Salt Compositions and Irrigation Levels affect Creeping Bentgrass Quality and Soil Characteristics in Four Rootzone Media

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Introduction

Salinity and sodicity are common problems in North Dakota (Fig. 1). Thirty four of the 52 counties in the state have saline or sodic soils as a result of low precipitation and high saline or sodic irrigation sources. High saline/sodicity inhibit plant growth, resulting in reduced turf quality. Water with high sodium absorption ratio (SAR) is likely to damage soil structure which may lead to erosion. Leaching at 110 to 120% evapotranspiration (ET) is a common technique to remove excess salt from the turf rootzone. However, only limited scientific information is available on the assessment of the efficiency of leaching factors associated with different rootzone construction types and properties.

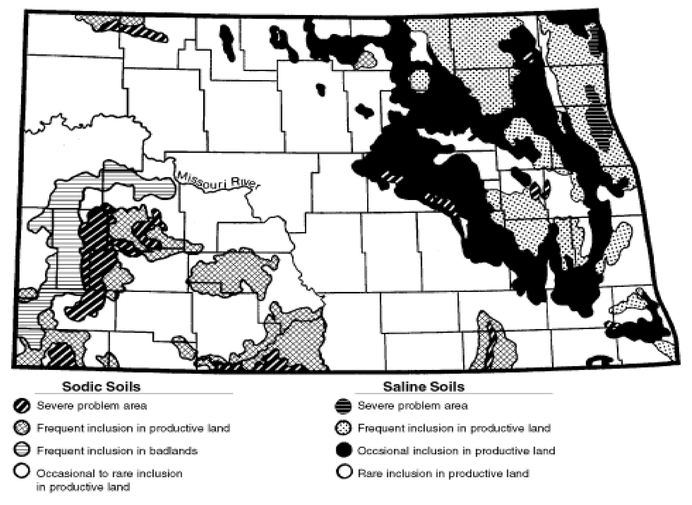

Fig. 1. The distribution of saline and sodic soils in North Dakota (Seelig, 2000).

Objectives

- To evaluate turfgrass response under saline conditions in four growing media.
- To evaluate characteristics of growing media as influenced by SAR and irrigation levels.

Materials and Methods

- 'SeaSide II' creeping bentgrass (*Agrostis stolonifera*) was seeded at 49 kg ha^{-1} with a starter fertilizer (10-10-10) at 49 kg N ha^{-1} in 6 mil transparent plastic tubes (5.4-cm diam., 40-cm high) and held vertically in polyvinyl chloride (PVC) containers in May 2008 (Fig. 2).
- The four rootzone media were mixed to stimulate USGA and California-style sand-based putting greens and clay and loamy clay soil-type push-up greens (Table 1).
- Grasses were mowed at 2 cm once weekly, fertilized once monthly, and irrigated every other day for three months before saline exposure. A micronutrients package was applied at 9 kg product ha^{-1} when the experiment was initiated. Nitrogen was applied at 24.5 kg ha^{-1} every other week during the study period (26 Nov. 2008 – 28 Jan. 2009).

Fig. 2. 'SeaSide II' creeping bentgrass in a greenhouse.

- The experiment was set up as a split-plot design with three replicates.
  - The whole-plot treatments were four growing media (Table 1) arranged in a RCBD.
  - The sub-plot treatments were a five by four factorial combination.
    1. Five SAR levels, control (tap water, EC = ~0.5 dS m^{-1}, SAR = ~1.0), 2.5, 5.0, 15.0 and ∞. Solutions with SAR ≥ 2.5 were salinized with NaCl, $CaCl_2 \cdot 2H_2O$, and $MgCl_2 \cdot 6H_2O$ to reach a saline level of 10 dS m^{-1}.
    2. Four irrigation levels at 60, 80, 100, and 120% of ET.
- All containers were saturated initially and those watered with tap water at 100% ET were weighed weekly to determine the irrigation levels.
- Data were collected on turf visual quality and clipping yield weekly. Soil profile was divided into four 10-cm sections when the experiment was terminated. Soil saturated hydraulic conductivity (Ksat) was measured on the surface layer. Soil EC and pH were recorded for all layers.
- Data were subjected to the PROC MIXED procedure and means were separated by Fisher's protected least significant difference (LSD) at $P \le 0.05$.

Table 1. Electrical conductivity (EC) and pH in four growing media.

Media type	Soil EC (dS m^{-1})	Soil pH
Clay soil	1.18	6.44
Loamy clay soil	1.02	6.09
USGA	0.17	6.80
California	0.17	6.80

Results

- Turfgrass performance

  Visual quality: All grasses started out with acceptable quality initially (quality = 8). Quality differences were first observed on 24 Dec. 2008, one month after saline exposure (Table 2). Grasses in soil-based media had higher visual quality than in sand-based media. Turf quality was lower in grasses irrigated with saline solutions. Irrigation levels did not affect visual quality in this study.

  Clipping yield: Tissue dry weight was affected by media type and SAR contents (Table 2). Differences in irrigation levels were only observed in one of the nine sampling dates. Interactions between media, SAR, and irrigation levels were detected periodically.
- Media properties

  Soil EC: Soil EC was the highest in the loamy clay soil and the lowest in the sand-based media for all layers (Table 3). Soil watered with tap water at 60% ET had the lowest salt contents. Soil EC levels increased with the irrigation levels, except in the top two 20 cm where no differences existed between irrigation levels at 100 and 120% ET.

