Foliar Nutrient Uptake by Cool-Season and Warm-Season Turfgrasses

University of Arkansas research lends insight into understanding turfgrass foliar feeding.

BY JAMES C. STIEGLER, MICHAEL D. RICHARDSON, DOUGLAS E. KARCHER, AND AARON J. PATTON

OBJECTIVES

- Determine the seasonal dynamics of the turfgrass cuticle in cool-season and warm-season turfgrass species managed under putting green conditions.
- Compare the seasonal uptake of foliar nitrogen by cool-season and warm-season turfgrass species managed under putting green conditions.

Start Date: 2008
Project Duration: Two years
Total Funding: $6,000

Foliar nitrogen is applied to the putting green turf and an ammonia volatilization trap is installed after application.

Foliar fertilization refers to the process of nutrient uptake through the foliage or other aerial plant parts. As a supplement to traditional root-feeding programs, foliar fertilization has been observed to be an increasingly common practice in today's golf course management. Recent surveys of Arkansas golf course superintendents indicate that nearly all superintendents use foliar fertilization on some area of the golf course, and this method of nutrient application often comprises a major portion of annual nitrogen (N) inputs to putting greens.

Although previous research has documented uptake of N by turfgrass leaves in controlled-environment studies, there have been no studies that demonstrate its potential effectiveness in a field environment. It is known from previous agricultural research that environmental factors and seasonal dynamics of leaf cuticle characteristics can influence the foliar absorption of N solutions. Therefore, the aim of this project is to increase scientific understanding of the turfgrass leaf cuticle, while assessing foliar uptake of N during a two-year putting green research trial.

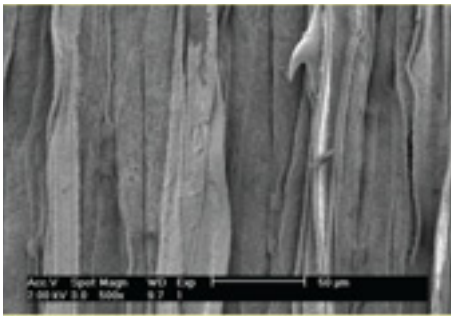
Experimental areas of Penn A1 creeping bentgrass and Tifeagle ultra-dwarf bermudagrass were developed on an established sand-based putting green in Fayetteville, Arkansas. The greens were maintained according to typical management practices for the region. Foliar uptake of N was studied each month from May to September to determine if foliar uptake was consistent across the growing season.

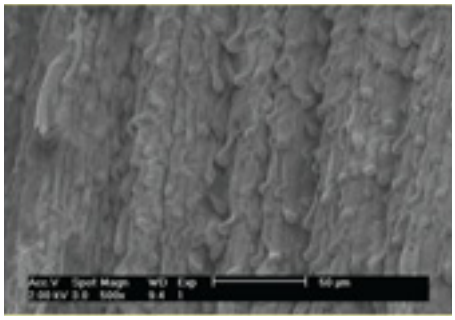
An isotopic tracer technique (^{15}N-labeled urea) that allows for positive identification and direct measurement of fertilizer N in the plant tissue was used in the study. Solutions were sprayed at two different rates to represent a low and high rate (0.10 or 0.25 lb. N per 1,000 sq. ft.) common to foliar fertilization rates of golf course superintendents. For a 24-hour period after treatment, plots received no irrigation or rainfall in order to track only foliar absorption of N. Plant tissues were sampled at 1, 4, 8, and 24 hours after application in order to develop a time-course analysis of foliar N uptake. In addition, an enclosed chamber with an internal acid trap was installed within the plots after treatment to estimate the volatilization of N as ammonia from the plots.

Chris Stiegler discusses various foliar fertilizer products for use on creeping bentgrass at the 2009 University of Arkansas turfgrass field day. Note the phytotoxicity associated with ammonium sulfate applications in the lower right plots.

Results from the first year of monthly foliar urea-N applications indicate that both species proved receptive to foliar uptake, and ammonia volatilization losses were minimal (averaged < 2% of applied N). A range of 24-57% of the fertilizer N applied was recovered in leaves and shoots at one hour after treatment, while peak foliar absorption was normally observed around four hours after treatment. Foliar uptake, when measured as a percent of N applied, was significantly reduced at higher application rates. The highest maximum absorption of N applied, observed over 24 hours, was in the month of May on bentgrass (76%). Absorption of N by bentgrass leaves was affected by month of the year, while ultradwarf bermudagrass was not affected.

On bentgrass, the significant decrease in N recovered within plant tissue as the season progressed (May averaged 59% of applied N across all sampling times, while September averaged 37%), is currently believed to be attributed to leaf cuticle changes that made leaves more hydrophobic and possibly less receptive to nutrient absorption. Continued laboratory investigations are underway to better understand this observed trend.





One goal of this research project was to determine if any differences in foliar nitrogen absorption could be related to leaf cuticle differences between creeping bentgrass and bermudagrass. To date, University of Arkansas scientists were unable to connect foliar nitrogen absorption with cuticle characteristics. Scanning electron micrographs of Penn A1 creeping bentgrass (left) and Tifeagle bermudagrass (right) show basic leaf surface cuticle morphology.

SUMMARY POINTS

- Both creeping bentgrass and ultradwarf bermudagrass greens are receptive to foliar uptake of urea nitrogen.

