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Title: Golfer Perception of Input-Limited Fairway Management in the Northcentral U.S.

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Objectives:
1. Document annual inputs for buffalograss, Kentucky bluegrass, and creeping bentgrass fairways under traditional and input-limited management in the northcentral U.S.
2. Determine the fairway species preference, and expected quality level, for golf course superintendents and professional and amateur golfers when inputs are known and unknown.
3. Link golfer quality expectations to annual management inputs.
4. Determine the combined effects of irrigation regimen and nitrogen fertility on pest incidence, and corresponding total pesticide use in creeping bentgrass, Kentucky bluegrass, and buffalograss fairways.

Start Date: 2017
Project Duration: 3 years
Total Funding: $69,020

Summary text:
Rational
It's commonly assumed that buffalograss (*Buchloë dactyloides*) fairways require fewer management inputs in the northcentral U.S. compared to more commonly used species such as Kentucky bluegrass (KBG; *Poa pratensis*) or creeping bentgrass (CBG; *Agrostis stolonifera*). However, negative opinions of buffalograss are common among golfers and superintendents, despite improved color and density characteristics of recently-released cultivars. Golfers may be more likely to accept buffalograss if management inputs compared to other species are quantified.

Methodology
We established 'Prestige' buffalograss, 'Barvette' KBG, and 'Pure Select' CBG in three plots (20 ft. × 30 ft.) each during 2016 (nine total plots) in Lincoln, NE. These plots are arranged in a randomized, complete block-design, and serve as the whole-plot treatment factor for the experiment. Sub plots are arranged in a 2 irrigation × 3 fertilizer × 2 pest control factorial treatment structure. Irrigation levels are 1) no supplemental irrigation or 2) standard reference evapotranspiration (ETo) replacement (i.e. 80% ET_o for CBG and KBG or 60% ET_o for buffalograss). Fertilizer levels are 1) unfertilized, 2) "standard" fertilizer (1 lb N/1,000 ft^2 in May, Sept., Oct. and Nov. for CBG and KBG; 1 lb N/1,000 ft^2 in June and July for buffalograss), or 3) a threshold program where 0.25 lbs N/1,000 ft^2 is applied when quality approaches an unacceptable level. Pest control levels are 1) untreated or 2) "standard" strategies to control weeds, diseases, and insects. Experimental management began in May of 2017, and diseases were controlled at the first sign of infection in standard pest control plots. We collected visual estimates of turfgrass quality (1-9, where 9=best and 6=minimum acceptable) weekly, counted dollar spot (caused by *Sclerotinia homoeocarpa*) infection centers when present, and mowed individual plots at 0.5 in. when needed based on visual inspection. Additionally, we determined the area under the disease progress curve (AUDPC) for dollar spot in 2017 {AUDPC = $\sum_{i=1}^{ni-1} ([y_i + y(i + 1)] / 2) (t(i+1) - t_i)$; where i is the order index for sampling dates, n is the number of sampling dates, y is total infection centers, and t is time}.

Preliminary Results

Turf quality

The combined effects of species × irrigation x pest control produced the highest-order interaction that affected average turf quality over the 2017 growing season. Well-watered CBG plots with pests controlled had the highest average quality (7.6), and KBG under similar management had only slightly lower quality (7.1). Unirrigated KBG plots with no pest control (average quality of 6.7) and irrigated buffalograss with or without pest control (average quality of 6.4 in both cases) were in the next statistical grouping. Buffalograss and KBG under other irrigation × pest control treatment combinations averaged acceptable quality over 2017 and CBG that was unirrigated and received pest control did not, but was not statistically different from unirrigated buffalograss with or without pest control. Creeping bentgrass that didn't receive pest control or was unirrigated had significantly lower, unacceptable average quality over 2017. Considering average turf quality and main effects, KBG (6.6) > buffalograss (6.2) > CBG (6.1), plots that were irrigated to ET-replacement (6.6) > unirrigated plots (6.0), standard fertilizer (6.5) > threshold-based (6.3) > untreated (6.1), and plots where pests were controlled (6.6) > untreated plots (6.0). Average quality provides only a snapshot of the effects of treatment combinations, and future analyses of weekly data will provide higher resolution during stressful periods in midsummer.

Pest incidence

Dollar spot was the most prevalent pest in 2017, and the combined effects of species × irrigation x pest control produced the highest-order interaction affecting dollar spot incidence. Dollar spot was most prevalent in well-watered CBG plots without pest control (AUDPC=2152). Well-watered KBG without pest control (AUDPC=826) and unirrigated CBG without pest control (AUDPC=758) were in the next statistical grouping. Dollar spot was never observed in buffalograss under any irrigation x pest control combination (AUDPC=0 in all cases), and CBG or KBG with or without ET-replacement that received pest control were not significantly different (AUDPC=14 to 76). Considering AUDPC and main effects, CBG (756) > KBG (302) > buffalograss (0), plots that were irrigated to ET-replacement (505) > unirrigated plots (200), and plots where pests were not controlled (678) > treated plots (27). The fertilizer main effect was not significant.

