CHAPTER 4

Annual Bluegrass and Creeping Bentgrass Competition Under Variable Irrigation Treatments

Abstract

Interspecific competition between annual bluegrass (*Poa annua* L. var. reptans) and creeping bentgrass (*Agrostis palustris* Huds. L.) has gained much attention over the years as efforts to control annual bluegrass economically have not been very successful. It is widely agreed that annual bluegrass is favored over creeping bentgrass in compacted soils especially when over irrigated. A 3-year study (1992-1994) was conducted at the Hancock Turfgrass Research Center to evaluate the interspecific competition between annual bluegrass and Penncross creeping bentgrass fairway turfs under three irrigation regimes: i) apply 2.5 mm daily irrespective of rainfall; ii) return soil to field capacity based on daily TDR estimated moisture deficits; and iii) apply 25 mm only upon the appearance of wilting stress. Irrigation blocks, established in 1989 with dimensions (11 x 11 m), were split (11 x 5.5 m) and seeded at random as pure stands of annual bluegrass or creeping bentgrass. The turfs were mowed at a height of 16 mm and maintained according to standard practices for cool-season fairway turfs in Michigan. Volumetric soil moisture content (VMC) was measured daily between 700 and 900 h except on rainy days using horizontally installed time domain reflectometry (TDR) probes at 0-5, 5-10, 10-15, and 15-25 cm depths. The TDR readings averaged over all depths were used to determine irrigation need for the field capacity treatment (FC). Turf biomass, quality ratings and interspecific competition were evaluated. Root mass densities were greatest in the 0-5 cm depth, ranging from 63-73 % of total root mass with an average of 69.7% for 1993 and 1994. The two year average for the percent root mass by depth for the 5-10, 10-15, and 15-25 cm depths were 15.9, 9.5 and 4.4% respectively. Quality ratings for bentgrass were significantly higher than for annual bluegrass. Annual bluegrass/creeping bentgrass species composition was not significantly affected by irrigation treatment. High bentgrass percentages on both annual bluegrass and creeping bentgrass plots was strong evidence of superior bentgrass competition over annual bluegrass under our conditions.

Introduction

Annual bluegrass (*Poa annua* L var. reptans) is a highly competitive species on closely mowed irrigated golf course fairways (Beard et al., 1978). The invasive nature of this weed is favored by: i) the proliferation of persistently viable seeds; ii) strong fibrous roots; iii) lack of a dormancy mechanism and iv) compacted soils (Beard, 1973; Beard et al., 1978; Gaussoin, 1988).

Proper shot control on fairways requires optimum turfgrass uniformity, density, smoothness, and resiliency (Beard, 1982). These factors depend, in part, on soil moisture content. Irrigation of fairway turf should be based on evaporative demand, rooting depth, soil moisture depletion, topography, and traffic intensity (Beard, 1982). Ideally, just enough water should be applied to meet plant requirements. In practice, turf irrigation continues to be a challenge for many turf managers, sometimes resulting in overwatering even as water shortages are reported in some parts of the U.S.

Both annual bluegrass and creeping bentgrass show striking similarities in adapted growing conditions and cultural requirements such as cutting height, mowing frequency, and a wide range of tolerance of fertilization requirements (Beard, 1973; Vargas, 1994). However, different pH, irrigation, and N fertilization requirements are traditionally recommended for each species (Beard, 1982; Vargas, 1994). High N application rates (Engel, 1974), high soil moisture content (Beard, 1982), and soil compaction (Wilson and Latham, 1969) also enhance annual bluegrass encroachment into bentgrass turf.

Various cultural factors influence population dynamics between the desired species and annual bluegrass. Phosphorus fertilization rates (up to 86 Kg ha^{-1}) have been shown to enhance annual bluegrass encroachment into Penncross creeping bentgrass whereas doubling the above P rate produced better bentgrass turf with less annual bluegrass (Goss et al., 1975).

Cultural practices such as clipping removal which removes seedheads can significantly reduce annual bluegrass encroachment into bentgrass plots (Gaussoin et al., 1985) while frequent irrigation generally favors annual bluegrass competition over the desired species (Mahdi and Stoutmeyer, 1953; Younger, 1959; Beard et al., 1978). To the contrary, Saffel (1994) found that irrigation frequency had no significant effect on annual bluegrass/creeping bentgrass population dynamics.