CONNECTING THE DOTS

An interview with Drs. Mike Richardson *and* Chris Stiegler *regarding foliar nutrient application for putting greens.*

Q: *Why do you think foliar feeding of putting greens has gained popularity among golf course superintendents?*

A: Research has shown that providing a small, consistent amount of nitrogen through foliar fertilization applications can result in more uniform growth and more consistent putting green conditions. This is certainly one of the most important reasons for the increased use of foliar fertilizers among golf course superintendents. Another obvious reason is the convenience of being able to tank-mix these fertilizers along with other pesticides and/or plant growth regulators, when compatible.

Q: *As you know, most superintendents keep the nutrition level of putting greens fairly lean in an effort to keep green speed up and limit thatch production. How well does foliar feeding fit into this "lean and mean" approach?*

A: Foliar feeding fits very well into this approach, as leaves have a minimized capacity to absorb nutrients when compared to roots. Though the amount of nutrients that can diffuse into the leaves/shoots at one time is less, the efficiency of uptake can be greater. Additionally, liquid applications offer more control to the turf manager through the ability to apply low rates of N more uniformly than trying to apply these same rates with granular sources.

Q: *How much nitrogen are superintendents typically applying as foliar applications?*

A: We conducted several surveys of golf course superintendents in order to gauge how much this nutritional practice was being used. Only 4% of the superintendents indicated they do not use foliar fertilization on their putting greens, while two out of every three respondents applied at least 25% of their total annual N inputs in this manner.

Q: *Your study showed that peak foliar uptake of nitrogen occurred at only four hours after application and that the percentage taken up by turf leaves was significantly reduced at higher nitrogen concentrations. What does this suggest to superintendents with regard to using foliar fertilization as a nutrient management tool?*

A: For maximum effectiveness, golf course superintendents should allow the nutrient solution to sit on the leaves for a couple of hours prior to syringing, irrigation, or other management practices. If the turf needs to be watered, the applied nutrients can still be absorbed by root uptake as the fertilizer remaining on the leaf surface would be rinsed into the rootzone. There is certainly a maximum amount of nitrogen that can be taken up through the leaves from a single application, and we recommend that lower rates (~0.10 lb. N per 1,000 sq. ft.) be used when possible. Higher foliar nitrogen rates also increase the risk of leaf burn.

Q: *It would seem that foliar fertilization would be an inefficient, short-term gain since the leaves are mowed. Does it result in enough nitrogen absorption to offer any enhanced residual nutrition for continued growth?*

A: Since mowing would remove only a very small percentage of the leaves, we assume that this loss of nutrient would be minimal. Our studies indicate that only a small percentage of a foliar N application reaches the roots over a period of several days. However, foliar application of N is an efficient way to supply the plant organs (leaves, stems, crowns) that can utilize the nutrient best. As far as residual nutrition, foliar fertilization does have its limitations compared to root feeding. Low application rates and rapid absorption would limit the long-term residual nutrition from a foliar application.

Q: *What did your volatilization (loss of N via ammonia) data tell you? Are these losses significant enough to add a urease inhibitor or a nitrogen stabilizer (e.g., N-Serve) to the spray mix?*

A: Our data suggest that ammonia volatilization losses following foliar urea-N applications are minimal (1-3%) and that foliar urea-N can be applied throughout the season without concern for substantial N loss via volatilization. There should be no need to add a urease inhibitor or nitrogen stabilizer to the spray mix, as it would not be worth the added expense.

Q: *Does the amount of nitrogen absorbed through the leaves depend on the nitrogen form (i.e., urea versus nitrate versus ammonium)?*

A: We did a follow-up foliar absorption study where we applied ^{15}N-labeled products like potassium nitrate and ammonium sulfate and compared their foliar uptake to urea. Our data from these trials suggest that urea and ammonium forms are taken up through turfgrass leaves more readily than nitrate. However, ammonium sulfate and potassium nitrate also caused some phytotoxicity on bentgrass that lasted a few days. So, considering its good foliar absorption characteristics and its safety, urea would still be the best choice out of these three possible sources.

Q: *Since foliar applications use such small nitrogen concentrations, do data support the idea that nitrogen losses from runoff or percolation past the rootzone are reduced compared to more conventional root-feeding programs?*

A: We are not aware of any studies that have actually compared foliar vs. root feeding programs, but lower application rates of nitrogen would certainly reduce the potential for runoff or leaching, as most of that nitrogen would be easily captured by the turf. It is no different than using a slow-release fertilizer, where the nutrient is released in small doses, which minimizes the environmental risk.

Jeff Nus, Ph.D., *manager, USGA Green Section Research.*

- Most of the nitrogen applied to putting green turfgrass foliage is absorbed in the first four hours after application.
- Foliar uptake in creeping bentgrass was reduced during warmer months, suggesting a change in the composition of the leaf cuticle.
- Loss of foliar-applied nitrogen to ammonia volatilization appears to be minimal.

RELATED INFORMATION

http://turf.lib.msu.edu/ressum/2008/71.pdf

James C. Stiegler, Ph.D., *graduate student;* Michael D. Richardson, Ph.D., *professor;* Douglas E. Karcher, Ph.D., *associate professor; and* Aaron J. Patton, Ph.D., *assistant professor; Department of Horticulture, University of Arkansas, Fayettevile, Ark.*