Salt Tolerance Screening of 74 Cool-Season Turfgrass Cultivars in Solution Culture

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Introduction

- Turfgrass is often subject to significant salt stress as a result of poor water quality, insufficient leaching, or exposure to environmental contaminants.
- Establishment of salt tolerant turfgrass cultivars can help to mitigate the effects of salts in irrigation water or the soil environment.
- It is often desirable to perform screenings for salt tolerance under controlled conditions.
- Digital image analysis has proven to be a useful tool for rapid quantification of turfgrass cover (Richardson et al., 2001).

Hypothesis

We hypothesize that newer, improved varieties of turfgrass can offer increased salt tolerance and that differences between them can be identified using digital image analysis techniques.

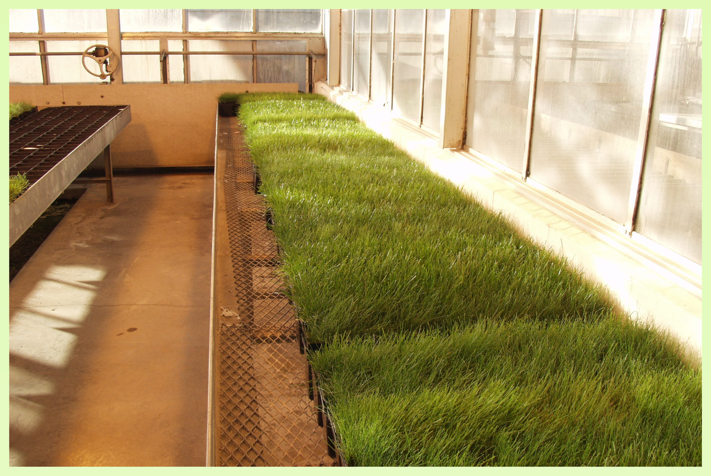
Objective

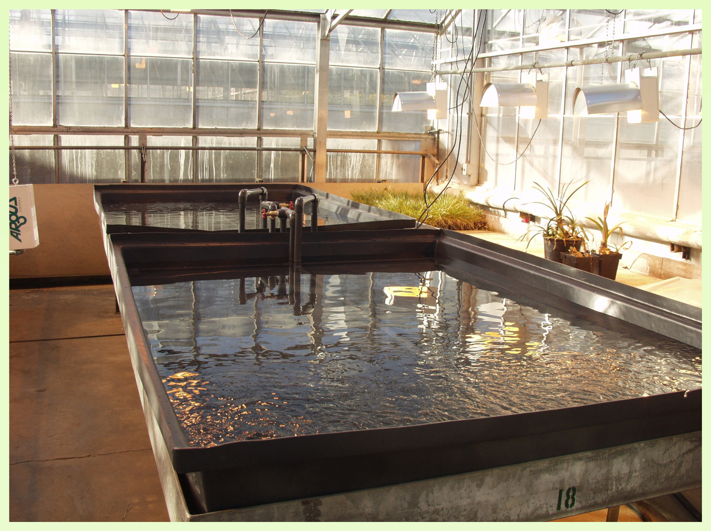
The objective of this research was to quantitatively evaluate the relative salt tolerance of improved turfgrass cultivars using nutrient solution culture in a controlled environment.

