Using the Illinois Soil Nitrogen Test on turf

A soil test may help superintendents decrease nitrogen fertility use.

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Turfgrass fertilization continues to be scrutinized and regulated because of environmental concerns and public perception. Phosphorus and potassium fertilizer recommendations are usually based on the results of a soil test. However, neither plant tissue nor soil testing is routinely used to evaluate nitrogen fertility needs (3) because of the complexity of the nitrogen in the soil (Figure 1).

Soil nitrate nitrogen is both spatially and temporally variable because of mineralization, immobilization, nitrification, leaching, denitrification and plant uptake. These processes are further influenced by soil water content, soil temperature and plant growth (3). 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.

Reducing nitrogen inputs

There is concern that turfgrass fertilization contributes to groundwater pollution (7). The majority of research has indicated that turfgrass fertilization with nitrogen poses little risk to the environment. Most of this research has been conducted on newly established turfgrass plots.

Nitrogen cycle

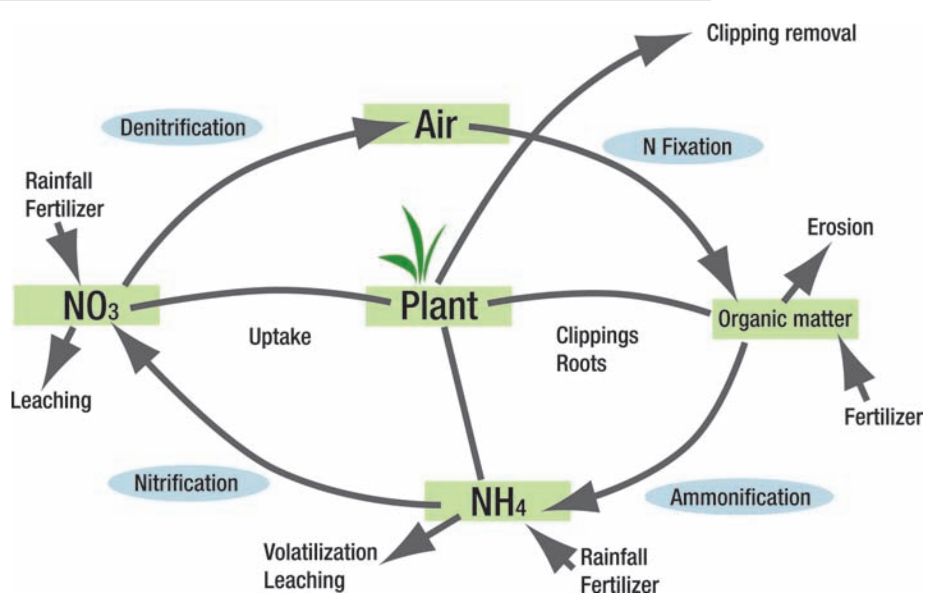

Figure 1. The complexity of the nitrogen cycle in turfgrass and other crops has hindered efforts to develop a reliable soil test for nitrogen.

However, it was recently reported that ^{15}N-labeled urea was detected in the leachate from a 10-year-old Kentucky bluegrass turf (1), suggesting that on older turf surfaces, mineralization of organic nitrogen fractions may exceed immobilization of fertilizer nitrogen.

Therefore, turfgrass management practices that could reduce nitrogen fertilizer inputs without sacrificing turfgrass quality would not only demonstrate environmental stewardship but also reduce maintenance expenditures. To accomplish this task, researchers have been testing anion exchange resins to measure nitrate nitrogen in the soil (6). These vinyl strips attract negatively charged ions like nitrate, NO_3^-. Essentially, the use of anion exchange resins provides superintendents a sense of plant-available nitrogen at time of sampling. To reduce nitrogen inputs, superintendents need a more stable test that is not as susceptible to spatial and temporal variability. A second method for reducing nitrogen fertilizer inputs involves using stored nitrogen in the soil that will mineralize (that is, organic nitrogen will convert to plant-available nitrogen). Researchers (5) have estimated that up to 3 pounds of nitrogen per 1,000 square feet could be released from mineralization of organic nitrogen in a mature bermudagrass system during a May-to-October growing season.

