than 5% on 14 of the 45 sampling dates. The coefficient of variation averaged 13% during the study, indicating that the variation in amino sugar N concentration within the sampling area was relatively small.
- Thatch accounted for a mean of 9% of the total amino nsugar itrogen, but was highly variable (CV=41%, Data not shown). Our current recommendation is to discard the thatch layer when analyzing for amino sugar nitrogen.
- No differences in amino nitrogen concentration were detected due to fertilizer application on any of the 22 sampling dates between 16 Apr and 16 Sep 2004 (Fig. 3).

Temporal Variability Study - 2009

- There was a net 18% decrease in the amino sugar N concentration of the soil during the study period (Fig. 4).
- The mean weekly fluctuation of amino sugar nitrogen was 8%. The maximum difference was a 20% increase observed between 17 July and 24 July 2008. However, the weekly difference was less than 5% on 21 of the 50 sampling dates. The coefficient of variation averaged 5% during the study.

Long Term Variability - Michigan State University Study

- No differences in amino nitrogen concentration were detected due to fertilizer application during the study (Fig. 5).
- The amino sugar nitrogen concentration was highest in the 5-10 cm soil layer and decreased in concentration as depth increased

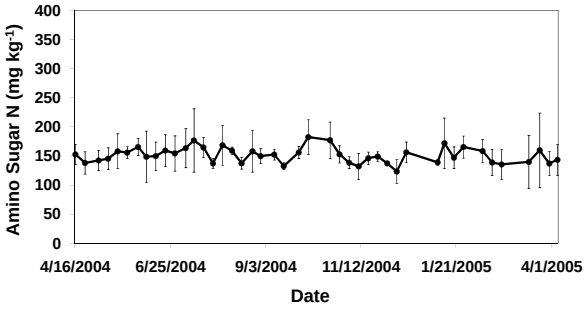

Figure 2. Seasonal variation in amino nitrogen content in 2004-2005. Two cores were taken weekly from each of 3 replicate plots and analyzed (n=6). Error bars denote standard deviation of the means.

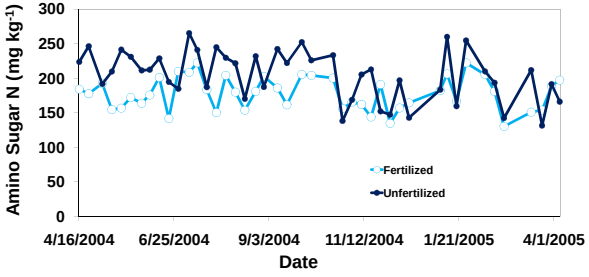

Figure 3. Seasonal variation in amino nitrogen content as affected by fertilizer application. Plots were divided into 3 replications, from which 2 cores were taken and analyzed (n=6). No statistically significant differences were observed on any date.

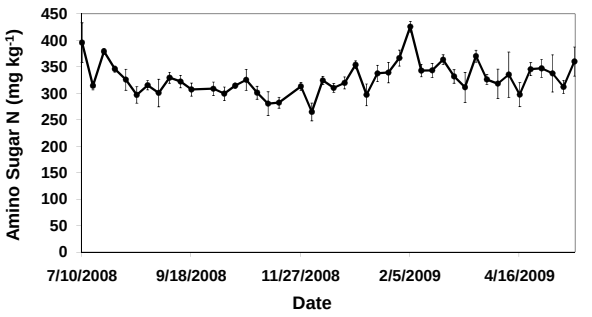

Figure 4. Seasonal variation in amino nitrogen concentration in 2008-2009. Two cores were taken weekly from each of 3 replicate plots and analyzed (n=6). Error bars denote standard deviation of the means.

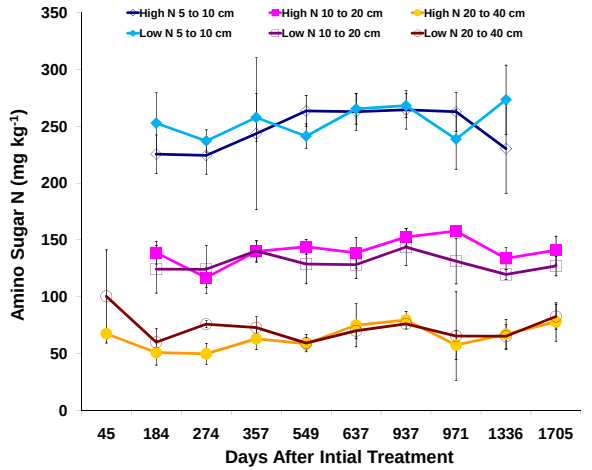

Figure 5. Long term variation in amino sugar nitrogen (N) content as affected by fertilizer application to lysimeter plots at Michigan State University between 2000 and 2005. No statistically significant differences due to the addition of fertilizer were observed on any sampling date. Four subsamples were analyzed from each nitrogen/depth plot (n=4).

Conclusions

1. The level of amino sugar nitrogen in the soil fluctuated very slowly over time in both of the Ohio tests, as well as the long term study at Michigan State. The weekly variability in amino sugar nitrogen was less than what is often observed when measuring soil nitrate nitrogen.

2. The addition of fertilizer to the turf had no measurable short-term or long term affect on the level of soil amino N. However, an ammoniacal fertilizer may have caused increases, because the test measures ammoniacal as well as amino sugar nitrogen in soil.

3. The Illinois Soil Nitrogen Test may have value for identifying those sites that will be non-responsive to nitrogen fertilization. We are attempting to identify a critical value of amino nitrogen, above which a response to added fertilizer would not be expected.

4. Further research is necessary to determine if the Illinois Soil Nitrogen Test can be used to make fertility recommendations to improve nitrogen use efficiency in turfgrass.

References

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