Materials & Methods

Experimental Setup

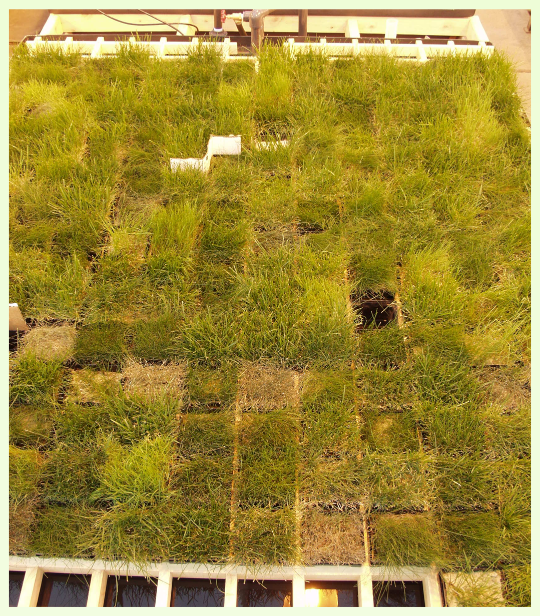
- 74 entries were selected based on input from turfgrass breeders as well as published data from previous trials in the northern United States (Rose-Fricker and Wipff, 2001; Koch and Bonos, 2011; Friell et al., 2012).
- Entries were seeded at 2 seeds cm^{-1} (Table 1) in 10.16 cm x 10.16 cm pots of silica sand with plastic screen in the bottom to allow root growth while containing the sand within.
- Pots were established in a greenhouse for 12-wks, beginning in fall 2010, and the experiment was repeated during summer 2011 with a 14-wk establishment period.
- During establishment, pots were fertilized with a dilute fertilizer solution and clipped weekly at 5 cm.





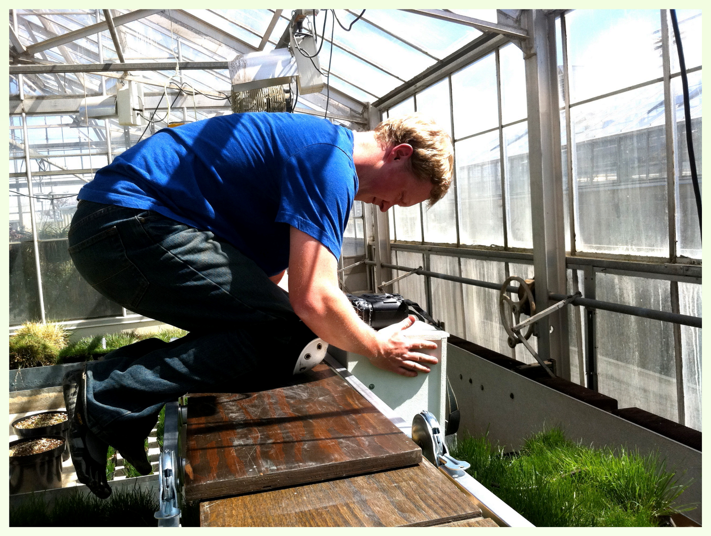
Treatment Applications

- Two large tubs were filled with 760 L of half-strength Hoagland solution (Hoagland and Arnon, 1950) amended with 5.5 mg L^{-1} EDTA-chelated iron.
- Three replications of each cultivar were suspended in each tub in a randomized complete block design.
- Pots were clipped weekly to 5 cm.
- Treatments consisted of supplementing the nutrient solution with 5 M sodium chloride (NaCl) solution added to a specified electrical conductivity.
- Following the 2-wk control treatment period, pots were held for 4 dS m^{-1}, 14 dS m^{-1}, and 24 dS m^{-1} successively, each for two weeks.
- Between treatment levels, nutrient solution was drained and replaced. Salinity levels were increased at a rate of 2 dS m^{-1} d^{-1} from the previous level to the next specified level.