Irrigation, Fertilizer, Fungicides, and Mowing

Creeping bentgrass and KBG plots under 80% ET-replacement received 14.3-in. (388,642 gal/acre) of irrigation from 1 May to 29 Nov. 2017, whereas buffalograss plots under 60% ET-replacement received 10.1 in. (274,777 gal/acre). Because this use would exceed 12 million cubic feet annually, our non-residential water costs from the City of Lincoln would be approximately $1.911/unit (748 gal). Therefore, it cost $992.91/acre to irrigate CBG and KBG, and $700.00/acre to irrigate buffalograss in 2017. Because plots were fertilized, treated with chlorothalonil, and mown on a per-plot basis, average expenditures for each are presented at the level of the smallest experimental unit (species × irrigation × fertilizer × pest control) in Table 1. Other fungicides and herbicides were applied in 2017, but we focus on chlorothalonil since dollar spot injury was so prevalent. Average season-long quality and AUDPC values are also presented in Table 1 for reference, but differences are not statistically significant at the level of this highest-order interaction.

Summary Points:

- Drought and dollar spot were the most common detractors of turf quality in 2017, and both disproportionately affected creeping bentgrass compared to other species.
- Chlorothalonil applied at the first sign of dollar spot infection essentially eliminated disease development in creeping bentgrass and Kentucky bluegrass, and only six to eight applications were required on average.
- Creeping bentgrass that did not receive fungicide applications did not average acceptable quality over 2017, regardless of other factors.
- Kentucky bluegrass provided acceptable quality over a range of management scenarios, and can persist in input-limited conditions if transient quality reductions during drought or severe dollar spot infestation are acceptable.
- Buffalograss expenditures were approximately half of other species under the most intense management level. Buffalograss was less affected by input-limited management than other species.
- Our cost analysis is intended only to compare expenditures among species and management scenarios under our experimental conditions, and to quantify general differences for a consumer survey next year. Cost per acre estimates are not intended to predict or suggest the resources needed to manage golf course fairways of species in our study.

Figure 1. A drone image showing replicated whole plots (20 ft. × 30 ft.) of creeping bentgrass (*A*), Kentucky bluegrass (*B*), and buffalograss (*C*) on 10 July 2017. Severe drought stress is visible in unirrigated sub plots (5 ft. × 10 ft.) of creeping bentgrass and Kentucky bluegrass.

Figure 2. Symptoms of injury from dollar spot in sub plots of creeping bentgrass on 22 August 2017. Only plots that received ET-replacement and threshold-based fungicide applications had acceptable quality.

Figure 3. Symptoms of injury from dollar spot in sub plots of Kentucky bluegrass on 22 August 2017. Dollar spot development was low at this time, but severity increased at later ratings.

Figure 4. Sub plots of buffalograss on 22 August 2017. Dollar spot was never detected in buffalograss in 2017.

Table 1. Expenditures and associated quality and dollar spot development of turfgrasses managed under a spectrum of scenarios in Lincoln, NE from 1 May to 29 November 2017.