Effective chemical annual bluegrass control has been reported by Gaul and Christians (1988). However, annual bluegrass control remains a permanent feature in turfgrass maintenance programs for many golf courses, with ever-increasing costs. The high cost of annual bluegrass control implies that cultural practices that discourage its competition with desirable species deserve further study. As an alternative, some turf scientists have suggested the use of annual bluegrass as a desired turfgrass species (Vargas, 1994). Development of improved annual bluegrass selections also has been reported (White, 1989).For most turf managers and researchers annual bluegrass control remains a major challenge.

With the growing competition for water amid declining water resources, the study of annual bluegrass competition under variable irrigation deserves renewed attention. This study evaluated the effect of three irrigation regimes on the plant responses and interspecific competition between annual bluegrass and creeping bentgrass under fairway conditions.

Materials and Methods

A 3-year study was conducted at the Hancock Turfgrass Research Center to evaluate interspecific competition between established annual bluegrass and creeping bentgrass under three irrigation regimes. The soil type was a modified Owosso sandy loam (fine-loamy mixed mesic Typic Hapludalf). Irrigation plots were established in 1989 (Saffel, 1994). The irrigation treatments were: i) apply 2.5 mm daily; ii) apply irrigation daily to return the soil to field capacity, based on moisture depletion as measured by time domain reflectometry (TDR); and iii) apply 25 mm only upon the appearance of wilting stress. Irrigation treatments served as whole plots with dimensions 11 x 11 m. Each plot was split (5.5 x 11 m) and seeded at random to either annual bluegrass or creeping bentgrass. Turfs were mowed three times a week at a cutting height of 16 mm and fertilized with phosphorus and potassium based on soil test with normal N recommendations for cool season fairway turfs in Michigan.

A rotary pop-up Rainbird Maxipaw sprinkler was located at each corner of the plots, with an average flow rate of 21.5 L h^{-1}. The operating pressure of the sprinklers was 276 kPa. The radius of throw was 11 m with head to head coverage. Irrigation was scheduled at 0300 each day to ensure minimum wind effects on application and distribution uniformities.

Time domain reflectometry (TDR) was used to measure volumetric soil moisture content (VMC) at four depths between 0700 and 0900 h except on days when rainfall interrupted data collection. The TDR data were used to schedule irrigation for the field capacity treatment and to provide a basis for comparing soil moisture retention and turfgrass performance under a range of irrigation scenarios practiced in Michigan.

The stainless steel TDR probes, 20 cm in length and 3.2 mm in diameter were installed horizontally, with a 5 cm center-to-center spacing at 2.5, 7.5, and 12.5 cm depths in three replicates. A fourth set of probes was installed with one at 17.5 cm and the other at 22.5 cm, replicated only twice due to the limited number of positions on the rotary switch used to direct the TDR signal from probe to probe. The arrangement of the probes provided moisture content estimates for the 0-5, 5-10, 10-15, and 15-25 cm depth, respectively. The probes were soldered to coaxial cables buried underground and connected to a switch box at the center of each plot.

Composite soil dielectric constant (ϵ) data for each treatment, replicate, depth and species (198 data points per day) as determined by TDR, were converted directly into VMC according to the equation (Topp et al., 1980):

$$\boldsymbol{VMC = 0.053 + 0.0292\epsilon - 0.00055\epsilon^2 + 0.0000043\epsilon^3.}$$

Data collected were stored according to probe number by plot and species for each date.

Root mass was determined using a 1.8 cm diameter probe. Three cores about 40 cm long were taken at random from each split-plot. The thatch layer was cut off and the remainder of each core was separated into subsamples corresponding to the depth increments of the sphere of influence of the probes: 0-5, 5-10, 10-15, and 15-25 cm. The roots were separated from the soil using a hydro-pneumatic elutriator (Smucker et al., 1982). Washed samples were rinsed with 5% alcohol and oven dried at 60°C for 24 h and weighed.

Interspecific competition was determined twice each year (14 July and 16 September 1992, 26 July and 10 September 1993, and 24 May and 29 July 1994) expressed as percent bentgrass on each split-plot. The predominant species at cross hairs of a 1 x 1 m grid on an entire split-plot was used to quantify the population dynamics of annual bluegrass and creeping bentgrass under the study conditions.

Clipping weights were taken three times during the growing season in 1993 and four times in 1994 using a mower with a 0.45 m swath for a 5 m distance. The fresh clippings were oven dried at 60°C for 24 hours and weighed.

Quality ratings were taken three times during the summer of 1993 and 10 times in 1994 for each species by irrigation treatment. Ratings were from 1 to 9, 9 representing ideal turf conditions and 6 as the minimum acceptable turf quality.

