The Driving Force!

Nitrogen — still an essential building block for sustaining healthy grass.

BY MAX SCHLOSSBERG, PH.D.

Striving for perfection begins with promoting healthy grass. Meeting nutritional requirements of the turf is essential and should be the number-one priority of the maintenance program.

Of all the managed turfgrass areas comprising a golf course, none is more valued or intensively maintained than the putting greens. Putting green square footage may represent less than 2% of the total managed golf course turf, yet putting green quality can make or break golfers' perception of playing conditions and, quite possibly, their entire golfing experience.

Nitrogen (N) fertilization is an important component of putting green management. Under optimal growth conditions and intermediate nutrient sufficiency, no other plant essential nutrient has as powerful an influence on turfgrass canopy color and vigor, root-to-shoot growth relations, and disease susceptibility. Likewise, when applied at rates commensurate with turfgrass requirements, traditional fertilizer sources that provide any/all plant essential nutrient(s) besides N (excepting acids or liming agents) do not have the profound effect on soil biochemical activity as do N fertilizers.

Nitrogen fertilizers include numerous quick-release (QR; e.g. salts, urea) and slow-release forms (SR; e.g. natural organics, synthetic organics, coated prills), each having its pros and cons. The advent of SR technologies may be the most notable advance in recorded fertilizer history. However, because the most effective SR fertilizers are water-insoluble, coated, or both, most are only available in granular or sprayable-powder forms. Low-SGN (size guide number) SR granulars are effective putting green fertilizers that minimize nutrient leaching loss and osmotic tissue desiccation, while steadily supplying available nutrients to turfgrass. Nevertheless, the persistent nature of granular SR fertilizers requires them to either be watered through the canopy, stabilized in the upper soil profile (i.e., applied following aeration or verticutting procedures) or free to persist on the putting surface, potentially redirecting golfers' putts before being carried away in the mower clippings. This is one of several justifications for liquid spray fertilizer application to putting greens during periods of peak golfing activity. Other reasons in support of this application method are:

- Frequent, light fertilizer applications optimize plant health and nutrient recovery (Bowman, 2003).
- Regular spray applications are already being made to putting greens during the peak season.

RESEARCH INVESTIGATIONS

These things considered, independent field studies were initiated on two putting greens, purposefully cohabited by creeping bentgrass (*Agrostis palustris* L. Pennn A4) and annual bluegrass (*Poa annua* L.). These experiments were facilitated in 2003 and 2004 at the Penn State University Valentine Turfgrass Research Center (University Park, Pa.) for the purpose of identifying:

- Annual N fertilization rate effect on color and health of putting greens cohabited by creeping bentgrass and *Poa annua*, and
- The potential interactive effects of QR-N form and/or systematic growth regulation on the first objective parameters.

- Nitrogen (N) — no other plant essential nutrient has as powerful an influence on turfgrass canopy color and vigor, root-to-shoot growth relations, and disease susceptibility. The research is clear; basic fertility needs must be met before the full benefit of fine-tuning fertility strategies can be realized.
- Ammonium-based nitrogen is a catalyst that stimulates the uptake of phosphorus (P) and manganese (Mn), two essential plant nutrients. Therefore, before corrective P or Mn applications are performed, consider including this nitrogen source in your fertility program, especially if phosphorus or manganese is reported as deficient based on plant tissue analysis.
- Rootzone soil organic matter and percolation rate are traits that should be factored into decisions regarding N fertilizer type, rate, and frequency of application. Perform soil analysis at least annually (physical and chemical) to assist in developing a fertility program that meets the needs of the turf.
- Limiting N inputs to achieve green speed is counter productive. Increase N fertility and frequency to satisfy N requirements of healthy turfgrass. This action, coupled with growth regulator application can further enhance plant health while still attaining the desired level of ball roll distance. First and foremost, strive to maximize the natural defense mechanisms of the turf.

METHODS

Though creeping bentgrass/annual bluegrass mixtures covered both experimental putting greens, their underlying rootzones possessed dramatically different physical and chemical properties (Table 1). Likewise, the topdressed pushup green (TDPU) was more than 20 years old at experiment initiation, while the sand-based green (SB) was constructed only two years prior. In both studies, fertilizer treatments (each comprising 1/13 of the annual rate) were applied April to October with a CO_2-powered hand sprayer in a volume of 2.2 gal./1,000 sq. ft. (95 GPA), every 15 ± 4 days. The 2-year experiment on the TDPU green evaluated a wide array of annual N rates (1.5-8 lbs. N/1,000 sq. ft./year) and ammonium to nitrate ratios (NH_4^+ as ammonium sulfate vs. NO_3^- as calcium nitrate) to determine their influence on color, health, and nutrient content of the putting surface.

