



# Salinity tolerance of nine fine fescue cultivars compared to other cool-season turfgrasses

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## ABSTRACT

Seed germination, seedling development, and vegetative growth of nine fine fescues cultivars ['Slender' creeping red fescue (*Festuca rubra* L. ssp. *rubra* and *Festuca rubra* L. ssp. *trichophylla* Gaud.), 'Firefly' and 'Reliant IV' hard fescue (*Festuca longifolia* Thuill.), 'Azure' and 'Marco Polo' sheep fescue (*Festuca ovina* L.), and 'Intrigue', 'Columbia II', 'Ambrose', and 'Jamestown II' chewing fescue (*Festuca rubra* L. ssp. *commutata* Gaud.)] were determined under saline conditions (NaCl at 0, 3, 6, 9, and 12 g L<sup>-1</sup>) and compared to 'Zoom' perennial ryegrass (*Lolium perenne* L.), 'Stonewall' tall fescue (*Festuca arundinacea* Schreb.), and 'Bewitched' Kentucky bluegrass (*Poa pratensis* L.). Salinity reduced final and daily germination rate. Similarly, seedling development (fresh weight, dry weight, and absolute water content) and vegetative growth (shoot and root dry weight and the longest root length) declined with increasing salinity levels. Daily germination rate, fresh weight and absolute water content, and root dry weight and the longest root length are more sensitive to salinity compared to other parameters during initial (germination and seedling development) and vegetative growth stages respectively; therefore, better indicators of salt tolerance. All fine fescue cultivars showed a constant ranking of relative salt tolerance at different growth stages. Overall, 'Zoom' perennial ryegrass, 'Slender' creeping red fescue, and 'Stonewall' tall fescue exhibited the most tolerance to high salt concentrations. However, limited variations existed in salinity tolerance among 'Bewitched' Kentucky bluegrass and the other fine fescue cultivars.

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## 1. Introduction

Fine fescues are a species within the *Festuca* genus with a fine, wire-like leaf texture (<1 mm wide). This group includes four major species, creeping red fescue (*Festuca rubra* L. ssp. *rubra* and *Festuca rubra* L. ssp. *trichophylla* Gaud.), chewing fescue (*Festuca rubra* L. ssp. *commutata* Gaud.), hard fescue (*Festuca longifolia* Thuill.), and sheep fescue (*Festuca ovina* L.) (Turgeon, 1991). Fine fescues have high tolerance to cold, shade, and poor soil conditions (Johnson, 2007). In addition, fine fescues, especially hard fescue and sheep fescue, exhibited adequate turf quality when evaluated over a wide range of climates under low maintenance regimes which included little to no irrigation, pesticide applications, or fertilization but frequent mowing (Diesburg et al., 1997; Watkins et al., 2011).

High soil salinity is a common problem in turfgrass management, especially in arid and semi-arid regions. It is caused by various conditions such as deficient precipitation, water percolation from high water tables, low-quality irrigation water, and salts from fertilizers and road deicers (Wu and Lin, 1993). Salinity adversely affects plant growth and development, resulting in reduced esthetics and playable conditions. Fine fescues have been

generally ranked as salt sensitive and only tolerate a range of 3–6 dS m<sup>-1</sup> (electrical conductivity of saturated soil paste extract, EC<sub>e</sub>) (Marcum, 2007). However, substantial inter- and intra-species differences in salinity tolerance exist in fine fescues. For example, salt tolerance decreased in the following order: weeping alkaligrass [*Puccinellia distans* (Jacq.) Parl.] > creeping red fescue > Kentucky bluegrass > chewing fescue > hard fescue and sheep fescue after approximately 90-day exposure to NaCl (Ahti et al., 1980). Jönsson and Nilsson (1977) germinated 16 creeping red fescue cultivars at 260 mM NaCl and found that 'Polar' and 'Dawson' showed the highest germination rate followed by 'Koket' and 'Novorubra', and 'Famosa' and 'Reptans' had the lowest germination rate. However, limited information is available on salt tolerance in newly released fine fescue cultivars (Harivandi et al., 2012). The objective of this study was to determine variations in salinity tolerance of nine fine fescue cultivars that produce adequate turf quality in field testing in the upper Northern Great Plains.