Species	Irrigation[u]	N Fertilizer[v]			Chlorothalonil[w]			Mowing[x]	Total Cost	Quality[y]	AUDPC[z]
		Lbs (N/1,000 ft^{2})		Cost ($/A)	(Apps)		Cost ($/A)	(Times)	($/A/Year)		
Creeping Bentgrass	**80%ET$_o$** 14.3 in. 388,642 gal/A *$992.91/A*	Stand.	4.0	*136.36*	Yes	7.3	*373.12*	33.7	*1,502.39*	7.9	32
			4.0	*136.36*	No	0.0	*0.00*	25.7	*1,129.27*	5.9	2315
		Thresh.	0.3	*11.36*	Yes	7.7	*390.08*	30.3	*1,394.35*	7.5	38
			0.9	*31.25*	No	0.0	*0.00*	24.0	*1024.16*	5.8	2148
		Untreat.	0.0	*0.00*	Yes	7.3	*373.12*	29.3	*1,366.03*	7.3	50
			0.0	*0.00*	No	0.0	*0.00*	21.0	*992.91*	5.5	1992
	No supplemental 0.0 in. 0.0 gal/A *$0.00/A*	Stand.	4.0	*136.36*	Yes	7.0	*356.16*	22.0	*492.52*	6.2	149
			4.0	*136.36*	No	0.0	*0.00*	19.0	*136.36*	5.4	563
		Thresh.	1.7	*56.82*	Yes	7.7	*390.08*	20.3	*446.90*	5.6	32
			2.4	*82.39*	No	0.0	*0.00*	19.0	*82.39*	5.1	936
		Untreat.	0.0	*0.00*	Yes	8.0	*407.04*	15.0	*407.04*	5.5	46
			0.0	*0.00*	No	0.0	*0.00*	14.0	*0.00*	5.1	775
Kentucky Bluegrass	**80%ET$_o$** 14.3 in. 388,642 gal/A *$992.91/A*	Stand.	4.0	*136.36*	Yes	6.7	*339.20*	41.7	*1,468.47*	7.5	5
			4.0	*136.36*	No	0.0	*0.00*	37.7	*1,129.27*	6.4	874
		Thresh.	0.7	*22.73*	Yes	6.3	*322.24*	36.3	*1,337.88*	6.7	5
			1.1	*36.93*	No	0.0	*0.00*	38.7	*1,029.84*	6.2	890
		Untreat.	0.0	*0.00*	Yes	6.7	*339.20*	38.7	*1,332.11*	7.1	33
			0.0	*0.00*	No	0.0	*0.00*	38.3	*992.91*	6.2	715
	No supplemental 0.0 in. 0.0 gal/A *$0.00/A*	Stand.	4.0	*136.36*	Yes	6.3	*322.24*	34.3	*458.60*	6.8	12
			4.0	*136.36*	No	0.0	*0.00*	34.3	*136.36*	6.5	376
		Thresh.	1.1	*36.93*	Yes	6.3	*322.24*	36.0	*359.17*	7.0	5
			1.3	*42.61*	No	0.0	*0.00*	32.7	*42.61*	6.3	382
		Untreat.	0.0	*0.00*	Yes	6.7	*339.20*	28.7	*339.20*	6.2	88
			0.0	*0.00*	No	0.0	*0.00*	29.0	*0.00*	5.9	240
Buffalograss	**60%ET$_o$** 10.1 in. 274,777 gal/A *$702.00/A*	Stand.	2.0	*68.18*	Yes	0.0	*0.00*	37.3	*770.18*	6.7	0
			2.0	*68.18*	No	0.0	*0.00*	37.7	*770.18*	6.5	0
		Thresh.	1.7	*56.82*	Yes	0.0	*0.00*	35.0	*758.82*	6.4	0
			2.1	*71.02*	No	0.0	*0.00*	34.7	*773.02*	6.3	0
		Untreat.	0.0	*0.00*	Yes	0.0	*0.00*	34.3	*702.00*	6.1	0
			0.0	*0.00*	No	0.0	*0.00*	35.0	*702.00*	6.3	0
	No supplemental 0.0 in. 0.0 gal/A *$0.00/A*	Stand.	2.0	*68.18*	Yes	0.0	*0.00*	34.0	*68.18*	6.1	0
			2.0	*68.18*	No	0.0	*0.00*	35.3	*68.18*	6.4	0
		Thresh.	2.3	*76.70*	Yes	0.0	*0.00*	32.0	*76.70*	6.1	0
			2.3	*76.70*	No	0.0	*0.00*	31.0	*76.70*	6.1	0
		Untreat.	0.0	*0.00*	Yes	0.0	*0.00*	26.7	*0.00*	5.7	0
			0.0	*0.00*	No	0.0	*0.00*	27.7	*0.00*	5.8	0

[u]Evapotranspiration (ET) replacement was based on standard recommendations for each species. Cost calculation is based on City of Lincoln non-residential water rates for high-volume users of $1.911/748 gallons.

[v]Standard (Stand.) fertilizer was 4, 4, or 2 lbs N/1,000 ft^{2}/year for creeping bentgrass, Kentucky bluegrass, or buffalograss, respectively. Threshold-based (Thresh.) applications (0.25 lbs N/1,000 ft^{2}) were made when quality approached an unacceptable level, and values represent a mean over three blocks. Untreated (Untreat.) plots were never fertilized. Urea (46-0-0) valued at $18/50 lbs bag was used for cost calculations.

[w]Chlorothalonil was applied in plots that received pest control (Yes) at 3.25 oz/1,000 ft^{2} ($50.88/A) at the first sign of dollar spot infection, and values represent a mean over three blocks. Untreated plots (No) never received an application.

[x]Plots were mown at 0.5 in. when deemed necessary by visual inspection. Values represent a mean over three blocks.

[y]Turfgrass quality (1-9, where 9=best and 6=minimum acceptable) was visually rated on a weekly basis. Values represent season-long means over three blocks and are not significantly different.

[z]Dollar spot infection centers were counted when present, and we determined the area under the disease progress curve (AUDPC) for dollar spot in 2017 {AUDPC = $\sum^{ni-1}_{i=1}$ ([y_i + y(i + 1)] / 2) (t(i+1) - t_i); where i is the order index for sampling dates, n is the number of sampling dates, y is disease severity, and t is time}. Values represent means over three blocks.