Nitrogen Fertilization of Putting Greens Cohabited by Penn 'A-4' Creeping Bentgrass and Annual Bluegrass

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Introduction

Of all the managed turfgrass areas comprising a golf course, none are more valued or intensively maintained than the putting greens. Putting green square footage may represent <2% of the total managed golf course turf, yet putting green quality can make or break a golfer's 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 providing any/all plant essential nutrient(s) besides N (excepting acids or liming agents) do not have the profound effect on soil biochemical activity that N fertilizers do.

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 their 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, 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 aerification or verticutting procedures) or free to persist on the putting surface, potentially redirecting golfer's 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. Further supports 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

These things considered, independent field studies were initiated on two putting greens, purposefully co-habited by creeping bentgrass (*Agrostis palustris* L. 'Penn A4') and annual bluegrass (*Poa annua* L.). These experiments were facilitated in 2003 and 2004 at the PSU 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.

Methods

Though creeping bentgrass/annual bluegrass mixtures covered both experimental putting greens, their underlying root zones possessed dramatically different physical and chemical properties (Table 1). Likewise, the topdressed pushup green (TDPU) was over 20 years old at experiment initiation, while the sand-based green (SB) was constructed only 2 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./1000 ft^2 (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/1000 ft^2•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/1000 ft^2•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 bi-monthly Primo MAXX (trinexapac-ethyl, 0.125 oz./1000 ft^2) growth regulator applications, for the same TDPU-green study purposes listed above.

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

* Determined using Mehlich 3 extractant
† Determined by loss on ignition (LOI)

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

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 purpose were: turfgrass shoot growth/vigor (clipping yield, in lbs dry clippings/1000 ft^2•day), canopy dark green color index (DGCI)(Karcher & 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 (Fig. 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 due to space constraints, 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/1000 ft^2, 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 (Fig. 2), with GR treatment increasing DGCI values 5%, regardless of N rate or form.

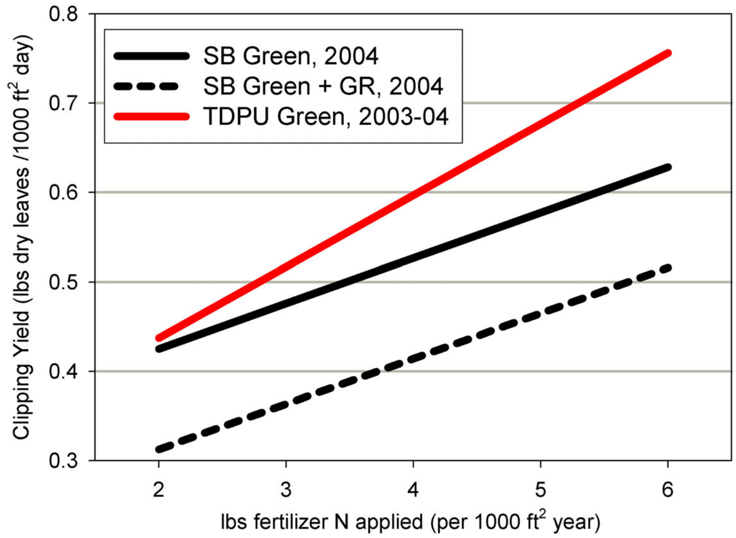

Fig. 1. Average daily clipping yield (shoot biomass production); by experimental putting green, annual nitrogen fertilizer rate, and trinexapac-ethyl (GR) application (sand-based green [SB] only).

