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University of California scientists conducted field experiments at Industry Hills Golf Club at Pacific Palms Conference Resort, City of Industry, CA to determine the optimal N fertility rate for southern California putting greens composed of mixed swards of *Poa annua* and creeping bentgrass.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 450 projects at a cost of \$29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Defining Nitrogen Fertility Rates for a *Poa annua*-Creeping Bentgrass Putting Green in California

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Mike Caprio, Kent Davidson, and Shoumo Mitra

SUMMARY

University of California scientists conducted field experiments at Industry Hills Golf Club at Pacific Palms Conference Resort, City of Industry, CA to determine the optimal N fertility rate for southern California putting greens composed of mixed swards of *Poa annua* and creeping bentgrass.

- Results from this study show that optimal and deficient annual N fertility rates for *Poa annua*-creeping bentgrass putting greens in California probably range from 6.0 to 3.0 lb/1000 ft², respectively.
- This information is a general guide, keeping in mind that annual N fertility rates may need to be adjusted depending on several factors, such as amount of play, soil type, expectations of turf quality, and green speed, and others.
- Lower annual N fertility rates resulted in significantly lower visual turfgrass quality and color, clipping yields, recovery from core cultivation, and shoot density.
- There also was a trend that lower annual N fertility rates resulted in more *Rhizoctonia* brown patch coverage, while higher annual N fertility rates resulted in more seedhead coverage.

Most golf course superintendents in California are managing *Poa annua* as their putting green turf. The major reason for this norm is the relatively mild climate of the region that usually results in newly established creeping bentgrass putting greens converting to *Poa annua* putting greens in 5 to 7 years. An exception to this rule is the warmer desert locations, such as Palm

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Springs, where bermudagrass and, less frequently, creeping bentgrass putting greens are maintained.

The major problems of managing *Poa annua* putting greens include: summer decline, which includes several issues, such as high temperatures, disease activity, traffic, and salinity; seedhead production, especially during the spring; and puffiness during the growing season (October through late December and February through June). In many other regions of the United States, *Poa annua* encroachment into creeping bentgrass putting greens can be controlled. Thus, considerable research has been and continues to be conducted on managing creeping bentgrass putting greens rather than on managing *Poa annua* putting greens.

The annual N fertility rates that have been tested on *Poa annua* grown in the field vary considerably. Goss et al. (5) tested N rates of 6.0, 12.0, and 20.0 lb/1000 ft². Engel (3) tested N



Nitrogen fertility-rate treatments were spray-applied every three weeks.

Application Dates for First 12 months of the Study																				
2006										2005										
11	1	22	15	12	13	4	25	15	6	27	17	7	28	19	9	30	21			
Jan.	Feb.	Feb.	Mar.	Apr.	Apr.	May	May	June	July	July	Aug.	Sept.	Sept.	Oct.	Nov.	Nov.	Dec.			
Application Dates for Second 12 months of the Study																				
Treatment	2007										2006									
	10	31	21	14	4	25	3	24	12	5	26	16	6	27	18	8	29	20	annual total ²	
	Jan.	Jan.	Feb.	Mar.	Apr.	Apr.	May	May	June	July	July	Aug.	Sept.	Sept.	Oct.	Nov.	Nov.	Dec.		
	----- lb/1000 ft ² -----																			
N5.5	0.20	0.30	0.30	0.40	0.40	0.40	0.40	0.30	0.20	0.20	0.20	0.20	0.20	0.40	0.40	0.40	0.40	0.20	5.5	
N4.2	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.20	4.2	
N2.8	0.10	0.10	0.20	0.20	0.30	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.20	0.20	0.20	0.10	2.8	
N1.5	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	1.5	
Applied to all plots																				
P ₂ O ₅	-	-	0.25	0.25	0.25	0.25	-	-	-	-	-	-	0.25	0.25	0.25	0.25	-	-	2.0	
K ₂ O	-	-	0.20	0.20	0.20	0.20	0.40	0.40	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.40	-	4.0	
Fe	Ferrous sulfate (FeSO ₄) applied by golf course superintendent once every 2 weeks at a rate of 2.0 oz/1000 ft ² .																			
PGR	Primo Maxx applied by golf course superintendent once every 2 weeks at 0.125 oz/1000 ft ² .																			
<p>²Plots were irrigated with recycled water. The water supplied an annual N rate of approximately 0.5 lb/1000 ft² (including ammonia, organic, nitrate, and nitrite forms of N).</p> <p>Note: There were three replications of each of four N fertility rates. Individual plot size = 6.0 x 11.0 ft.</p> <p>Note: N sources were ammonium nitrate (20-0-0; 10.55 lb/gal) for December, January, and February; ammonium sulfate (8-0-0-9S; 10.2 lb/gal) for March and April; and low biuret urea (20-0-0; 9.35 lb/gal) from May through November. P source is ammonium polyphosphate (10-34-0; 11.7 lb/gal). K source was potassium sulfate ESP-K (1-0-8-2.5S; 9.7 lb/gal).</p> <p>Final spray volume for each N fertility rate treatment application was 2.0 gal/1000 ft². All N fertility rate treatments applied with a CO₂ sprayer mounted on a cart.</p>																				

Table 1. N, P₂O₅, K₂O, and Fe application schedule for the N fertility study on a *Poa annua*-creeping bentgrass putting green.