## 2. Materials and methods

### 2.1. Plant materials

Twelve grasses, including nine fine fescue cultivars ('Slender' creeping red fescue, 'Firefly' and 'Reliant IV' hard fescue, 'Azure' and 'Marco Polo' sheep fescue, and 'Intrigue', 'Columbia II', 'Ambrose',

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and 'Jamestown II' chewing fescue, 'Zoom' perennial ryegrass, 'Stonewall' tall fescue, and 'Bewitched' Kentucky bluegrass were used in this experiment. A separate study showed that these cultivars provided high turfgrass quality in a field trial in Fargo, ND (unpublished data).

## 2.2. Seed germination and seedling development on agar medium

Seeds of each grass were surface sterilized following the method of Zhang et al. (2011). Seeds were soaked in 70% ethanol for 5 min and then submerged in 2% sodium hypochlorite solution for 20 min, followed by three rinses with deionized/distilled water ( $\text{ddH}_2\text{O}$ ). Sterilized seeds were placed in 100 mm  $\times$  15 mm petri dishes containing 20 mL of 0.6% agar (Sigma–Aldrich Co., St. Louis, MO). Aliquots containing NaCl at 0, 3, 6, 9, or 12 g L<sup>-1</sup> were added to the medium. The EC of each salt solution was measured with an EC meter (Model 1054; VWR International LLC, West Chester, PA) and found to be 0.0, 5.5, 9.2, 12.8, and 18.0 dS m<sup>-1</sup>, respectively. The medium was autoclaved at 121 °C and 103 kPa for 20 min before pouring into petri dishes. Thirty seeds were placed in each petri dish. Dishes were sealed with parafilm and placed in a culture room at 25  $\pm$  2 °C (day/night) under fluorescent light (36  $\mu\text{mol s}^{-1} \text{m}^{-2}$ ) with a 16-h day and 8-h night photoperiod. The number of germinated seeds per dish was counted three times a week for four weeks. A seed was considered to be germinated when its emerged shoot was visible (McCarty and Dudeck, 1993). Final germination rate and daily germination rate were calculated following the method of Zhang et al. (2011) in which final germination rate (%) =  $100 \times [(\sum n)/30]$  and daily germination rate (% d<sup>-1</sup>) =  $100 \times [(\sum (n/D))/30]$ , respectively, where  $n$  was the number of new seeds germinated at each counting and  $D$  was the number of days accumulated up to that counting. Seedlings were harvested when the experiment was terminated (week 4). Fresh weight, dry weight (oven-dried for 24 h at 65 °C), and absolute water content (fresh weight–dry weight), an indicator of leaf area (Hughes et al., 1970), were recorded. To provide an accurate indication of salinity tolerance, data under saline conditions were standardized as the percent of the control (0 g L<sup>-1</sup> NaCl) (Teolis et al., 2009). The higher the ratio of the saline level to control, the greater the salinity tolerance.

This experiment was a 5 (salinity levels)  $\times$  12 (grasses) factorial design arranged in a RCBD with three replicates (petri dishes). All data were subjected to analysis of generalized linear model (SAS, 2004). Means were separated with Fisher's protected least significant difference at  $P \leq 0.05$ .

## 2.3. Vegetative growth in a hydroponic system

Seeds were sown into 46 cm  $\times$  61 cm flats containing Sunshine LC1 Mix (Sun Gro Horticulture Distribution Inc., Bellevue, WA) in February 2012 in a greenhouse on the North Dakota State University campus. Grasses were mowed at 7.5 cm once a week and hand watered every other day after germination. A water soluble fertilizer (20.0N–8.4P–16.6K, JR Peters, Inc., Allentown, PA) was applied at 12.5 kg ha<sup>-1</sup> N once a month. Grasses were exposed to saline conditions after a 3-month establishment period in the greenhouse.