In 2004, the SB green experiment evaluated a narrow range of treatments that showed most positive responses on the TDPU green the previous year. These treatments were: 3 or 5 lbs. N/1,000 sq. ft./year in one of four QR-N forms: ammonium nitrate, ammonium sulfate, 9 parts NH_4-N:1 part NO_3-N, or 9 parts NH_4-N:1 part dicyandiamide-N (DCD, an organic nitrification-inhibitor containing 67% N by mass), with or without bimonthly Primo MAXX (trinexapac-ethyl, 0.125 oz./1,000 sq. ft.) growth regulator applications, for the same TDPU-green study purposes listed above.

Table 1
Preliminary soil fertility/chemical properties of experimental putting green rootzones (composite samples of upper 3", thatch removed).

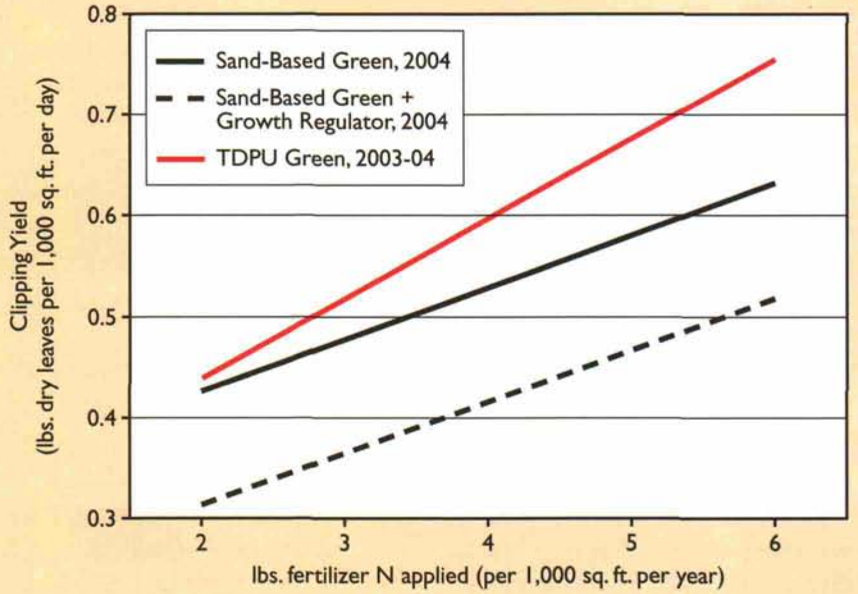
Soil Properties	Experimental Green[1] TDPU	SB
Soil pH (1:1 H_2O)	7.0	7.5
CEC (meq/100 g soil)[2]	8.1	4.7
Soil Organic Matter (% mass)[3]	4.0	1.3
$CaCO_3$ equivalency (% mass)	2.0	3.3
	— lbs. nutrient/acre[2] —	
P_2O_5	293	67
K	141	31
Mg	365	134
Ca	2,512	1,624

[1]Topdressed pushup green (TDPU) and sand-based green (SB)
[2]Determined using Mehlich 3 extractant
[3]Determined by loss on ignition (LOI)

As mentioned, these sites were maintained as golf course putting greens throughout the experimental periods. Corrective P_2O_5 and K_2O fertilizer applications were made prior to each experimental season. All plots were equally mowed (0.125" height, 6-7 days a week), irrigated, and treated with plant protectants when necessary. Outside of the described treatments, no systemic fungicides, growth regulators, fertilizers, or wetting agents were applied to either study. Measurements collected for evaluative purposes were:

Figure 1

Average daily clipping yield (shoot biomass production) by experimental putting green, annual nitrogen fertilizer rate, and trinexapac-ethyl (GR) application (sand-based green [SB] only).



turfgrass shoot growth/vigor (clipping yield, in lbs. dry clippings/1,000 sq. ft./day), canopy dark green color index (DGCI, Karcher and Richardson, 2003), and tissue nutritional status (nutrient concentration in dry clippings). These data were collected 2-5 times per study/year, within 4 to 12 days of treatment application, and analyzed by regression and/or analysis of variance statistical procedures.

RESULTS

Statistically, shoot growth/vigor response was better correlated to rate of N fertilizer application than to form of the QR N (data not shown). Expectedly, growth response to N was direct. However, clipping yield measured on the SB green lagged behind yields measured on the identically N-fertilized TDPU green (Figure 1). Further, Primo MAXX (GR) application to the SB green depressed growth rate to 74% of the control plot growth rate independent of N rate or form.