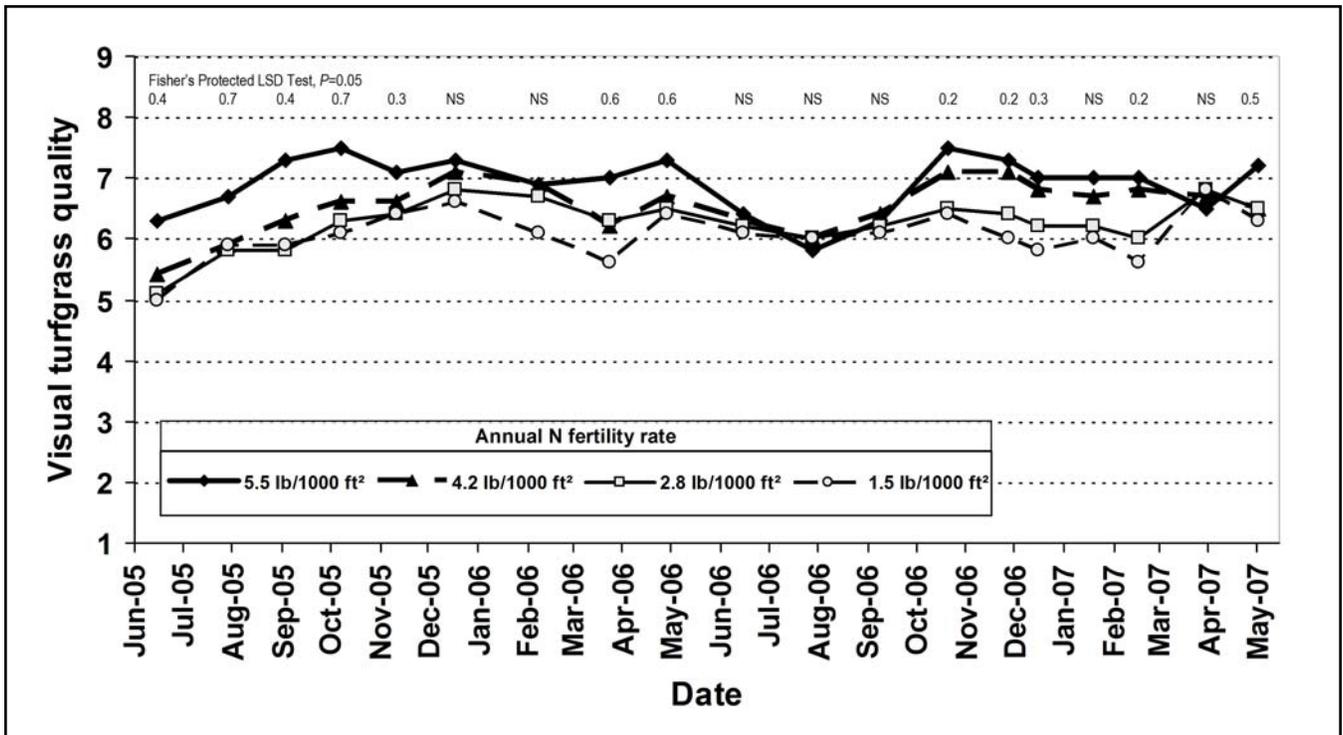


Figure 1. The effect of annual N fertility rate on visual turfgrass quality of a *Poa annua*-creeping bentgrass putting green from June 2005 to May 2007 (1 to 9 scale, with 1=worst, 5=minimally acceptable, and 9=best putting green).