The experimental design was a split-strip plot design with three replications. The irrigation treatment served as whole plots. The two turf species were the split, and the strip was the depth. This design allowed for the evaluation of soil moisture retention by depth and by species under the three irrigation regimes and all possible interactions. The data were analyzed using the Statistical Analysis System (SAS) general linear models with the Student Newman Keuls (SNK) mean separation procedure (SAS Institute, Inc., 1994).

Results and Discussion

The analysis of variance showed that irrigation treatment (IRR), turf species (SPE), depth (DEP) and the interactions IRR*SPE and IRR*DEP significantly affected root mass density. Root mass distribution by depth for the different irrigation treatments is presented in Table 4.1. Root mass density in the 0-5 cm depth was significantly higher than in all other depths. The data indicated a range of 63 to 73% of the root mass within the 0-5 cm depth for the three sampling dates. The 5-10 cm depth had about 1.5 times more roots than the 10-15 cm depth and more than three times the root mass density of the 15-25 cm depth averaged across species.

The highest root mass density was recorded in early June, 1994 in the 0-5 cm depth. Samples taken in late July and mid-August for this depth were generally lower with the exception of 27 July 1994 in the stress treatment. This agrees with the conclusion of Koski et al. (1983), who reported reduction in root mass for cool-season grasses from heat and water stress during the hot summer months. The root mass densities for the 0-5 cm depth for STR were higher than for FC on all sampling dates but higher than DLY only on 27 July 1994. Root mass density for STR were highest in the 5-10 cm depth for all sampling dates.

Root mass density averaged across depths for annual bluegrass and creeping bentgrass are presented in Table 4.2. Bentgrass had significantly higher root mass densities than annual bluegrass for all sampling dates for the DLY and FC. For STR root mass density for bentgrass was significantly higher than for annual bluegrass only in 1993. The lack of significant difference between species in 1994, may be explained by heavy rainfall that coincided with the peak of the summer heat

Clipping weights by irrigation treatment are shown in Table 4.3. The irrigated treatments had higher clipping weights than the stress treatment, particularly during dry periods. Even when the differences were not significant, the stress plots had consistently.

Table 4.1. Mean root mass density averaged across species by irrigation treatment, 1993 and 1994.

Irrigation Treatment	Depth	Date		
		18 Aug. 1993	6 June 1994	27 July 1994
		Kg m^{-3}		
DLY	0-5 cm	26.4a†	33.6a	21.9a
	5-10 cm	5.9b	5.7b	5.9b
	10-15 cm	3.8bc	3.5bc	3.6bc
	15-25 cm	1.3d	1.5d	1.1d
FC	0-5 cm	21.2a	28.3a	20.7a
	5-10 cm	4.8b	4.7b	4.3b
	10-15 cm	3.9b	4.6b	4.2b
	15-25 cm	1.5c	1.2c	2.0c
STR	0-5 cm	25.6a	30.2a	29.0a
	5-10 cm	7.1b	7.0b	8.4b
	10-15cm	3.3c	3.3c	2.8c
	15-25 cm	2.0c	2.3c	2.0c

† Means within columns by irrigation treatment followed by the same letter are not significantly different. LSD $\alpha = 0.05$. DLY, FC, and STR and 2.5 mm daily, field capacity, and stress treatments, respectively.

lower clipping weights than did the irrigated treatments. Similar results were reported by Saffel, 1992 suggesting that turfs on the stress plots may not fully recover from moisture stress induced within the growing season. Differences in clipping weight between the 2.5 mm daily and the field capacity treatments were not significant at the 5% probability level. But differences in clipping weight between the FC and DLY were significant at lower probability levels only during dry periods (15 July and 17 Aug. 1993). Differences in clipping weight between species were not significant. This was probably due to the high percentages of bentgrass encroachment on annual bluegrass plots or an inherent similarity in ET for both species as reported by Beard, 1973; and Saffel, 1994.

Table 4.2. Root mass density averaged across depths for annual bluegrass and creeping bentgrass by irrigation treatment, 1993 and 1994.

Irrigation Treatment	Species	Date		
		18 Aug. 1993	6 June 1994	27 July 1994
			Kg m^{-3}	
DLY	Bent	9.1a†	12.7a	11.2a
	Poa	8.7b	9.5b	5.0b
FC	Bent	8.2a	12.7a	10.1a
	Poa	3.9b	6.7b	5.5b
STR	Bent	8.6a	10.6a	10.8a
	Poa	5.8b	10.7a	10.2a

† Means within columns by irrigation treatment followed by the same letter are not significantly different. LSD $\alpha = 0.05$. DLY, FC, and STR are 2.5 mm daily, field capacity, and stress irrigation treatments, respectively.

