

ABSTRACT

Creeping bentgrass (*Agrostis palustris* Huds.) is the most common turfgrass used for putting greens in much of the northern United States. However, its high quality surface means that use will always be pushed southward, into areas for which it is marginally adapted. Newer cultivars of bentgrass are often underrepresented in research, and thus the objective of this work was to examine the performance of newer creeping bentgrass cultivars at two southern locations, when managed under varying nitrogen (N) fertilization rates. Beginning in March 2016, experiments were conducted at the Atlanta Country Club (ACC) (Marietta, GA) and the experiment station at Griffin, GA, on established (seeded Sept 2015) USGA-type putting greens consisting of 'Pure Distinction', 'AU Victory', '007', 'V8', 'T1' and a 'Penn A1/A4' mix. Nitrogen treatments were solution urea at 0, 0.2, 0.5, 1.0, 1.5 and 2.0 g N m⁻², sprayed every other week. There were 4 replications of each N Rate/cultivar treatment. Collected data included relative color and quality, green firmness, and root and shoot densities. In the early spring (Feb-May) of 2016 bentgrass quality, color and shoot density generally increased as N rate increased, regardless of cultivar. However, with the onset of summer heat bentgrasses fertilized with the two highest rates of N were severely affected, with significant tissue damage and death. Thus, in 2017 N applications in the two highest treatments were adjusted to weekly applications. At the ACC June 2016 shoot density was highest in Pure Distinction, followed by AU Victory, and then shoot density in 007. Penn A1/A4, T1 and V8 were equal. June root length density was greatest in T1, followed by V8, with root length density in all other cultivars equal. In 2017 application of the highest rates of N on a weekly basis prevented the damage observed in 2016.

METHODS & MATERIALS

- The study was conducted in 2016 and 2017 at the Atlanta Country Club (ACC), Marietta, GA (Figure 1), and the University of Georgia, Griffin, GA.
- There were four replications of each cultivar/N Rate treatment, with each plot measuring 1 x 1 m in size. The study was a 6 x 6 factorial of N Rate and cultivar arranged in a randomized complete block design.
- For each study new putting greens were constructed, with 90/10 (v/v) sand/peat mixes for the greensmix. Each putting green was seeded with the creeping bentgrass cultivars outlined in Table 1 in September, 2015. Seeded research areas were maintained by golf course and university personnel for establishment through March 2016, after which N fertilizer treatments were initiated.
- Nitrogen fertilizer treatments were applied using urea (46-0-0) as the N source, applied as a foliar treatment using a walk-behind CO₂-powered sprayer at a 841 L ha⁻¹ (90 gpa) spray volume. Table 2 outlines the exact N rate/timing treatments applied in each year.
- In both years N treatments started in March of that year and were ended in September. From September 2016 to January 2017 the N rate treatments not applied, and the research area was uniformly fertilized for recovery and growth, prior to the start of the second year of data collection in March. No N was applied in the month of February.
- Collected data included monthly relative color and quality using a 1 – 9 relative scale, with a score of '1' for dead and/or brown turf and a score of '9' for lush, dark green turf. Additional collection included twice-yearly root and shoot data, with shoot density performed via hand-counting of removed shoots. Washed roots were scanned for root-length measurements, with subsequent drying for determination of dry weight.

Table 1. Creeping bentgrass cultivars seeded in the cultivar x N rate trials in Marietta and Griffin, GA, 2015-2017. All cultivars were seeded in September, 2015 at a rate of 9.8 g m⁻².

Creeping Bentgrass Cultivar	Commercial Information
Penn A1 and A4 blend	Tes-2-Green
T1	Jacklin Seed
V8	Jacklin Seed
007	Seed Research of Oregon
Pure Distinction	Pure Seed
AU Victory	Auburn University

Table 2. N rate treatments used in the cultivar x N rate trials in Marietta and Griffin, GA, 2016-2017. All N was applied at the rates and timings shown below as urea (46-0-0) solution in an 841 L ha⁻¹ spray volume.

Timing of applications (split applications)		N g m ⁻² application	
2016 N Rates	2017 N Rates	2016	2017
0	0	never	never
0.9	0.9	0.25 weekly	0.25 weekly
0.9	0.9	0.45 biweekly	0.45 biweekly
1.8	1.8	0.9 biweekly	0.9 biweekly
2.7	2.7	1.4 biweekly	0.7 weekly
3.5	3.5	1.8 biweekly	0.9 weekly

RESULTS

Table 3. Analysis of variance for root and shoot data, 2016 and 2017, Atlanta CC and Griffin, GA.

Factor	Atlanta Country Club				Griffin, GA	
	June 2016	Nov 2016	June 2017	June 2016	Sept 2016	
	Shoot Density				Root Length	
	P > F				P > F	
Cultivar	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
N Rate	0.0001	0.0001	0.0001	0.0001	0.0001	0.11
Cultivar x N Rate	0.46	0.15	0.08	0.08	0.55	0.62
	Root Length				Dry Weight	
	P > F				P > F	
Cultivar	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
N Rate	0.0001	0.0001	0.0001	0.0001	0.0001	0.25
Cultivar x N Rate	0.18	0.27	0.27	0.08	0.80	0.80
	Dry Weight				Dry Wt/Root	
	P > F				P > F	
Cultivar	0.0001	0.0001	0.0001	0.0001	0.0001	0.40
N Rate	0.0001	0.0001	0.0001	0.0001	0.0001	0.01
Cultivar x N Rate	0.02	0.06	0.06	0.02	0.01	0.01

Figure 2. Effect of N rate on shoot density of creeping bentgrass as affected by sampling date and location, 2016 and 2017, Atlanta CC and Griffin, GA.