  Soil pH: Clay soil had the highest pH. Soil pH differences in the SAR levels decreased as soil depth increased (Table 3).

  Soil Ksat: Water moved faster in sand-based rootzone than in soil rootzone (Table 3). Saturated water conductivity decreased as the SAR increased.

Conclusions

- At a moderate saline level (EC = 10 dS m^{-1}), SAR affected soil EC and pH down to 30 cm rootzone depth. Although the differences were not reflected in turf quality, clipping yield was affected by SAR levels.
- Saturated water conductivity was less vulnerable to SAR influence in sand-based media than soil media.
- Irrigation at 100% ET had the least reduction in Ksat.

Table 2. Turfgrass visual quality and clipping yield (mg week^{-1}) as affected by growing media, sodium absorption ratio (SAR), and Irrigation (I) levels on two selected dates.

		Quality		Clipping yield (mg week^{-1})	
		24 Dec.	28 Jan.	24 Dec.	28 Jan.
Media (M)	Clay soil	7.1 a‡	5.4 a	38 a	70 a
	Loamy clay soil	7.1 a	5.8 a	41 a	77 a
	USGA	5.4 b	4.2 b	18 b	26 b
	California	5.9 b	4.5 b	16 b	25 b
SAR (S)	Control	6.7 a	5.5 a	32 a	59 a
	2.5	6.4 b	4.9 b	29 ab	52 b
	5	6.3 b	4.9 b	27 bc	47 bc
	15	6.2 b	4.8 b	27 bc	46 c
	∞	6.2 b	4.8 b	26 c	45 c
Irrigation (I)	60%	6.4 a	5.0 a	28 a	44 b
	80%	6.5 a	5.0 a	29 a	50 a
	100%	6.3 a	5.0 a	29 a	52 a
	120%	6.2 a	5.0 a	28 a	53 a
M x S		NS†	NS	NS	NS
M x I		NS	NS	NS	NS
S x I		NS	*	NS	NS
M x S x I		NS	NS	*	NS

* Significant at the 0.05 probability level.
† NS, nonsignificant at the 0.05 probability level.
‡ Means followed by the same letter within columns are not significantly different according to LSD (0.05).

Table 3. Properties of four growing media as affected by sodium absorption ratio (SAR) and irrigation (I) levels.

		EC (dS m^{-1})				pH				Ksat (cm h^{-1})
		0 – 10 cm	10 – 20 cm	20 – 30 cm	30 – 40 cm	0 – 10 cm	10 – 20 cm	20 – 30 cm	30 – 40 cm	0 – 10 cm
Media (M)	Clay soil	0.85 b‡	0.59 b	0.46 b	0.41 b	7.87 a	7.87 a	7.91 a	7.96 a	0.06 c
	Loamy clay soil	1.20 a	0.99 a	0.75 a	0.65 a	7.58 b	7.49 d	7.52 d	7.52 b	0.46 b
	USGA	0.43 c	0.32 c	0.27 c	N/A¶	7.58 b	6.65 c	7.73 b	N/A	89.20 a
	California	0.43 c	0.30 c	0.23 c	0.22 c	7.30 b	7.73 b	7.63 c	7.61 b	65.43 a
SAR (S)	Control	0.31 c	0.26 b	0.28 c	0.34 b	7.72 a	7.75 a	7.73 a	7.71 a	5.52 a
	2.5	0.86 a	0.61 a	0.44 b	0.42 a	7.48 d	7.63 c	7.69 b	7.70 a	5.60 a
	5	0.83 ab	0.62 a	0.47 ab	0.46 a	7.49 d	7.63 c	7.66 b	7.66 a	3.15 ab
	15	0.81 b	0.64 a	0.47 ab	0.46 a	7.55 c	7.67 b	7.68 b	7.69 a	3.07 ab
	∞	0.82 b	0.63 a	0.48 a	0.45 a	7.66 b	7.74 a	7.73 a	7.71 a	2.06 b
Irrigation (I)	60%	0.65 c	0.47 c	0.34 d	0.34 d	7.59 ab	7.70 a	7.72 a	7.73 a	3.68 ab
	80%	0.71 b	0.52 b	0.40 c	0.40 c	7.56 b	7.68 a	7.70 a	7.69 ab	3.35 b
	100%	0.77 a	0.60 a	0.47 b	0.45 b	7.56 b	7.68 a	7.69 a	7.69 b	5.99 a
	120%	0.77 a	0.62 a	0.51 a	0.51 a	7.61 a	7.69 a	7.69 a	7.67 b	2.30 b
M x S		*	*	*	*	*	*	NS	NS	*
M x I		*	*	NS	*	NS	NS	NS	*	NS
S x I		*	*	*	NS	NS	NS	NS	NS	NS
M x S x I		*	NS†	NS	NS	NS	NS	NS	NS	*

* Significant at the 0.05 probability level.
† NS, nonsignificant at the 0.05 probability level.
‡ Means followed by the same letter within columns are not significantly different according to LSD (0.05).
Ksat values were transformed to natural logarithms for statistical analysis. The means were converted back to cm h^{-1}.
¶ N/A, not applicable; soil EC and pH were not measured in the pea gravel 30 – 40 cm below the surface of the stimulated USGA sand-based putting green media.