However, the two soils studied released considerably different amounts of inorganic nitrogen. Compared to a mature turfgrass system, recently established turfgrass with reduced organic matter accumulation would supply a lower amount of mineralized nitrogen. Use of a soil test that could measure organic nitrogen in the soil is desirable. Furthermore, overapplication of nitrogen fertilizers might be reduced if estimates of mineralizable nitrogen were available. Use of a soil test — rather than the current practice of applying nitrogen based on visual appearance — could also result in more-quantitative nitrogen-fertility recommendations.

Illinois Soil Nitrogen Test

The Illinois Soil Nitrogen Test (ISNT), which was developed by Richard Mulvaney of the University of Illinois, identifies sites in production agriculture that are not responsive to nitrogen fertilizer. The test measures amino sugar nitrogen fractions in the soil organic nitrogen pool, which supplies the plant with nitrogen through mineralization.

Amino sugar nitrogen is relatively stable compared to nitrate (NO_3^-) and ammonia (NH_4^+), thus making it a better predictor of season-long nitrogen-fertility requirements (9). Superintendents could use this information to predict soil nitrogen availability to the plant. The potential advantages of this test are that soil nitrogen availability could be predicted and this information could be used to adjust fertilizer rates. Timing of soil sampling may be less important because amino sugar nitrogen fraction does not fluctuate as much as other forms of soil nitrogen.

However, the variability of amino sugar nitrogen over space and depth in a managed turfgrass system is not currently known. For the ISNT to be useful, one must be able to sample such that the spatial variability does not interfere with the interpretation of the test result. Therefore, our objective was to determine the spatial variation of soil amino sugar nitrogen in managed turfgrass systems in order to determine sampling recommendations.

Materials and methods

To determine the spatial variation of amino nitrogen in the soil, soil samples were collected from two fairways on each of two golf courses in Minnesota and analyzed for amino sugar nitrogen concentration. Heritage Links Golf Course in Lakeville, Minn., is a more recently established course (approximately 10 years old). The original farm land was significantly altered during construction of the course. Midland Hills Country Club in Roseville, Minn., is about 85

A hydraulic probe was used to collect soil cores from fairways in 2003 and 2004.
Photo by B. Horgan

A diffusion unit was used to measure soil amino nitrogen content. (**A**) One gram of soil or a 0.2-gram sample of thatch was added to a Mason jar with sodium hydroxide. A petri dish containing 5 milliliters of boric acid indicator solution was suspended from the jar lid. (**B**) The sealed unit was placed on a hot plate at 118 F-122 F (48 C-50 C) for 5 hours. (**C**) After heating, the petri dish was removed, 5 milliliters of distilled water was added, and the solution is titrated with sulfuric acid. Amino nitrogen content is calculated as $S \times T$ = amino nitrogen ppm, where S is the volume of sulfuric acid and T is the titer. **Photos by D. Gardner**

years old. Fairways at both courses were mowed at 0.5 inch (1.2 centimeters) and maintained for golf play. Annual nitrogen fertilizer inputs ranged from 111.5 to 119.5 pounds/acre (125 to 134 kilograms/hectare) for Midland Hills CC and 143 to 175 pounds/acre (160 to 196 kilograms/hectare) for Heritage Links GC. Soil cores were collected on 30-foot (9.1-meter) centers to a depth of 18 inches from two fairways on each golf course using a 1.5-inch-diameter hydraulic probe mounted on a utility vehicle. The leaf tissue and thatch were removed, and then each core was separated into three sections by depth: 0-6 inches (0-15 centimeters), 6-12 inches (15-30.5 centimeters) and 12-18 inches (30.5-46 centimeters). Each section was weighed, dried and then stored for analysis.

Each sample was analyzed using established methods (3,4).

In order to determine the uniformity of amino sugar nitrogen distribution on the fairways, general geostatistical methods were used, and maps were generated using an interpolation technique called *ordinary kriging* (2). To test for a spatial correlation in amino sugar nitrogen levels between depths for a given fairway, the data were analyzed.

