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Effects of Salinity on Seed Germination and Physiological Traits of Tall Fescue (*Festuca arundinacea* Schreb.)

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ABSTRACT

Irrigation water salinity is one of the most progressive environmental factors limiting the growth and productivity of plants. The objective of this study was to evaluate the effects of salt stress on seed germination and some quantitative trait of tall fescue (*Festuca arundinacea* Schreb). For this purpose, a laboratory experiment was conducted at seed laboratory, Islamic Azad University, Isfahan Branch. The traits were radicle and plumule length, fresh and dry weight of radicle and plumule and some properties of seed germination such as germination percent, mean germination time, germination speed, and germination energy and vigor index. Seeds were arranged in petri dishes with 4 replications in completely randomized design with six levels of water salinity including 0, 4, 5, 6, 7 and 8 dSm^{-1}. The results indicated that salinity stress had significant effect on seed germination and physiological characteristics. The results indicated that salinity of irrigation water significantly reduced all studied properties except of germination time. The values of these properties were continuously decreased with increasing salinity levels. However, time of germination in salinity levels of 4−7 dSm^{-1} was significantly higher than that distilled water. Seed vigor index was more affected by salinity stress than germination percent.

Keywords: Salinity, Germination, Turfgrass, Radicle, Plumule, Seed

INTRODUCTION

In the arid and semiarid regions, increasing demand for water, has forced to apply non-potable water such as saline water for plant irrigation. Water salinity is one of the most progressive environmental factors limiting the growth and productivity of plants in irrigated areas (Katerji *et al.*, 2003; Asgari *et al.*, 2012). Iran comprises of about 90 percent of arid or semi-arid lands (Qadir *et al.* 2008), and saline soils in the country cover more than 34 million ha (FAO 2000). Water shortage and drought is another crisis which is increasing in the last few decades in central parts of the country. This is one of the major limiting factors of plant growth (Sadeghian and Yavari, 2004).

Due to the low rainfall, irrigation of soils is necessary for prosperous plant growth. But, reduction of appropriate water resources is a major factor that can limit agricultural activities. One imperative response to this challenge is the use of anomalistic (saline) sources of water.

Salinity stress due to increased apply of non-potable water sources for irrigation imposes major limitations on plant growth (Yu *et al.*, 2015). Salt strongly affects plant growth, development and productivity (Epstein *et al.*, 1980). The detrimental impacts of salinity on plant growth may be attributed to toxicity of excessive Na, Cl, SO_4, CO_3, HCO_3, and BO_3, as well as nutrient imbalance and deficiency (Bowman *et al.*, 2006). Using saline water for cropland irrigation leads to soil salinization, reduction in crop yield and degradation of the soil resources, if appropriate management practices are not adapted (Ould Ahmed *et al.* 2007). Salinity induces osmotic stress by inducing both the accumulation of toxic levels such as Na and Cl and the uptake inhibition of plant essential nutrients (Munns, 2002). Osmotic stress also leads to the reduction of water uptake capability by plant roots and therefore reduction of plant growth and productivity (Netondo *et al.*, 2004). Generally, salinity prevents plant growth, with reductions in plant biomass (Rameeh *et al.*, 2004).

Tall fescue (*Festuca arundinacea*) is a greatly applied cold season turfgrass. In many cases, this turfgrass is grown under fluctuating photosynthetic photon flux densities (Xu et al., 2013). Salinity stress of turfgrass is becoming prevalent because of the increase in using wastewater containing salts for turfgrass irrigation. The need for salt tolerant turfgrass cultivars has considerably increased in recent decades (Marcum, 2006). Plant parameters such as shoot growth, root mass, root length, and turf quality are well suited for examining salinity tolerance in turfgrass species (Alshammary *et al.*, 2004). Under salinity stress, managing turfgrass is becoming more important with the increasing use of recycled water for irrigation (Leskys *et al.*, 1999). Therefore, the objective of this study was to evaluate the effects of salt stress on seed germination and some quantitative trait of turfgrass.