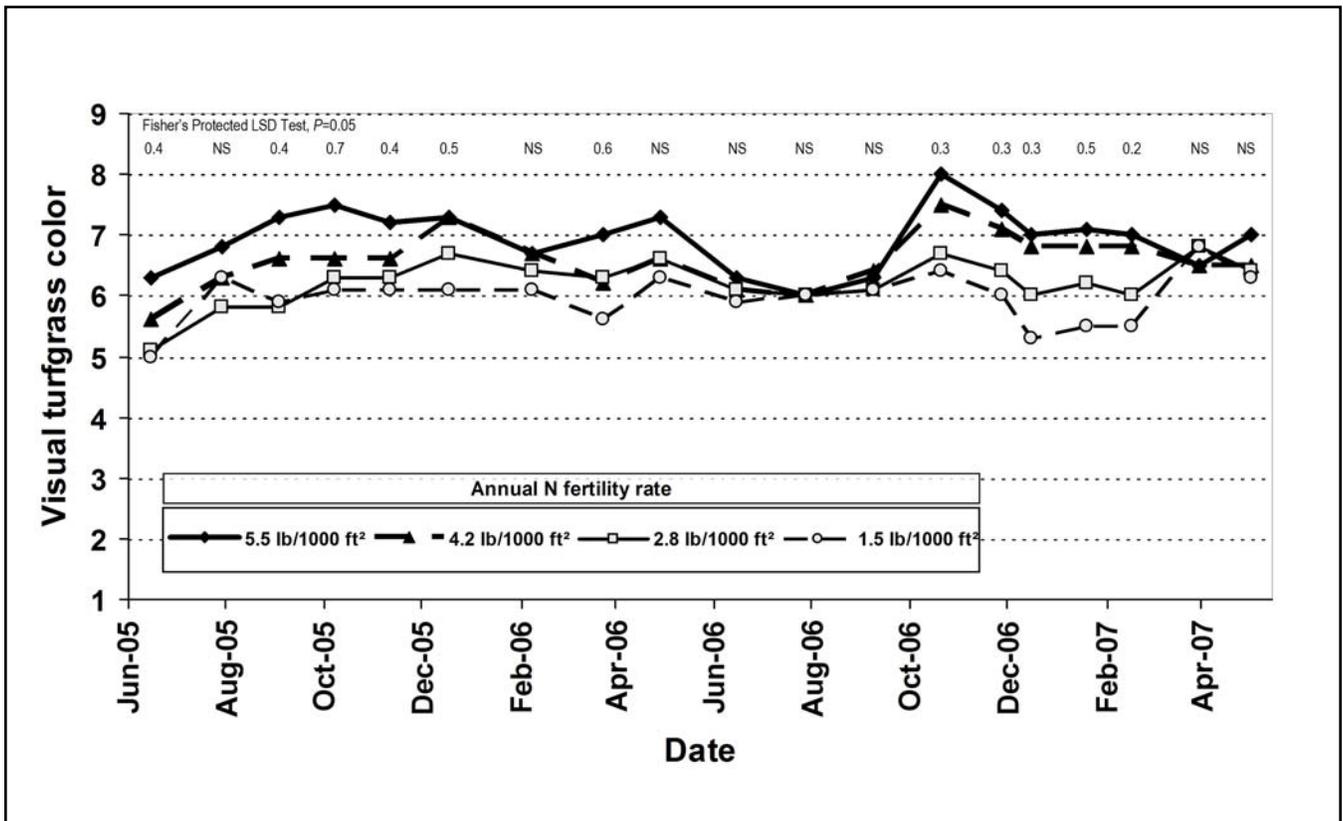


Figure 2. The effect of annual N fertility rate on visual turfgrass color of a *Poa annua*-creeping bentgrass putting green from June 2005 to May 2007 (1 to 9 scale, with 1=brown, 5=minimally acceptable, and 9=darkest green putting green).