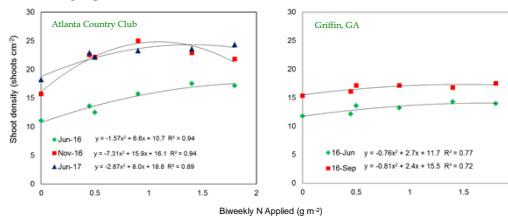


Figure 3. Effect of N rate on total root length of creeping bentgrass as affected by sampling date and location, 2016 and 2017, Atlanta CC and Griffin, GA.

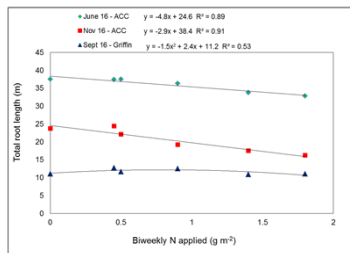


Table 4. Shoot density of bentgrass cultivars as affected by sampling date and location, 2016-2017, Atlanta Country Club and Griffin, GA.

Cultivar	Atlanta Country Club			Griffin, GA	
	June 2016	Nov 2016	June 2017	June 2016	Sept 2016
Pure Distinction	18.2 a	26.1 a	22.3 bc	14.3 a	19.6 a
AU Victory	16.4 b	24.7 a	26.0 a	14.3 a	18.9 ab
007	14.3 c	22.4 b	23.8 b	14.4 a	17.7 bc
Penn A1/Penn A4	13.7 cd	19.4 c	22.3 bc	10.3 b	13.2 d
T1	13.2 cd	20.1 c	21.6 c	14.6 a	14.4 d
V8	12.0 d	17.3 d	18.3 d	11.0 b	16.2 d

Within each sampling date means followed by the same letter are not significantly different from each other at an alpha of 0.05.

Table 5. Root length density of bentgrass cultivars as affected by sampling date and location, 2016-2017, Atlanta Country Club and Griffin, GA.

Cultivar	Atlanta Country Club		Griffin, GA
	June 2016	Nov 2016	Sept 2016
	Root Length (m)		
Pure Distinction	36.0 b	14.7 d	10.8 b
AU Victory	36.0 b	18.7 c	14.4 a
007	31.0 c	21.4 b	10.6 b
Penn A1/Penn A4	34.0 b	21.7 b	8.6 c
T1	38.8 a	27.2 a	14.7 a
V8	40.0 a	19.4 bc	10.5 bc

Within each sampling date means followed by the same letter are not significantly different from each other at an alpha of 0.05.



Figure 1. The research test putting green at the Atlanta Country Club, Marietta, GA. April, 2016

Table 6. Relative color and quality of creeping bentgrass as affected by N rate and rating date, 2016. Atlanta Country Club.

N Rate g N m ⁻² mo ⁻¹	Color (1 - 9 scale)			Quality (1 - 9 scale)		
	April	June	August	April	June	August
0	5.7 c	2.8 e	2.3 d	6.0 b	2.9 d	2.8 c
0.9 (split weekly)	6.0 de	4.7 d	5.1 b	6.3 b	4.8 c	4.9 a
0.9 (split biweekly)	6.2 d	5.3 c	5.2 b	6.0 b	5.2 c	4.8 ab
1.8 (split biweekly)	7.1 c	6.9 b	7.0 a	6.3 b	6.7 b	4.3 b
2.7 (split biweekly)	7.9 b	8.2 a	5.3 b	6.9 a	7.6 a	2.8 c
3.5 (split biweekly)	8.5 a	8.1 a	4.0 c	6.9 a	7.3 a	1.7 d

Within each sampling date means followed by the same letter are not significantly different from each other at an alpha of 0.05.

Figure 4. Left - creeping bentgrass plots as affected by N rate, April, 2016. Right - example of damage caused by biweekly application of high rates of N, July, 2016. Atlanta Country Club.



CONCLUSIONS

- The interaction of N rate and cultivar was not significant for root length, shoot density, and bentgrass color or quality (Table 3). However, the interaction was significant for dry weight of bentgrass roots (Table 3). This was because the cultivars T1, Pure Distinction, AU Victory and V-8 often had high root dry weight when no N was applied, with a substantial reduction in dry weight when the top two N rates were applied. The cultivar 007 and the Penn A1/A4 blend were less affected by nitrogen additions, with lower root dry weights across all rates of added N.
- Shoot density was often maximized at N rates of 2.2 to 2.8 g N m⁻² mo⁻¹ (Figure 2). Root length often decreased as N rate increased (Figure 3).
- Shoot density of the cultivars occurred in this general order, from highest to lowest: Pure Distinction = AU Victory ≥ 007 > Penn A1/A4 blend = T1 > V8 (Table 4).
- Root length of the cultivars was often the reverse of that observed with shoot density, with a general order (from longest to shortest) of: T1 ≥ V8 ≥ 007 = Penn A1/A4 blend = Pure Distinction = AU Victory (Table 5).
- In early spring higher rates could be applied safely as biweekly applications, but by June it damaged the turf (Table 6, Figure 4). When these same rates were switched to split weekly applications (Table 2, in 2017) turfgrass damage did not occur.
- Two years of observation revealed that cultivars tended to perform similarly across a range of N rates. The highest rate of N was not needed for the highest quality turf, and it significantly reduced root growth.
- Nitrogen rates of between 2.2 to 2.8 g N m⁻² mo⁻¹ were needed for best color, quality and shoot density, but those rates had to be applied as weekly split treatments to avoid summer damage via phytotoxicity.