Research Report
to
Rocky Mountain Environmental Golf Institute
by
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Project 1 title:
Selection of Water Saving Kentucky Bluegrass and Tall Fescue for Colorado Turfgrass Industry

With a rapidly expanding population and an epic geography dictating Colorado as a head water state, the topics of water use and conservation are ever present to the citizens of Colorado. Selecting species and cultivars that use less water while maintaining acceptable quality will mitigate irrigation demands. Field research is conducted to: 1) compare turfgrass quality and growth of 15 Kentucky bluegrass entries, 19 tall fescue entries, 1 perennial ryegrass line under different irrigation treatments [80% reference ET (ET_o), 60% ET_o, and 40% ET_o] applied twice weekly, 2) determine relative drought resistance of different entries, and 3) document water quantity required for each entry to maintain acceptable and desirable turf quality and thereby assessing their water use efficiency. A full set of replicated study plots, i.e. 9 blocks, with each block consisting of 35 cool season turfgrass entries were established in 2017 with field study conducted in 2018 and 2019. Irrigation at 100% ET was applied during pre-deficit irrigation period (prior to May 31). Deficit irrigation period (irrigation at 40, 60, and 80% ET) starts from June and ends in September, which is followed by recovery period when irrigation amount at 100 to 120% ET water applied. Data were collected weekly on turf quality, water input, green coverage, drought stress symptoms and survival. A light-controlled digital imaging tool and image analyzing software were used to objectively derive turf quality parameters.

Research findings in 2017 to 2018:

1) During establishment, perennial ryegrass, tall fescue, and Kentucky bluegrass had 72%, 29%, and 1.5% ground coverage at 20 days after seeding. At 30 days after seeding perennial ryegrass had about 90% coverage which is higher than tall fescue (64% coverage). Kentucky bluegrass had only 32% ground coverage. Three months after seeding all three species had great establishment.

2) Perennial ryegrass was among the top performer except during peak summer at 40% ET (Table 1);

3) The total irrigation water was 24, 20, and 15 inches, whereas the total water received (i.e. irrigation + precipitation) was 34, 29, and 25 inches for 80%, 60%, and 40% ET treatments, respectively, in 2018. Based on 2018 data, regression analysis predicted that different Kentucky bluegrass differ in their irrigation requirement (ET level) in maintaining acceptable quality, ranging from 51% to 70 % ET (Table 2). The irrigation levels to maintain optimal quality ranged from 97 to 120 % ET among Kentucky bluegrass cultivars. Cultivars 'Midnight' and 'PST-K13-141' exhibited lowest irrigation requirement in 2018 among Kentucky bluegrass cultivars. The irrigation requirements to maintain acceptable tall fescue quality and optimal turf quality were 42-48% and 99-101%, respectively, among tall fescue cultivars (Table 2).

4) In general, tall fescue entries did better earlier in the irrigation treatment than Kentucky bluegrass entries. However, Kentucky bluegrass improved in ranking with continued deficit irrigation, and displayed better recovery than TF at 40% ET;

5) At 60% ET, there were 10 entries that maintained acceptable quality throughout the 2018 growing season (Table 1). Those entries included 'SR 4650' Perennial Ryegrass, DLFPS 321/3678, 'RS4', 'Thor", 'Supersonic', 'Thunderstruck', 'Kingdom', and 'Catalyst' tall fescue, and several other experimental lines. However, for these entries, the average quality rating was below the minimum acceptable quality rating of 6 at the 40% ET level.

6) Of all the bluegrass entries, line PST-K13-141 (from Pure-Seed Testing), NAI, and Midnight had the highest turf quality among Kentucky bluegrass entries in this study.

7) Of all the tall fescue entries, cultivar 'Thor', line 'DLFPS 321/3678' (from DLF Pickseed), 'RS4' (from Landmark Turf and Native seeds), 'Catalyst', and 'PST-5SDS' (from Pure Seed testing) were the top performers.

8) Research and data collection for the 2018 season showed that en masse, tall fescue entries showed higher overall quality than Kentucky bluegrass cultivars in all 3 reference ET_o treatments while Kentucky bluegrass cultivars showed increased ability to recover from drought. These initial results could be due to tall fescues adapted ability to excavate deeply within the soil profile in water uptake while Kentucky bluegrass adaptively reverts to dormancy in the face of drought stress.