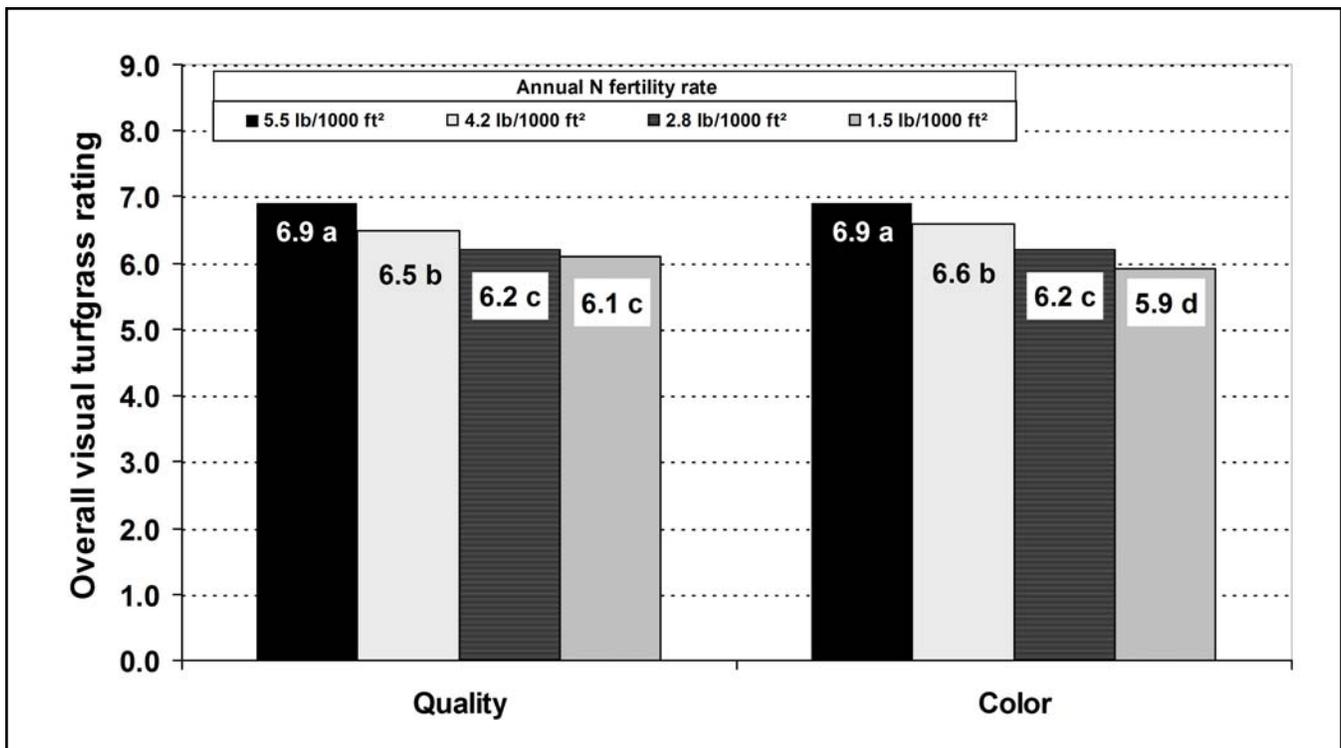


Figure 3. The effect of annual N fertility rate on overall visual turfgrass quality (1 to 9 scale, with 1=worst, 5=minimally acceptable, and 9=best putting green) and color (1 to 9 scale, with 1=brown, 5=minimally acceptable, and 9=darkest green putting green) of a *Poa annua*-creeping bentgrass putting green from June 2005 to May 2007.

rates of 4.0 and 8.0 lb/1000 ft². Dest and Guillard (1) tested N rates of 2.0 to 2.5 lb/1000 ft². Dest and Allinson (2) tested N rates of 3.0 lb/1000 ft². Gaussoin and Branham (4) tested N rates of 2.0 and 6.0 lb/1000 ft². It should be noted that factors such as the length of growing season and amount of rainfall can affect recommendations concerning annual N fertility rates.

In a relatively recent GCSAA/CGCSA Chapter Cooperative Research Program study, Green et al. (6) tested annual N fertility rates of 6.0 and 11.0 lb/1000 ft² on an in-use *Poa annua* putting green in southern California and reported that the lower rate was close to optimal in terms of visual turfgrass quality and color ratings, coverage of seedheads, mottling and patchiness, disease activity, leaf wilting and rolling, and scalping, root and crown mass, and concentration of total N in clipping tissue. The lower N rate ranged from 4.24% to 5.81% total N in clipping tissue which is within the published target range of 4.5% to 6.0% for creeping bentgrass.

Since there is a trend for golf course super-

intendents to apply less N on *Poa annua* putting greens, it would be useful to evaluate the lower range of annual N fertility rates. These data could be combined with other data concerning optimal annual N fertility rates, so that golf course superintendents in southern California could be offered a range of optimal, sufficient, and deficient rates. This information could serve as a general guide, keeping in mind that N rates may need to be adjusted depending on such factors as amount of play, soil type, salinity, leaching requirements, amount of rainfall, irrigation with recycled water, N application schedule, rates, and N sources, Fe and plant growth regulator applications, and others.

Objectives

To determine the optimal N fertility rate for southern California putting greens composed of mixed swards of *Poa annua* and creeping bentgrass.