MATERIALS AND METHODS

In order to determine the effects of water salinity on seed germination and physiological trait of tall festuca a laboratory experiment was conducted at seed laboratory, Islamic Azad University, Isfahan Branch in 2015. Seeds of tall fescue were submerged in 5% sodium hypochlorite solution for 2 min, followed by three rinses with deionized/distilled water. Also, seeds were disinfected with Benomyl fungicide solution for 2 min, followed by three rinses with deionized/distilled water. Then, 25 seeds were seeded in each Petri dish (8 cm in diameter) with 4 replications in completely randomized design with six levels of water salinity including 0, 4, 5, 6, 7 and 8 dSm^{-1} (NaCl). The plants were maintained in a germinator for three weeks of growth period, with similar humidity (45%) and temperature (25°C). Several physiological characteristics of turfgrass such as radicle and plumule length, fresh and dry weight of radicle and plumule and some properties of seed germination such as germination percent, mean germination time, germination speed, and vigor index were determined at the end of growth period.

Analysis of variance was used to assess the effects of salinity on all analyzed plant properties. Means were compared by least significant difference (LSD) test (p<0.05). Statistical procedures were carried out using SAS version software package 9.1 for Windows.

RESULTS

Results showed that salinity levels significantly affected seed germination and physiological growth properties of tall fescue with the exception time of germination (Tables1 and 2). Seed germination rates, and plant mass, decreased as salinity levels increased (Table 1 and 2). The values of these properties were continuously decreased with increasing salinity levels. However, time of germination in salinity levels of 4−7 dSm^{-1} was significantly higher than that distilled water (Table 1). Vigor index was more affected by salinity stress than germination percent (Table 1). Under salinity levels of 8 dSm^{-1}, seed germination percentage, germination speed, uniformity of germination, and vigour index were reduced approximately 17, 29, 40, and 53% compared to distilled water, respectively (Table 1). Under salinity levels of 8 dSm^{-1}, time of germination was increased about 15% compared to distilled water (Table 1). Mean comparisons showed that water salinity had significant effect on radicle length (Table 2). Radicle length strongly decreased with increasing salinity levels. Compared with the distilled water, radicle length was 57% lower under salinity levels of 8 dSm^{-1}. Also results indicated that plumule length, fresh and dry weights of radicle, fresh dry weights of plumule under salinity levels of 8 dSm^{-1} were about 19, 16, 35, 19, and 24-times lower than those of distilled water, respectively.

Table 1. Germination properties of tall fescue affected by water salinity

Salinity	Germination percentage	Germination speed	Uniformity of germination	Time of germination	Vigor index
(dSm^{-1})	(%)	-	-	day	-
0	81.75 a	0.133a	0.112 a	8.43 b	3.20 a
4	78.17 ab	0.120b	0.111 a	9.81 a	2.61 b
5	76.17 b	0.121b	0.074bc	9.38 a	2.15 c
6	71.83 c	0.111 c	0.079b	9.47 a	1.66 d
7	71.33 cd	0.103cd	0.070c	9.70 a	1.72 d
8	67.67 d	0.095d	0.067c	8.81 b	1.51 d
LSD	3.82	0.008	0.0095	0.57	0.29

In each column, the values followed by at least one common letter are not statistically ($p<0.05$) different, according to LSD test.

Table 2. Growth properties of Tall Fescue affected by water salinity

Salinity	Radicle length	Plumule length	Fresh weight of radicle	Dry weight of radicle	Fresh weight of plumule	Dry weight of plumule
(dSm^{-1})	(cm)	(cm)	(mg)	(mg)	(mg)	(mg)
0	5.23 a	2.30 a	1.27 a	0.48 a	5.26 a	0.83 a
4	3.98 b	2.42 a	1.15 ab	0.43 b	4.70bc	0.73 b
5	3.26 c	2.15 ab	1.15 ab	0.34 c	4.95b	0.73 b
6	2.41 d	1.96 bc	0.78 c	0.31 c	4.69 cd	0.70 bc
7	2.89 c	1.75 c	1.25 a	0.34 c	4.59 bc	0.67 cd
8	2.24 d	1.87 bc	1.07 b	0.31 c	4.25c	0.63 d
LSD	0.41	0.28	0.17	0.044	0.48	0.056

In each column, the values followed by at least one common letter are not statistically ($p<0.05$) different, according to LSD test.