Successive yearly research regimes and data collection are necessary, and study will be continued throughout 2019 and 2020 to determine the amount of water needed to maintain acceptable quality for each included turfgrass cultivar.

Table 1. Top ranked entries in 2018.

Top Kentucky Bluegrass Entries	Number of times in top statistical ranking	Top Tall Fescue Entries	Number of times in top statistical ranking	Overall Top 10 Entries	Number of times in top statistical ranking
PST-K13-141	11	Thor	15	'SR 4650' Perennial Ryegrass	15
PST-K11-118	9	DLFPS 321/3678	14	'Thor' tall fescue	15
Midnight	5	RS4	14	DLFPS 321/3678	14
		PST-5SDS	14	'RS4' tall fescue	14
		Catalyst	13	PST-5SDS	14
				'Supersonic' tall fescue	13
				'Thunderstruck' tall fescue	13
				'Kingdom' tall fescue	13
				'Catalyst' tall fescue	13
				PST-R511 tall fescue	13

Table 2. Regression analysis to generate irrigation requirements (% ET) to maintain minimal acceptable turf quality and optimal turf quality for selected Kentucky bluegrass and tall fescue cultivars.

Kentucky bluegrass entries	**% ET to maintain minimal acceptable turf quality**	**% ET to maintain optimal turf quality**
PST-K13-141	51 %ET	97% ET
PST-K11-118	53 %ET	104% ET
Midnight	57% ET	97% ET
BAR PP 110358	62% ET	104%ET
Babe	64%ET	110% ET
PST-K13-143	70%ET	120% ET
Tall fescue entries	**% ET to maintain minimal acceptable turf quality**	**% ET to maintain optimal turf quality**
F31 Catalyst	42%ET	101 %ET
F21 DLFPS 321/3678	44% ET	99% ET
F26 Thor	44% ET	100%ET
F28 RS4	48% ET	100% ET

Photo 1. Plots in July 2018, 1 month after deficit irrigation treatments.

Photo 2. Field plots in September 2019, 3.5 months after deficit irrigation treatments.

Project II title:

Relationships of soil analysis, turf quality, and shoot analysis of Kentucky bluegrass under effluent water irrigation on golf courses

Golf courses in the western United States are increasingly being irrigated with effluent water. Very limited research information is available regarding the degree of accumulation of different minerals or salts in turfgrass shoots when effluent water is used for irrigation. More research is needed to determine the relationships among soil salinity parameters, turf quality, and shoot mineral concentrations.

Research was conducted on eight golf courses in the semiarid front range of Colorado, including three courses with effluent water irrigation for 10 years, three courses with effluent water irrigation for 18 to 26 years, and two courses with surface water for irrigation for 15 and 18 years. Turf quality of Kentucky bluegrass (*Poa pratensis*), the most widely used turfgrass species in the United States, was evaluated on 25 roughs from the above-mentioned golf courses. Concurrently, Kentucky bluegrass shoot samples and soil samples were collected from these sites. Shoots of Kentucky bluegrass were analyzed for mineral concentrations of sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), chloride/chlorine (Cl), boron (B), sulfur (S), phosphorus (P), manganese (Mn), iron (Fe), and zinc (Zn)Electrical conductivity (EC) and sodium absorption ratio (SAR) of soil saturated paste were determined.

Kentucky bluegrass at the surface-water irrigation sites and the 10-year effluent water irrigation sites had similar turf quality ratings. The average turf quality of Kentucky bluegrass irrigated with effluent water for 18 to 26 years was lower than that of the surface-water irrigation group and of the 10-year effluent water irrigation group (Table 1). Sodium accumulation in the shoots was found in all courses irrigated with effluent water. Mean sodium ion (Na+) concentration in Kentucky bluegrass shoots in milligrams/kilogram was 329 for the surface-water irrigation group; 1,427 for the 10-year effluent water irrigation group; and 3,256 for the 18+-year effluent water irrigation group. Effluent water irrigation increased clipping sodium by 4.3 times in the 10-year group and by 9.9 times in the 18+-year group; it increased chloride by 1.5 times in the 10-year group and by 1.3 times in the 18+-year group. Kentucky bluegrass shoots irrigated with effluent water for 18+ years had 3.5 times the boron concentration and 16% lower potassium concentration than Kentucky bluegrass shoots irrigated with surface water.