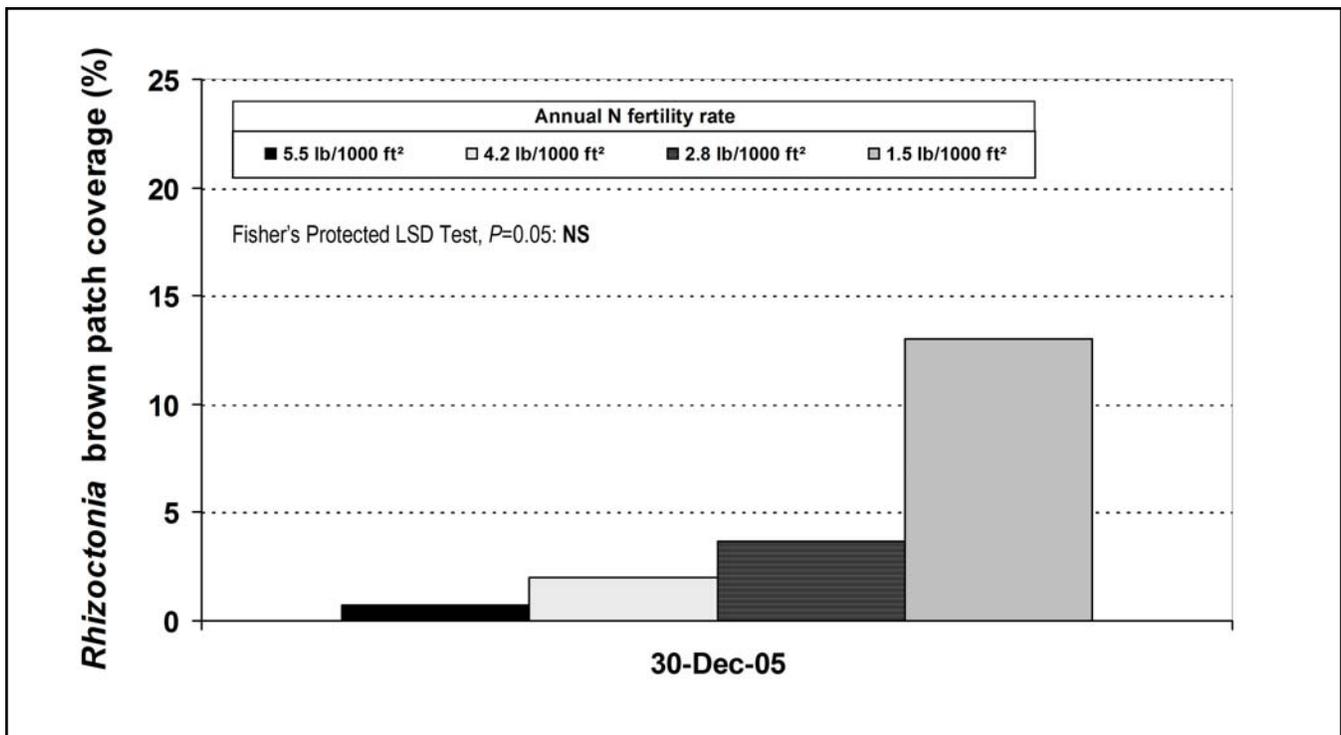


Figure 4. The effect of annual N fertility rate on percent coverage of *Rhizoctonia* brown patch of a *Poa annua*-creeping bentgrass putting green on Dec. 30, 2005.

Materials and Methods

Location

The location of this study was an 8,500 ft² mature *Poa annua*-creeping bentgrass nursery located at Industry Hills Golf Club at Pacific Palms Conference Resort, City of Industry, California. The majority of the nursery was covered with *Poa annua*, especially during the cool season. The nursery was established in November 1997 by planting cores of *Poa annua* and seeding creeping bentgrass on to an 11-inch deep sand rootzone which was constructed with sand that met USGA recommendations.

The nursery did not have a drainage system. It was irrigated with recycled water which had the following most-recent, two-year average N concentrations at the water treatment plant: 1.6 ppm ammonia N; 1.4 ppm organic N; 3.9 ppm nitrate N; and 0.08 ppm nitrite N (6.98 ppm total N). Based on previous work at this golf course, irrigation of putting greens supplies an annual N fertility rate of approximately 0.5 lb/1000 ft². Selected results of a soil test taken on 6 Apr. 2005,

prior to application of annual N fertility rate treatments, showed: pH = 6.8; Sodium Absorption Ratio (SAR) = 2 (low); Exchangeable Sodium Percentage (ESP) = 2% (low); extractable Fe = 14.9 ppm (sufficient); Cation Exchange Capacity (CEC) = 2.3 meq/100 g (low); Organic Matter (OM) = 0.80% (low); Olsen-P = 7.2 ppm (low); exchangeable K= 64 ppm (low); exchangeable Ca = 602 ppm (sufficient); exchangeable Mg = 69 ppm (low); exchangeable Na = 52 ppm; and 93%, 5%, and 2% sand, silt, and clay, respectively.

Treatments

Annual N fertility rates, ranging from 1.5 to 5.5 lb/1000 ft², were evaluated for two years on a *Poa annua*-creeping bentgrass putting green nursery (Table 1). Irrigation with recycled water supplied an annual N fertility rate of approximately 0.5 lb/1000 ft². During the study, levels of P, K, and Fe were maintained at commonly-practiced levels.

The four annual N fertility-rate treatments (1.5, 2.8, 4.2, and 5.5 lb/1000 ft²) were arranged