Spatial variability of amino sugar nitrogen in fairways

Kriged maps of the four sampled fairways in Minnesota showed that the two fairways from Heritage Links displayed a greater degree of spatial heterogeneity than the two fairways from Midland Hills at all sampling depths (Figure 2). We also found no correlation between soil depths, meaning that the concentration of amino sugar nitrogen did not decrease uniformly as depth increased (Figure 3).

Because certain forms of nitrogen can move through the soil profile, our goal in analyzing the different depth fractions was to determine whether there had been any differential movement of nitrogen to a deeper soil depth before being converted to organic nitrogen. Amino sugar nitrogen did not decrease uniformly with increasing soil depth, and this may make interpretation of the test results more difficult in certain applications.

However, for routine use of the test, we believe that standard practices for gathering soil cores for analysis of other nutrients will be acceptable when analyzing for amino sugar nitrogen. Care will be needed to develop a specific and uniform guideline as to the depth of core to take when analyzing for amino sugar nitrogen. To further develop site-specific nitrogen fertilizer applications, our data suggests bulking soil from four or five locations within a 328-foot (100-meter) section of each fairway.

Amino sugar nitrogen

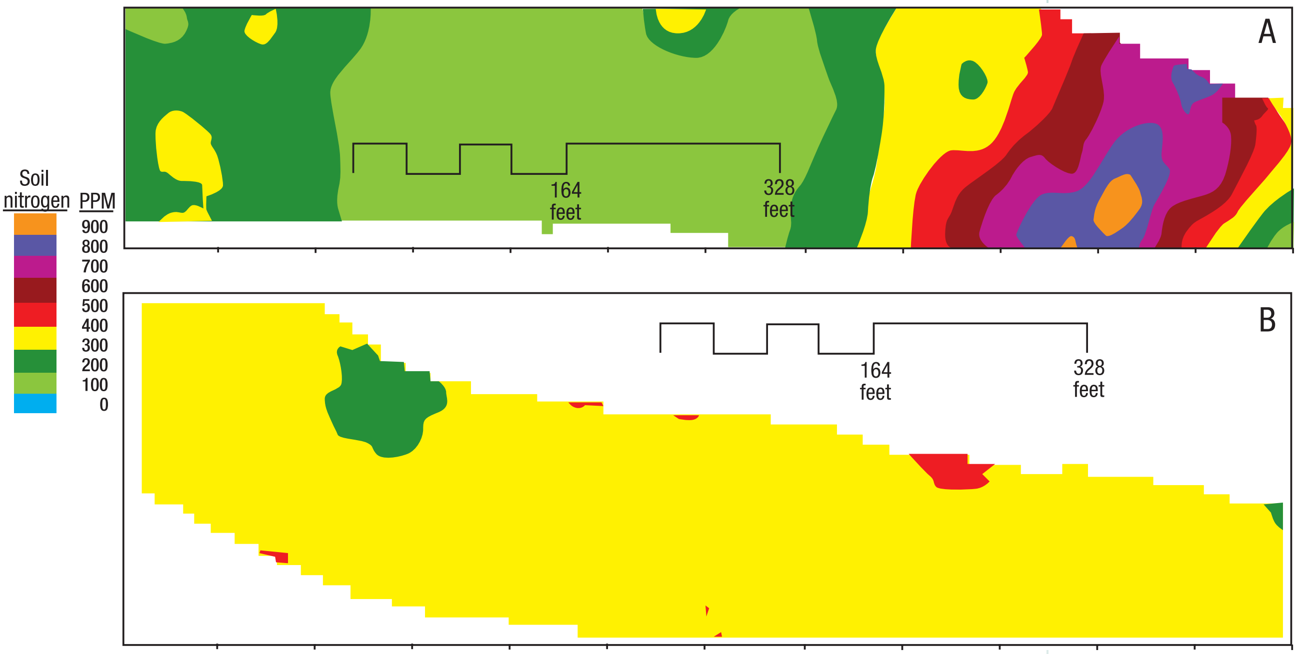

Figure 2. Spatial variability of amino sugar nitrogen on fairways of two Minnesota golf courses. More spatial variability and lower overall values were measured on a fairway at Heritage Links (**A**), which is a newer golf course. Midland Hills (**B**) is an older course with a more uniform distribution and overall higher levels of amino sugar nitrogen.