There was a negative linear relationship between turf quality and sodium concentration in the shoots (Figure 1). Soil SAR at a depth of 0 to 8 inches (0 to 20 centimeters) was highly

associated with Kentucky bluegrass shoot sodium (Figure2). Sodium accumulation in the shoots was the leading plant variable causing the decline of turf quality under effluent water irrigation. Therefore, it is reasonable to believe that water treatment and management practices that can reduce soil SAR and sodium concentration in Kentucky bluegrass shoots would improve turf quality and plant health.

Table 1. Mean separation of turf quality, soil electrical conductivity (EC), soil sodium absorption ratio, and shoot mineral concentration of Kentucky bluegrass grown on golf course roughs under different years of recycled water irrigation.

Parameter[z]	Surface Water	Recycled Water Irrigation (10 years)	Recycled Water Irrigation (18-26 years)
Turf quality	8.2a[y]	7.8a	7.1b
Na	329c	1,427b	3,256a
Ca	3,856b	3,426b	5,159a
Mg	1,874b	2,725a	1,780b
K	20,637a	22,642a	17,372b
Cl	5,027b	7,545a	6,734a
B	5.9b	7.7b	20.8a
P	4,513	3,864	4,517
K/Na	64.3a	16.6b	6.3c
S	1,996b	1,285c	4,517a
Fe	282.4a	105.4b	270.8a
Zn	35.99a	25.29b	36.31a
Mn	51.8b	33.5b	104.6a
Soil EC	1.0b	1.2b	2.4a
Soil SAR	1.1c	3.5b	9.4a

[z] Units are mg kg^{-1} except for K/Na ratio, soil EC (dS m^{-1}), soil SAR, and turf quality (1-9 scale, 9 = best).

[y] Means within a row followed by the same letter are not significantly different based on LSD (0.05). No letters shown indicate not statistically significant.