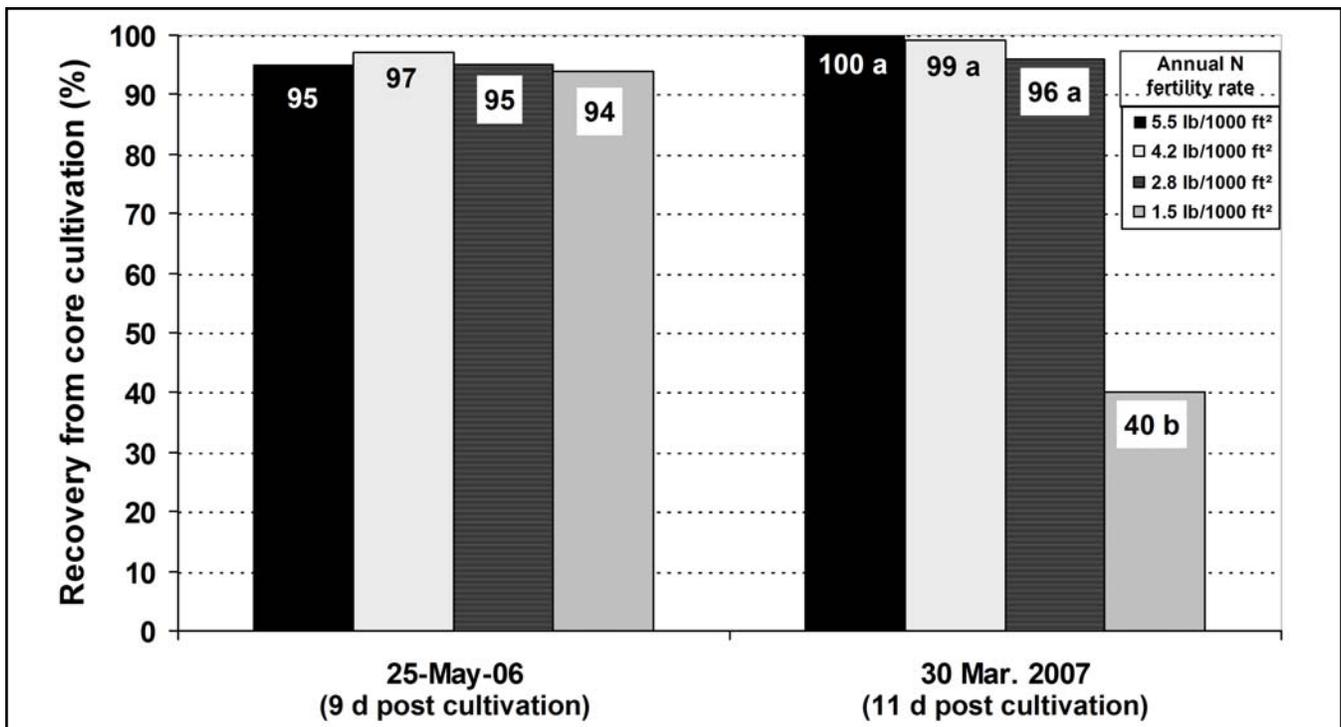


Figure 5. The effect of annual N fertility rate on percent recovery from core cultivation of a *Poa annua*-creeping bentgrass putting green. Core cultivation conducted May 16, 2006 and March 19, 2007 with 0.5-inch hollow tines and cores removed. Means followed by the same letter are not significantly different.

in a randomized complete block design with three replications. Individual plot size was 6.0 x 11.0 ft with 1.0- or 3.0-ft borders between plots. Nitrogen fertility-rate treatments were spray-applied every three weeks. The first N fertility-rate treatment application was April 13, 2005 and the last application was April 25, 2007. Table 1 also shows how P and K were applied to maintain sufficient and representative nutrient levels. It also should be noted that Fe was tank-mixed (2 oz ferrous sulfate/1000 ft²) with Primo (0.125 oz Primo Maxx/1000 ft²) and applied every two weeks.

Plot Management

Starting in April 2005, the nursery was maintained in exactly the same way as other greens on the golf course. Putting green nursery was mowed 5 to 6 times per week at a 0.140-inch height of cut. A walk-behind 22.0-inch wide Jacobsen greens mower was used, except on weekends when a triplex mower was used. Groomers were attached to walk-behind mowers.

Putting green nursery was rolled 1 or 2 times per week.

Putting green nursery was irrigated for optimal putting green conditions. Syringing and hand watering was applied as needed. Leaching with 1.5 to 3.0 inch of water occurred the last Sunday of each summer month, or as needed. Note that the green was not watered with the irrigation system from March to mid-May 2006 due to construction on the golf course. During this time, water was transported by a water truck and the green was watered by hand using a hose.

Core cultivations occurred on 22 Feb. and 16 May 2006 and 19 Mar. 2007 with 0.50-inch diameter hollow tines and cores were removed. Cultivations were followed with sufficient topdressing. Verticutting was conducted as needed followed by light topdressing. Light topdressing occurred 8 to 9 times per year. Insecticides and herbicides were applied as needed. Fungicides were applied to prevent moderate to severe disease activity.