DISCUSSION

The present study aims to investigate salt stress effects on seed germination and some quantitative trait of tall fescue. The results revealed that water salinity affects morphological, physiological, and seed germination traits. The results indicated that salinity of irrigation water significantly reduced all studied properties. This finding is in accordance with many other studies. In many studies vegetative growth and crop yield decreased with increase in irrigation water salinity (Rameeh *et al.,* 2004; Marcum, 2007; Huang *et al.,* 2009; Wang and Zhang, 2010; Yarami and Sepaskhah, 2015). For example, Zhang *et al.* (2013) indicated that salinity reduced final and daily germination rate, fresh weight, dry weight, and absolute water content and vegetative growth such as shoot and root dry weight and the longest root length.

In present study, vigor index was more affected by salinity stress than germination percent. However, Zhang *et al.* (2013) found that daily germination rate, fresh weight and absolute water content, root dry weight and the longest root length were more sensitive to salinity compared to other properties. Zhang *et al.* (2011) illustrated that salinity reduced the final and daily germination rate of 12 turfgrasses. High salt contents in the soil may prevent seed germination mainly due to the osmotic effect (Alshammary, 2012). Increase in salt concentrations greatly enhances the percentage of abnormal seedlings, due to the salt toxic action on germinating seeds (Lima *et al.,* 2005).

Marcum and Murdoch (1994) also reported that shoot growth was reduced by 50% at the salinity level of $35.9-36.4$ dSm^{-1} NaCl in two fescue varieties which is in agreement with our present study. Also, Uddin *et al.* (2010) reported that shoot and root growth rate gradually decreased as the salinity increased. Salinity affects many plant physiological and morphological properties such as seed germination, growth, and water and nutrient uptake (Willenborg *et al.,* 2004). Photosynthesis is a main parameter used to monitor plant response to abiotic stress. Salinity stress reduces the ability of plant to uptake water and decrease growth rate, and consequently photosynthesis rate (Jensen *et al.,* 1996). Xu *et al.* (2013) also demonstrated that shoot height, root length, shoot and root mass of turfgrass decreased significantly with increasing NaCl concentrations.

Marcum (2008) reported that shoot growth of turfgrass species declined linearly with increased salinity stress. Pompeiano *et al.* (2014) also found that top plant growth, expressed as cumulative clipping dry weight of warm–season grasses significantly decreased with increasing salinity. Water salinity may lead to significant morphological, physiological and biochemical changes in higher plants (Pompeiano *et al.,* 2014). Yu *et al.* (2015) reported that water salinity stress imposed serious limitations to growth and physiological activities of bermudagrass. In a greenhouse experiment, Gao *et al.* (2012) investigated physiological responses of tall fescue leaves to carbonate, chloride, and sulfate and found that NaCl had the lowest EC and highest osmotic potential, and induced less growth reduction and physiological stress compared to Na_2CO_3, Na_2SO_4, and $CaCl_2$. This study showed that salinity reduces or delays seed germination, seedling development, and vegetative growth which are similar to the finding in turfgrass species (Marcum, 2007).

CONCLUSIONS

This work indicated that salinity stress in tall fescue may be reflected by plant properties such as seed germination, and plant growth. The results confirmed that salinity stress had significant effect on seed germination and physiological characteristics. Salinity of irrigation water significantly reduced all studied properties (with the exception of time of germination). Vigor index was more affected by salinity stress than germination percent.

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