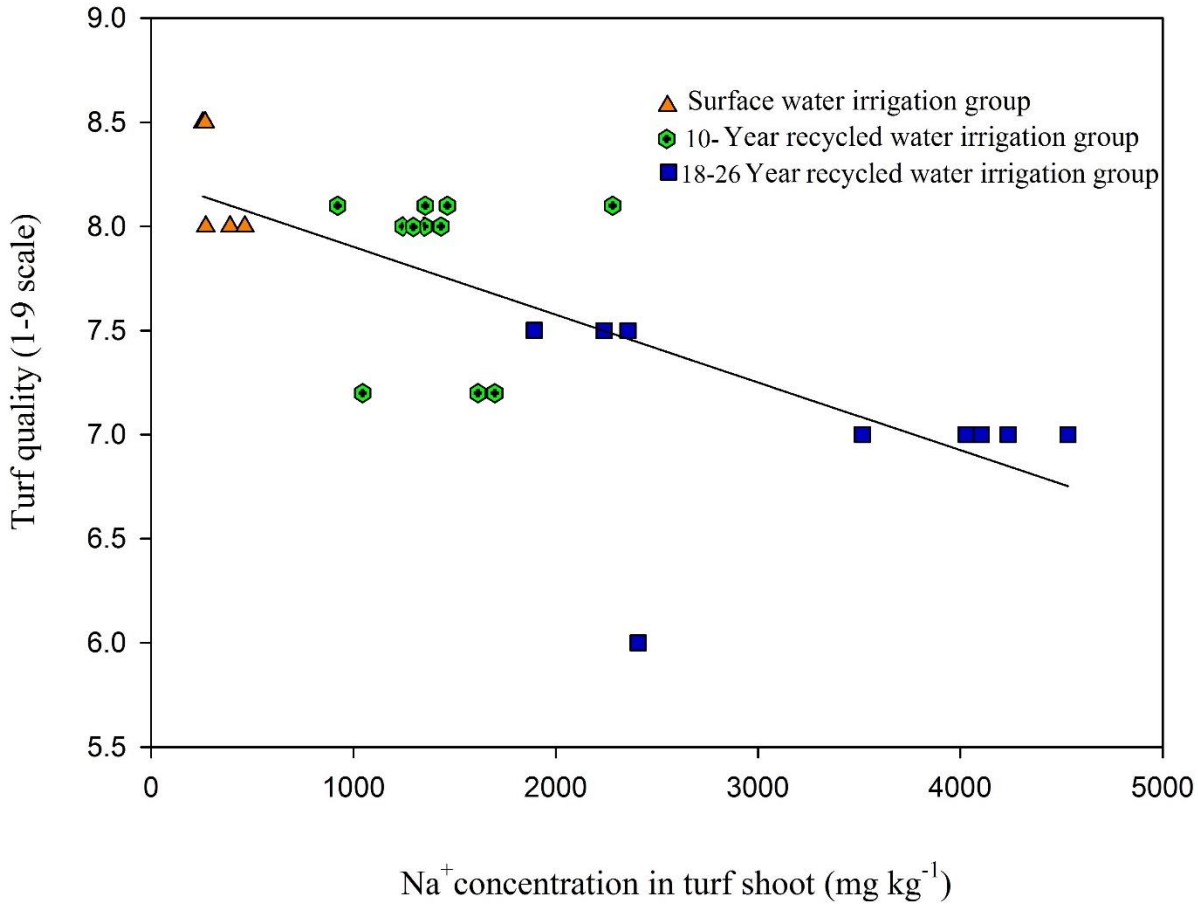

Figure 1. Relationship between shoot Na concentration and turf quality under three irrigation regiments.

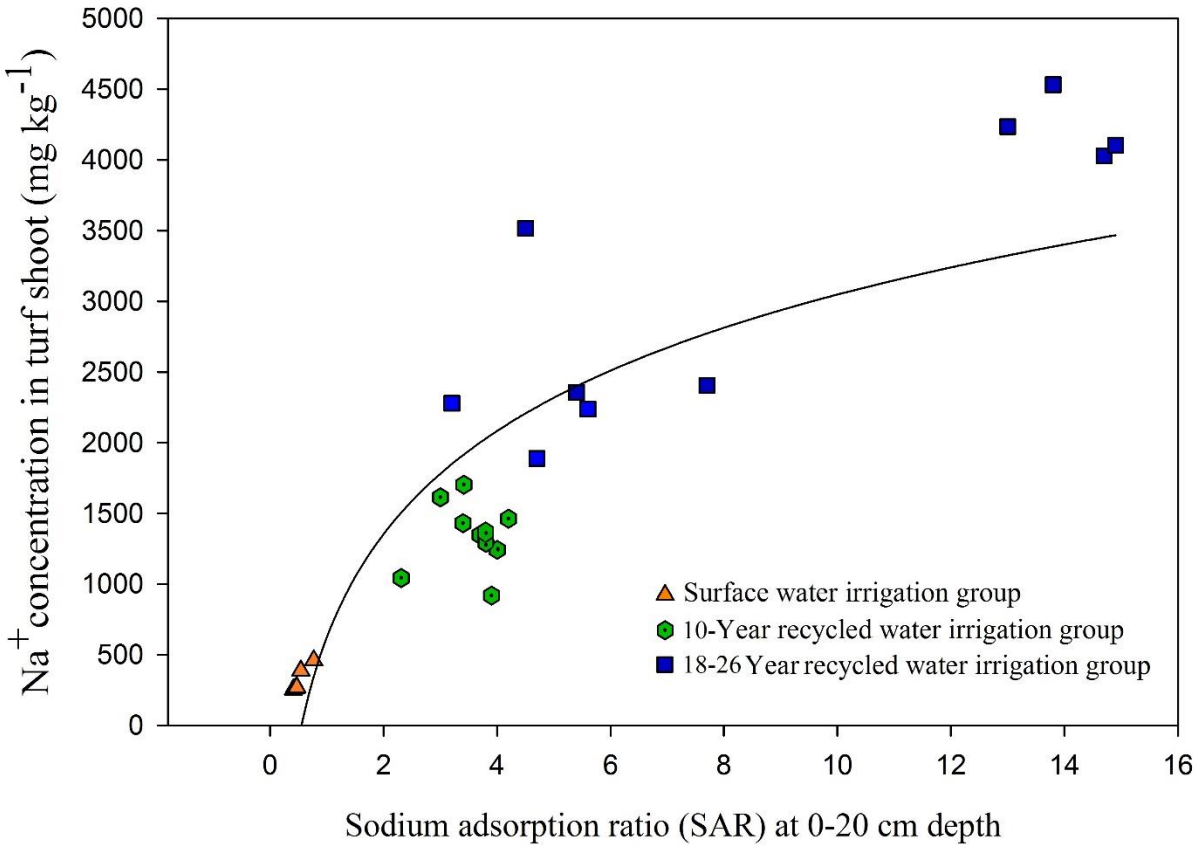

Figure 2. Relationship between soil SAR (0-20 cm) and shoot Na concentration of Kentucky bluegrass under three different irrigation regiments.