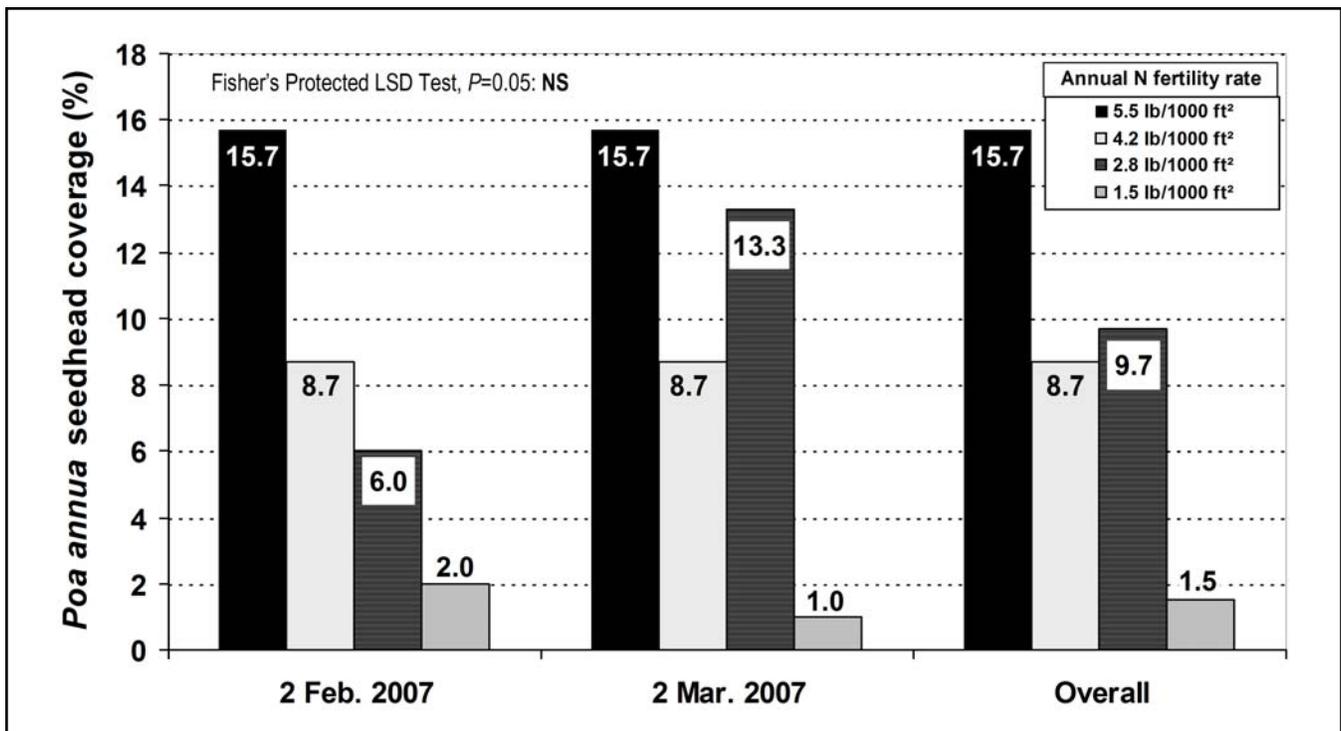


Figure 6. The effect of annual N fertility rate on percent *Poa annua* seedhead coverage

Data Collection

Starting in June 2005, visual turfgrass quality and color ratings were taken every 4 to 6 weeks. Visual ratings of disease activity, *Poa annua* seedhead coverage, and recovery from core cultivation also were taken. Measurements of clipping yields, concentration of total N, P, and K in clipping tissue, and 2-day plant uptake of N, P, and K were measured in July, October, January, and April. At the end of the two-year study, cores were taken to measure shoot density and root mass density. Soil analyses for total N, Olsen-P, and exchangeable K, Ca, Mg, and Na were taken 1 and 2 years following N fertility rate-treatment initiation.

Results

Visual Turfgrass Quality and Color

All annual N fertility-rate treatments provided satisfactory visual turfgrass quality and color (Figures 1-3). In terms of annual N fertility-

rate treatments (lb/1000 ft²): 5.5 > 4.2 > 2.8 and 1.5. If the additional N supplied in irrigation (approximately 0.5 lb/1000 ft² per year) is included, then, in terms of annual N fertility-rate treatments (lb/1000 ft²): 6.0 > 4.7 > 3.3 and 2.0. It is probable that the optimal and deficient annual N fertility rates range from 6.0 to 3.0 lb/1000 ft², respectively.

This range would be a general guide, keeping in mind that annual N fertility rates may need to be adjusted depending on several factors, such as: amount of play; soil type; salinity and leaching requirements; amount of rainfall; irrigation with recycled water; N application schedule, rates, and N sources; Fe and plant growth regulator applications; and others.

Disease Incidence

During December 2005, there was an outbreak of *Rhizoctonia* brown patch. Ratings showed a non-significant trend that as annual N fertility rates increased, the coverage of *Rhizoctonia* brown patch decreased (Figure 4).