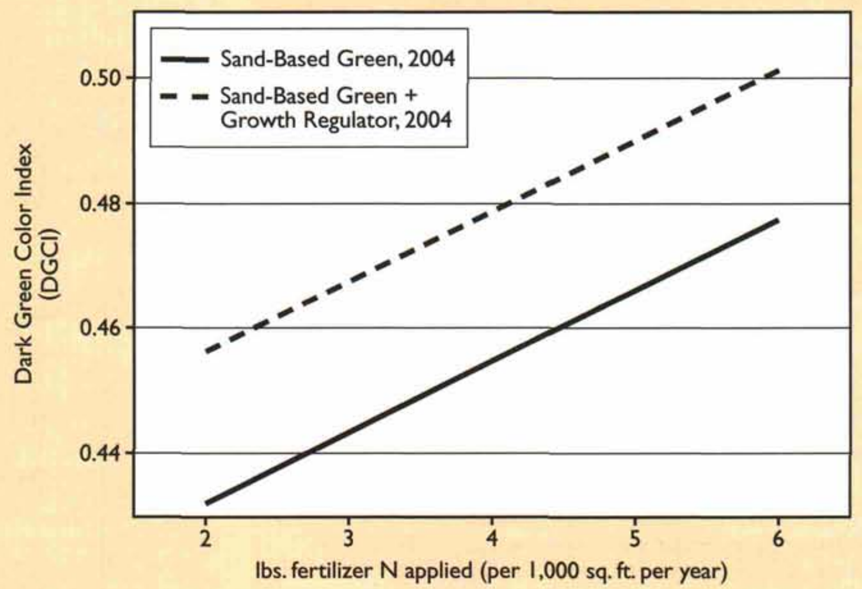
Canopy color, measured by dark green color index (DGCI), was significantly affected by both N rate and form on the TDPU green. Though not shown here, a significant effect of fertilizer ammonium content on DGCI was observed over 2 years on the TDPU green. At annual N rates exceeding 5 lbs. N/1,000 sq. ft., canopy DGCI levels significantly increased when ammonium comprised half (4% increase) or >80% (6% increase) of the fertilizer N. Conversely, canopy color on the SB green was affected most by N rate or GR (Figure 2), with GR treatment increasing DGCI values 5%, regardless of N rate or form.

Shoot tissue nutrient concentration data, an integral requirement in the comprehensive evaluation of turfgrass health, provided valuable information. In both greens, N fertilization rate directly affected N, K, Cu, and Zn levels in tissue. However, the more interesting nutrient level responses to N-fertilizer applications were observed on the TDPU green, particularly the direct relation of tissue P and Mn levels to increasing ammonium content at every N rate (Figure 3).

Of the treatments applied to the SB green, GR application decreased K and Mn concentration in shoots by 5% and 15%, respectively. As with the TDPU green, N rate and N form interacted to affect shoot Mn levels significantly (Figure 4).

Figure 2

Average dark green coloration (by DGCI) of sand-based putting green (SB), by annual nitrogen fertilizer rate and trinexapac-ethyl application.



SUMMARY

These data support previous research results and provide new insight into putting green turfgrass nutritional response to N. The difference observed in shoot growth between the two greens was not expected, considering similar conditions of light, temperature, and N fertilizer reapplication frequency. The lesser growth rate of the SB green, when compared to the TDPU green, illustrates the limited nutrient sequestering capacity and nutrient mineralization activity associated with young, low-OM, sand-based root media. Moreover, University Park received 29" of rain between May and October in 2004, and the relatively limited nutrient uptake in the SB green may have resulted from nutrient leaching. Thus, rootzone soil OM and percolation rate are traits that should be factored into decisions regarding N fertilizer type, rate, and frequency of reapplication.

Nitrogen form played a significant role in canopy color and tissue P on the TDPU green, and it affected Mn tissue levels of both greens. The N form associated with these enhancements was ammonium. Exclusive use of ammonium sulfate for N fertilization is a well-recognized soil-acidifying strategy. In both greens, ammonium sulfate fertilization resulted in significant tissue Mn increases, regardless of soil chemical properties (Table 1) or historical micronutrient fertilizer applications.

The observed effects of Primo MAXX GR on putting green growth and color are in agreement with recent research (McCullough et al., 2005). Use of the GR did not interact with N rate or form, but consistently increased canopy color (5%) while suppressing shoot growth (26%), tissue K (5%), and tissue Mn (15%) in the 4- to 12-day period following GR application. Ideally, these results will be considered by golf course superintendents who have not adopted GR use as a maintenance practice, yet fervently withhold nitrogen fertilizer from their bentgrass/*Poa* cohabited putting greens for the

Figure 3

Average leaf tissue P or Mn concentration from topdressed-pushup (TDPU) green, by ammonium content of quick-release N fertilizer and annual nitrogen fertilizer rate.