Amino sugar nitrogen at two sites

The fairways at Midland Hills showed consistently high concentrations of amino sugar nitrogen in the samples, compared to previously published values in agriculture and our observations at other turfgrass sites. Forty-six samples from Midland Hills fairway No. 2 showed concentrations of amino sugar nitrogen ranging from 338 ppm to 450 ppm, while 20 sampling locations interspersed throughout the fairway showed lower amino sugar nitrogen concentrations ranging from 225 ppm to 338 ppm (Figure 2). Midland Hills fairway No. 14 had slightly lower amino sugar nitrogen concentrations than Midland Hills fairway No. 2.

In contrast, the fairways at Heritage Links were considerably more variable over space, and displayed a large range of amino sugar nitrogen concentrations (Figure 2). Heritage Links fairway No. 3 had a sample with an amino sugar nitrogen concentration of 952 ppm and also 14 samples with high amino sugar nitrogen concentrations ranging from 474 ppm to 953 ppm among samples located on the easternmost (right side) of the fairway. Heritage Links fairway No. 13 had a sample with the lowest amino sugar nitrogen concentration measured at the 0-6 inch (0-15 centimeter) depth (73 ppm) (Figure 3). Heritage Links fairway No. 13 also had 16 sample locations on each end of the fairway with lower amino sugar nitrogen concentrations (73 ppm-256 ppm), and these concentrations increased toward the middle section of the fairway. There were 11 samples around the middle section of the fairway with higher amino sugar nitrogen concentrations ranging from 384 ppm to 512 ppm (Figure 3).

Spatial variability of amino sugar nitrogen

Heritage Links is a relatively young site. A considerable amount of soil movement occurred during golf course construction at the site, which may be the reason for its greater degree of spatial heterogeneity. According to earlier work (8), immo-

For more information about the Illinois Soil Nitrogen Test and a list of laboratories that can perform the test, go to:
http://illinoissoilntest.nres.uiuc.edu/request.html

Heritage Links, fairway No. 13

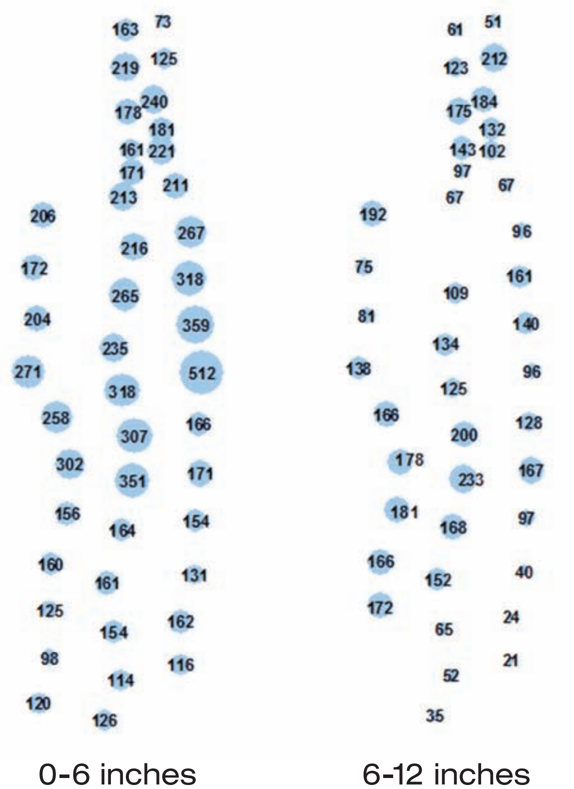

Figure 3. Comparison of amino sugar nitrogen values from the upper 6 inches (**left**) of soil and the 6-12 inch (**right**) soil horizon on Heritage links fairway No. 13. The amount of amino sugar nitrogen in the top 6 inches of soil was not related to the amount of amino nitrogen found at lower sampling depths.

bilization of applied fertilizer nitrogen occurs for a defined period following turfgrass establishment. The age of Heritage Links falls into the period described in this earlier research (8), and the amino sugar nitrogen concentrations may not have reached a point where mineralization will yield added inorganic nitrogen for plant uptake.