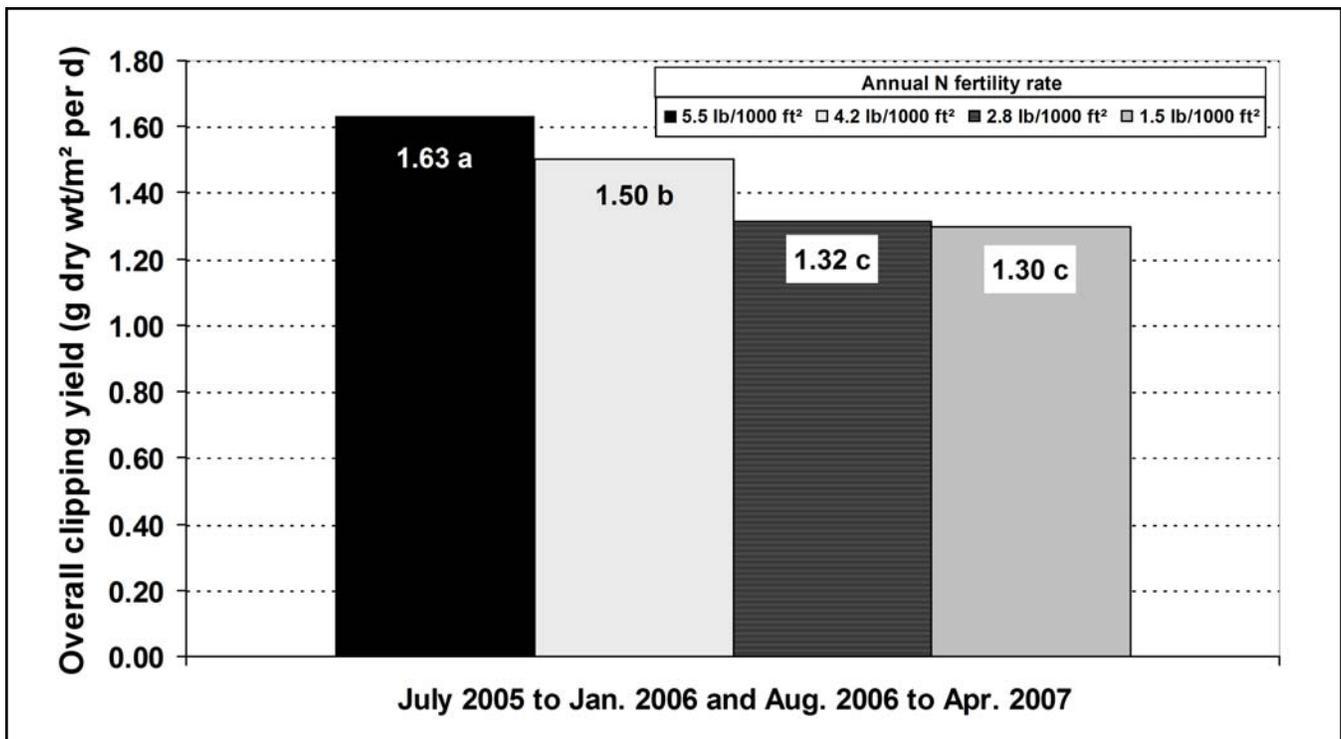


Figure 7. The effect of annual N fertility rate on overall clipping yield of a *Poa annua*-creeping bentgrass putting green from July 2005 to January 2006 and August 2006 to April 2007.

Recovery from Core Aeration and *Poa annua* Seedhead Development

During the second year, the 1.5 lb/1000 ft² annual N fertility-rate treatment had less than 50% recovery from core cultivations compared to the other annual N fertility-rate treatments (Figure 5). This observation was expected since lower annual N fertility rates resulted in slower growth. Ratings of *Poa annua* seedhead coverage showed a non-significant trend that as annual N fertility rates increased, the coverage of seedheads also increased (Figure 6). It is possible that the lower annual N fertility rates resulted in insufficient growth potential to produce relatively high seedhead coverage.

Clipping Yield

Clipping yield was significantly affected by annual N fertility-rate treatments (Figure 7). In terms of annual N fertility-rate treatments (lb/1000 ft²): 5.5 > 4.2 > 2.8 and 1.5. If the addi-

tional N supplied in irrigation (approximately 0.5 lb/1000 ft² per year) is included, then, in terms of annual N fertility-rate treatments (lb/1000 ft²): 6.0 > 4.7 > 3.3 and 2.0. Clipping yield also was affected by season, with the lowest yield during January (data not shown).

Concentration of N, K, and P in Clippings

On selected dates, there were significant differences among annual N fertility-rate treatments for N and K concentrations (data not shown). Concentrations of N and K were within published target sufficiency ranges for creeping bentgrass, except during January. There were no significant differences among annual N fertility-rate treatments for P concentrations. Concentrations of P varied by date, but remained within the published target sufficiency ranges for creeping bentgrass.

Conclusions

Results from this study show that optimal and deficient annual N fertility rates for *Poa annua*-creeping bentgrass putting greens in California probably range from 6.0 to 3.0 lb/1000 ft², respectively. This information is a general guide, keeping in mind that annual N fertility rates may need to be adjusted depending on several factors, such as amount of play, soil type, salinity, and leaching requirements, amount of rainfall, irrigation with recycled water, N application schedule, rates, and N sources, Fe and plant growth regulator applications, expectations of turf quality and green speed, and others.

Lower annual N fertility rates resulted in significantly lower visual turfgrass quality and color, clipping yields, slower recovery from core cultivation, and lower shoot density. There also was a trend that lower annual N fertility rates resulted in more *Rhizoctonia* brown patch coverage, while higher annual N fertility rates resulted in more seedhead coverage. The Final Report, including all data, is available at <http://ucrturf.ucr.edu>, UCRTRAC section, UCRTRAC Accumulative Research Summary, Project E-6.

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