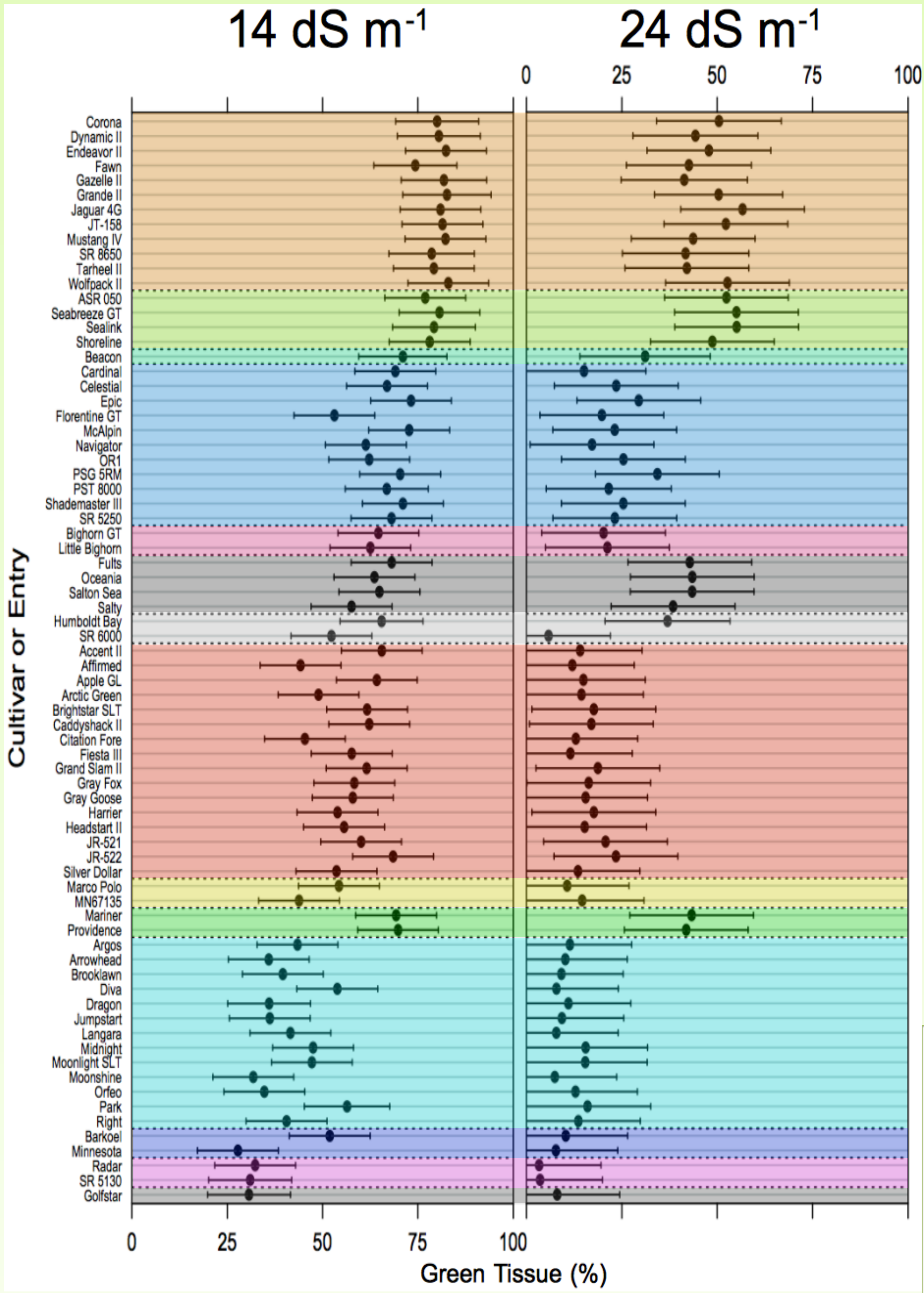
Data Collection & Analysis

- Digital images were collected at the end of each treatment level for each experimental run using a custom light box.
- Pictures were analyzed for percent green tissue (Figure 2) using a custom image processing script written using Image Processing Toolbox in MATLAB.
- Experimental runs were combined and modeled with a linear mixed effects cell means model using the *lme* function in the *nlme* package in R Project for Statistical Computing.
- Random effects terms were used to incorporate blocking into the model. Confidence intervals were determined at the α=0.05 level using the *intervals* function.



Results

Figure 1. Cultivar effects on percent green tissue following exposure to increasing levels of salinity in nutrient solution culture. Species are color coded, separated by dotted lines, and sorted by mean response at 14 dS m^{-1}. Error bars represent 95% confidence intervals.