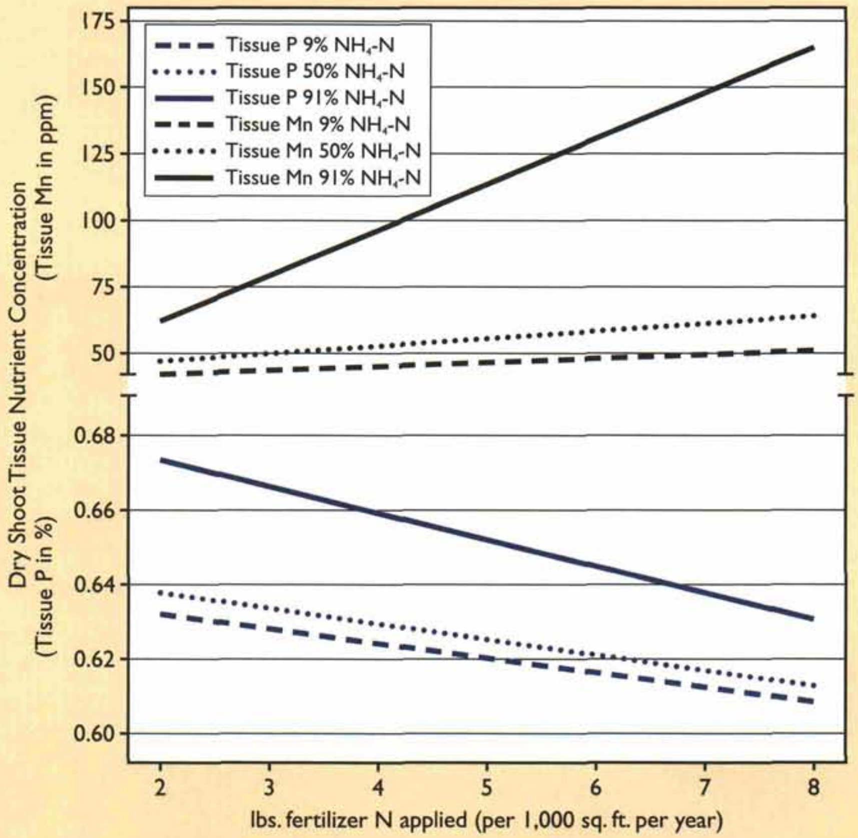
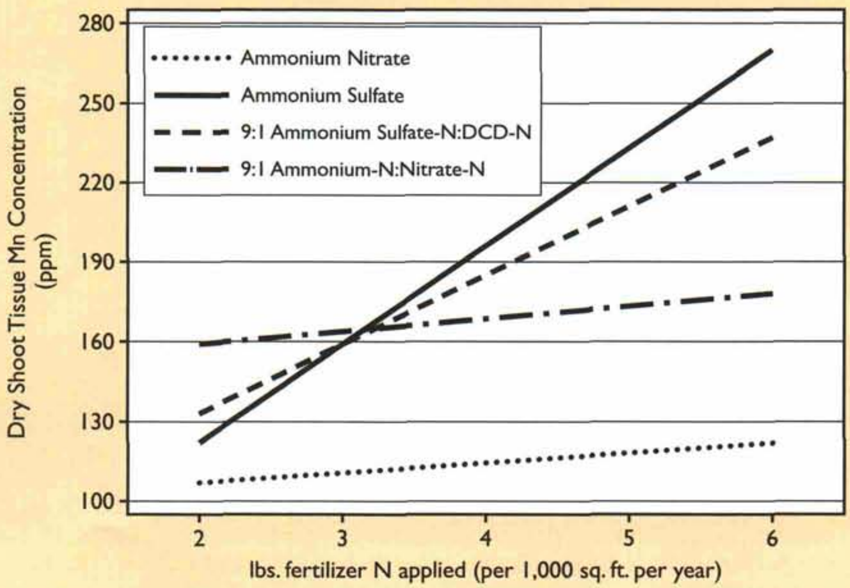


Figure 4

Average leaf tissue Mn concentration from sand-based (SB) green, by quick-release N fertilizer formulation and annual nitrogen fertilizer rate.



purpose of enhancing ball roll distance. An important message that can be derived from these results is this: Suitable green speed can be mutually excluded from suboptimal leaf N and disease susceptibility. Increase your N fertilization frequency and rate to satisfy the N requirements of healthy turfgrass (>4% tissue N). This action, coupled with initiation of GR applications, is an effective and widely used method to significantly enhance plant health and canopy color (Figure 2) without an undesired concomitant increase in shoot growth (Figure 1).

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