The higher overall amino sugar nitrogen values observed at Midland Hills, compared to Heritage Links, may be due to the older age of the turfgrass stand on the Midland Hills fairways, and the routine fertility practices during Midland Hills' history. The relatively high concentration of amino sugar nitrogen in the samples from Midland Hills indicates a significant amount of potentially mineralizable nitrogen present in these soils. Future research will determine the effect of amino sugar nitrogen concentrations and added nitrogen fertilizer on turfgrass responsiveness.

Comparing amino sugar nitrogen to soil organic matter

There was a correlation between amino sugar nitrogen and soil organic matter content, and this was more apparent on the more spatially variable fairways at Heritage Links. The association between amino sugar nitrogen concentration and organic matter was lower on the older, more uniform fairways of Midland Hills. However, although there was a correlation between organic matter and amino sugar nitrogen within each golf course, the course that had higher mean amino sugar nitrogen values also had lower mean organic matter values. The mean amino sugar nitrogen concentration at Heritage Links was 326 ppm, and the mean organic matter content was 4.95%. In contrast, the mean organic matter content at Midland Hills was 4.84%, and the mean amino sugar nitrogen concentration was 393 ppm.

Because soil organic matter is not uniformly mineralizable, it is possible that as a site matures and the organic matter becomes more complex, the amino sugar nitrogen content will provide a more reliable predictor of potential mineralization of nitrogen than would the organic matter content.

There seemed to be less spatial variability at Midland Hills than at Heritage Links. One possible reason is that Midland Hills is an older course and as such, over time, an equilibrium has been reached that does not appear to exist on the sampled fairways at Heritage Links. Heritage Links is a younger course, and it is possible that the variability observed on these fairways is due to the age of the golf course where fairways have not had time to reach equilibrium.

Conclusions

Although the amino sugar nitrogen concentrations measured on the four sampled fairways varied, the spatial correlation present would allow traditional soil sampling techniques to be used to assess the soil amino sugar nitrogen concentration within an area such as a fairway. There was also enough variability within an area that the sampling technique used would permit the identification of areas with higher and lower amino sugar nitrogen values on a fairway and allow for the potential development of site-specific application of nitrogen fertility.

To further develop site-specific nitrogen fertilizer applications, our data suggest bulking soil from four or five locations within a 328-foot (100-meter) section of each fairway. With the exception of Heritage Links fairway No. 13, the fairways sampled from both golf courses showed that amino sugar nitrogen concentrations were spatially correlated over distances of 328 feet (100 meters) or less. Our data show that if new samples were taken from these fairways, and the samples were taken from locations separated by more than 328 feet (100 meters), then the samples would be considered independent. More research is required to assess whether this spatial structure is similar across golf courses of varying ages. Current USGA-funded research is focusing on refining the interpretation of the test values for turfgrass management.

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The research says

→ The two fairways from the 8-year-old course displayed a greater degree of spatial heterogeneity than the two fairways from the 85-year-old course at all sampling depths.

→ Although the amino sugar nitrogen concentrations measured on the four sampled fairways varied, the spatial correlation would allow traditional soil sampling techniques to be used to assess the soil amino sugar nitrogen concentration within a fairway.

→ There was enough variability within an area that the sampling technique would permit the identification of areas with higher and lower amino-sugar nitrogen values and allow the potential development of site-specific application of nitrogen fertility.

→ To further develop site-specific nitrogen fertilizer applications, our data suggest bulking soil from four or five locations within a 328-foot section of each fairway.