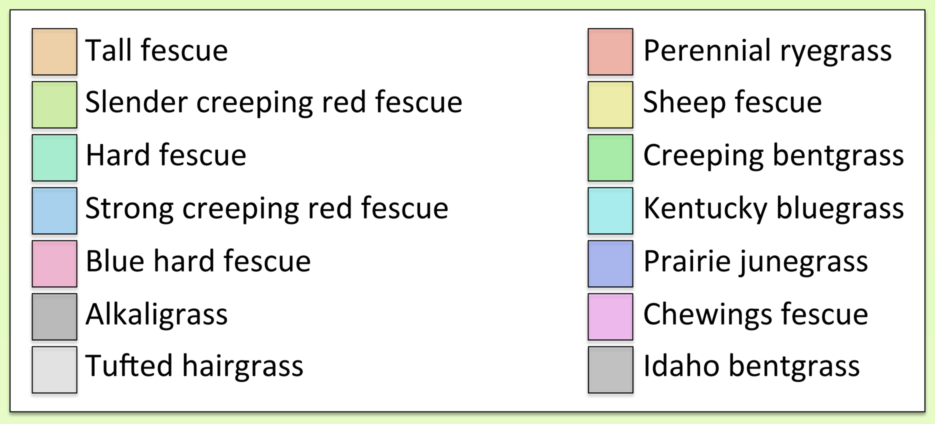
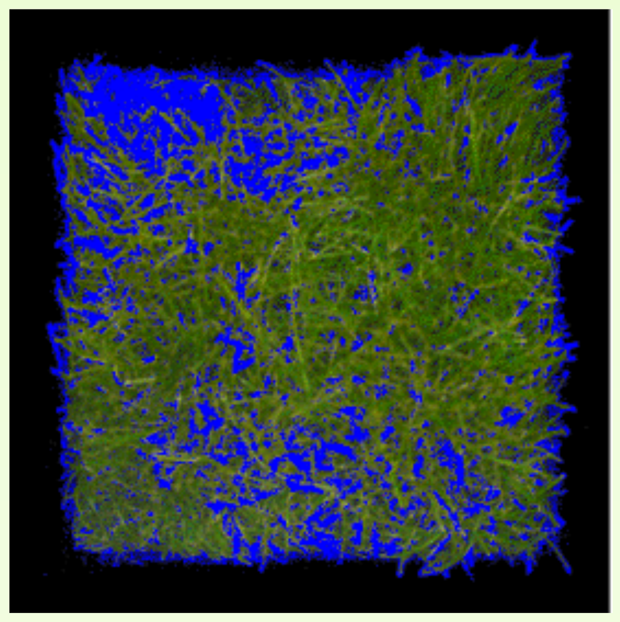


Figure 2. Example of results from MATLAB digital image processing algorithm for a single pot



75.51% green tissue

Table 1. Equivalent seeding rates for species in the salt tolerance trial

Species	Entries	Seeding Rate (kg ha^{-1})
fine fescue *Festuca spp.*	23	244.1
tall fescue *Festuca arundinacea* Schreb.	14	341.7
Kentucky bluegrass *Poa pratensis* L.	13	73.2
perennial ryegrass *Lolium perenne* L.	16	390.5
tufted hairgrass *Deschampsia cespitosa* (L.) P. Beauv.	2	97.6
prairie junegrass *Koeleria macrantha* (Ledeb.) Schult.	2	146.5 – 195.3
creeping bentgrass *Agrostis stolonifera* L.	2	48.8
alkaligrass *Puccinellia spp.*	4	195.3
Idaho bentgrass *Agrostis idahoensis* Nash	1	146.5

Discussion

- Digital image analysis allowed for a more accurate measure of salinity tolerance during vegetative growth than visual rating methods.
- Tall fescue cultivars outperformed those of other species at the 14 dS m^{-1} treatment level. Nitrogen status, weather, disease, and other field phenomenon not captured by greenhouse experiments may explain improved performance in comparison to field trials.
- Slender creeping red fescue cultivars performed best at the 24 dS m^{-1} treatment level. Results confirm the salt-tolerance ranking of red fescue species suggested by Humphreys (1981) with entries of slender creeping red fescues performing better than those of strong creeping red fescue or Chewings fescue.
- Alkaligrass performed well at all treatment levels in this experiment and was previously found to be highly persistent on roadsides where damage due to NaCl was known to be a problem.
- The method does not account for foliar exposure that may be experienced due to salt spray off of impervious surfaces or during irrigation with low-quality water.

Future Research

Mixtures of the best-performing cultivars from this trial can be optimized for tolerance to salts in the soil environment.

References

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