Quality ratings for the different irrigation treatments and turf species for 1993 and 1994 are presented in Table 4.4. Quality ratings for the daily treatment (DLY) were consistently higher than for the stress treatment (STR). However, differences between DLY and FC were significant only 2 of 7 rating dates. Quality ratings for creeping bentgrass were significantly higher compared to those for annual bluegrass on all rating dates

Table 4.3. Clipping weight means across species by irrigation treatment for 1993 and 1994.

Irrigation Treatment	Date			
	18 July 1993	24 Aug. 1993	18 Sept. 1993	20 June 1994
	g m^{-2}			
DLY	15.7a†	12.1a	13.0.a	15.7a
FC	12.8a	11.9a	12.1a	12.7b
STR	6.0b	8.2b	7.5b	6.0c

† Means within columns by date followed by the same letter are not significantly different. LSD $\alpha = 0.05$. DLY, FC, and STR are 2.5 mm daily, field capacity, and stress irrigation treatments, respectively.

Table 4.4. Turfgrass quality ratings by irrigation treatment and species.

	Date						
	6/20/93	7/15/93	8/17/93	9/1/93	9/15/93	6/2/94	8/22/94
<u>Treatment</u>							
DLY	8.2a†	7.8a	7.8a	8.9a	8.8a	8.7a	9.0a
FC	8.0ab	7.3b	7.7a	8.3ab	7.6ab	8.8ab	8.8ab
STR	7.9b	5.0c	6.2b	7.3b	7.3b	8.3b	8.6b
<u>Species</u>							
Bent	8.2a	7.3a	7.6a	8.6a	8.1a	8.4a	8.5a
Poa	7.3b	6.3b	6.8b	7.7b	7.7b	8.3b	7.6b

† Means within columns for each treatment followed by the same letter are not significantly different. LSD $\alpha = 0.05$. DLY, FC, and STR are 2.5 mm daily, field capacity, and stress irrigation treatments, respectively.

The percent bentgrass in both bentgrass and annual bluegrass plots is given in Table 4.5. The percent bentgrass on annual bluegrass plots ranged from a low of 52% in 1992 on annual bluegrass stress plots to over 81% for the daily irrigation treatment in 1994. High bentgrass counts on both annual bluegrass and creeping bentgrass plots was strong evidence of superior bentgrass competition under our study conditions. The analysis of variance showed that irrigation had no significant effect on annual bluegrass and creeping bentgrass population dynamics under our conditions. This finding is consistent with that of Saffel (1992) but contradicts the popularly held view that higher irrigation favors annual bluegrass competition over bentgrass (Younger, 1959). It must be noted that there was limited traffic on this experimental site compared to that on golf course fairways.

Table 4.5. Percent creeping bentgrass in annual bluegrass and creeping bentgrass plots as affected by irrigation treatment.

Irrigation Treatment	Species	1992		1993		1994	
		7/14	9/16	7/26	9/10	5/24	7/29
		% Composition					
DLY	Bent*	93.0a†	93.1a	97.0a	95.3a	81.4a	91.6a
	Poa	65.3b	64.3b	79.3b	78.5b	73.0b	81.9a
FC	Bent	89.7a	91.0a	96.7a	97.0a	78.2a	87.5a
	Poa	74.7b	76.3b	79.7b	79.3b	70.1b	76.4b
STR	Bent	85.7a	94.0a	95.0a	97.0a	87.9a	89.8a
	Poa	62.0b	52.0b	75.2b	65.3b	70.4b	75.0b

† Means within columns for each treatment followed by the same letter are not significantly different. LSD $\alpha = 0.05$. DLY, FC, and STR are 2.5 mm daily, field capacity, and stress irrigation treatments, respectively. * Plots were established in 1989 as pure stands. Saffel, 1992.

Conclusions

The analysis of variation showed that irrigation treatment did not significantly affect the percent composition of annual bluegrass and Penncross creeping bentgrass. Consistently high bentgrass percentages in annual bluegrass and bentgrass plots was strong evidence of superior bentgrass competition under our study conditions.

Penncross creeping bentgrass had superior quality than annual bluegrass on most sampling dates. With the exception of 20 June 1994, there was no significant difference in quality ratings between the 2.5 mm daily and the field capacity treatment. Quality ratings for both irrigated treatments were significantly higher than for the stress treatment.

Root mass densities for the creeping bentgrass was significantly higher than for annual bluegrass in both irrigated treatments for all sampling dates. About 63 to 70% of the root mass averaged across species was within the 0-5 cm depth. Although root data was collected for two years, root mass densities for early June were higher than those sampled later in the summer.

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