Salinity tolerance of mature grasses was determined using a hydroponic system following the method of Zhang et al. (2012) with slight modifications. Each grass was represented by one plug (6 cm in diam.) randomly harvested from the flats. Twelve grass plugs were transplanted to a foam plate (30 cm  $\times$  25 cm  $\times$  2 cm) containing 12 wells (6 cm in diam.). Nylon screen was glued to the bottoms of the foam plates to support the grass plugs but allow roots to penetrate through. The hydroponic system was comprised of 15 containers (32 cm  $\times$  30 cm  $\times$  15 cm; five salinity levels  $\times$  three replicates) with constantly aerated half strength Hoagland's

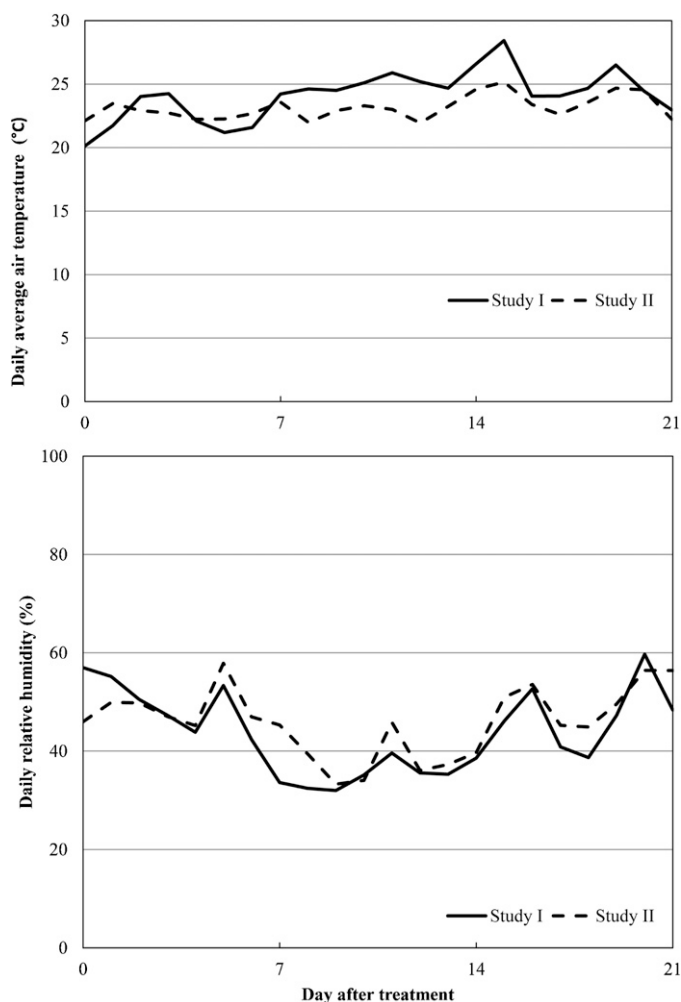


Fig. 1. Daily average air temperature (°C) and relative humidity (%) of Studies I and II.

solution (Hoagland and Arnon, 1939). The salinity levels of the salt solutions were 0 (control), 3, 6, 9, and 12 g L<sup>-1</sup> NaCl (final EC = 1.7, 7.1, 12.1, 17.0, and 21.1 dS m<sup>-1</sup>). Sodium chloride was added gradually at 3 g L<sup>-1</sup> d<sup>-1</sup> over a 4-d period to reach the final concentration. The containers were refilled with tap water or NaCl solutions daily to maintain a constant water level and refreshed once weekly during the experiment. At day 4, grasses were mowed at 7.5 cm and all roots were clipped at the base of the foam plates to assure a uniform start.

Grass plugs were hand mowed once a week at 7.5 cm and clippings were collected for a period of 3 weeks. Clippings of each grass cultivar were combined and oven-dried at 65 °C for 48 h to determine shoot dry weight. At the end of week 3, roots were harvested. The longest root length was recorded and root dry weight was determined using the same method to determine shoot dry weight.

The experiment was conducted simultaneously in two greenhouses (Studies I and II). Ambient air temperature in each greenhouse was recorded daily with HOBO RH/Temp data loggers (model no. Ho8-003-02, Onset Corp., Bourne, MA) (Fig. 1). Both studies were arranged in a split-plot design with salinity levels being the whole-plot factor and grasses being the sub-plot factor. Data under saline conditions were expressed as a percent of the control (0 g L<sup>-1</sup> NaCl) to accurately represent salt tolerance using the same method previously described when analyzing seed germination and seedling development. Data were subjected to analysis

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