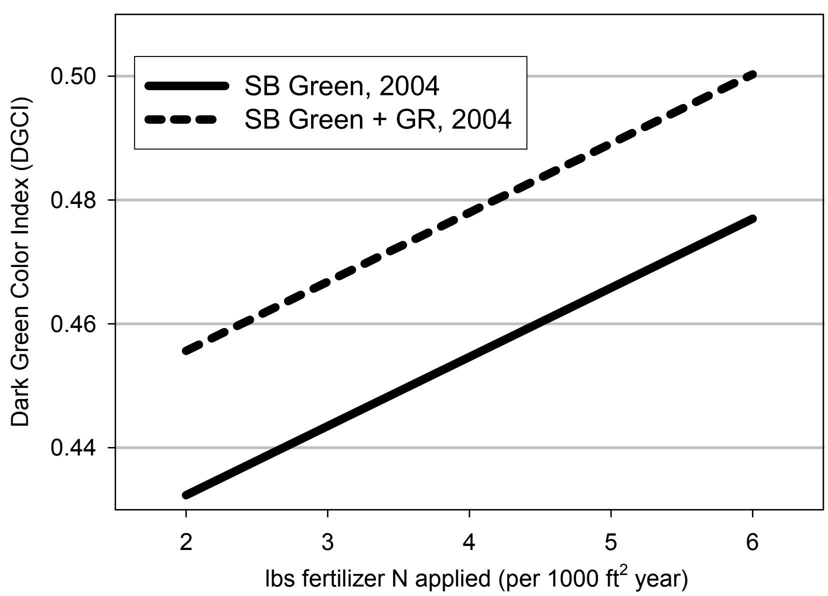

Fig. 2. Average dark green coloration (by DGCI) of sand-based putting green, by annual nitrogen fertilizer rate and trinexapac-ethyl application.

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 (Fig. 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 (Fig. 4).

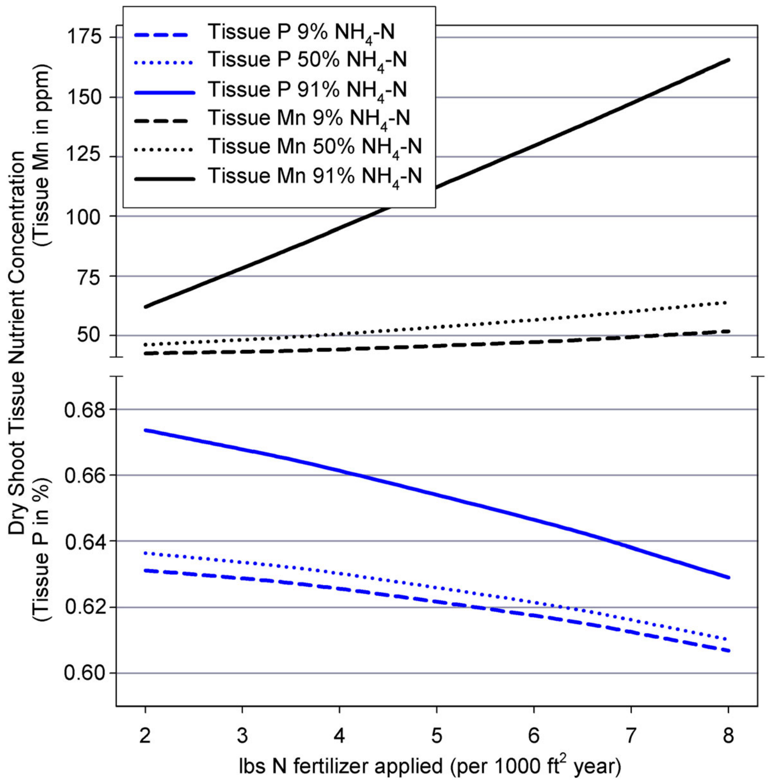

Fig. 3. Average leaf tissue P or Mn concentration from topdressed-pushup (TDPU) green, by ammonium content of quick-release N fertilizer and annual nitrogen fertilizer rate.

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 2 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, root zone soil OM and percolation rate are traits that should be factored into decisions regarding N fertilizer type, rate, and frequency of reapplication.

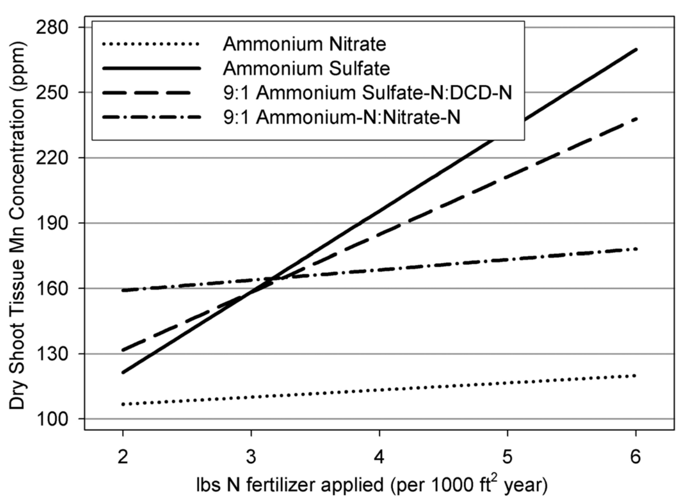

Fig. 4. Average leaf tissue Mn concentration from sand-based (SB) green, by quick-release N fertilizer formulation and annual nitrogen fertilizer rate.

Nitrogen form played a significant role in canopy color and tissue P on the TDPU green, and 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 4-12 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 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 (Fig. 2) without an undesired concomitant increase in shoot growth (Fig. 1).

Acknowledgements
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References

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