Salt Tolerance Should Be Considered When Choosing Kentucky Bluegrass Varieties

By Yaling Qian

Salt problems in turfgrass sites are becoming more common for many reasons: accelerated urban development in Western states; fresh water conservation; the use of wastewater or other irrigation waters containing salts; seawater intrusion into turf facilities located on coastal sites; and road de-icing.

The extreme drought in 2002 in New Mexico, Colorado, Wyoming, Utah and Arizona resulted in mandatory turf watering restrictions in many of the major cities in those states. Many golf courses were forced to use low-quality water for irrigation. Reductions in irrigation can also increase soil salinity levels thanks to reduced leaching.

Kentucky bluegrass, one of the most widely used cool-season turfgrasses in the temperate United States, is considered salt-sensitive, reported to tolerate less than 4 micromhos/centimeter (mmhos/cm) soil salinity (Harivandi et al., 1992). While the mmho/cm is used as a unit indicating the level of salinity, it is in fact a unit for electrical conductivity (the higher electrical conductivity indicates the higher level of salinity). It reads as milli-mho per centimeter.

Three major points need to be considered when dealing with bluegrass salinity stress:

- as salinity levels increase, the temperature window for Kentucky bluegrass seed germination is narrowed;
- high summer temperatures intensify Kentucky bluegrass salinity stress; and
- not all bluegrasses are the same. Under salinity stress, certain cultivars perform better than others.

We will take a look at each of these three issues separately.

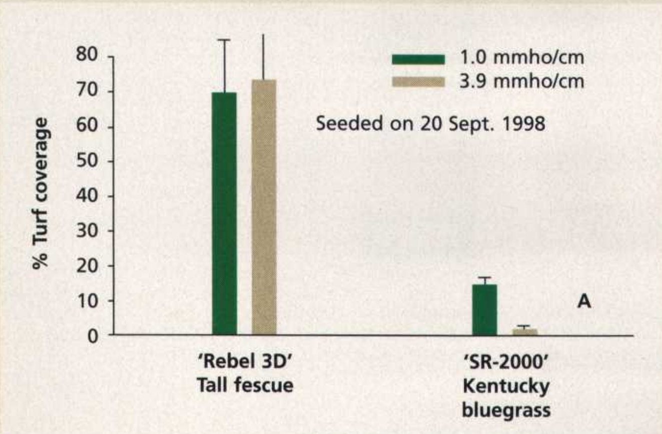
Seed germination window

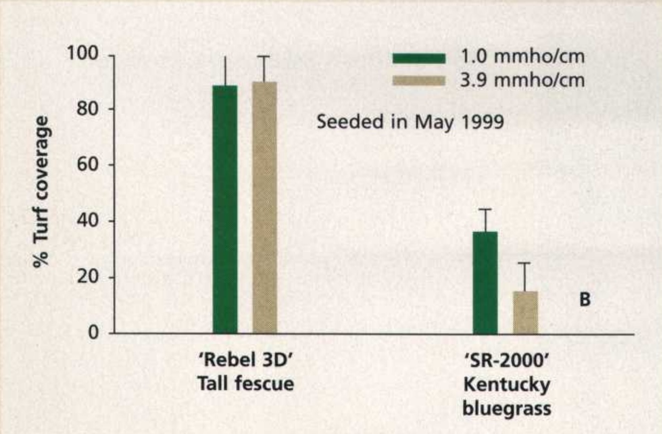
In the South Platter River basin, it is common for underground water to have a moderate level of salinity. We have observed that when irrigation water contains 3 to 4 mmho/cm salts, to establish Kentucky bluegrass by seeding in mid-September in northern Colorado is often unsuccessful.

Environmental conditions, such as tempera-

FIGURE 1

Effects of salinity on the establishments (% turf coverage) of tall fescue and Kentucky bluegrass. Turf establishment was rated about 2 months after seeding.





ture, may have a profound effect on turfgrass seed germination under saline conditions. Understanding the interaction of temperature and salinity on turfgrass germination, and its variation among species would aid in optimizing seeding time under salinity conditions.

We investigated the interactive effects of temperature and salinity on germination of NuStar Kentucky bluegrass in comparison with Rebel 3D tall fescue, a more salt-tolerant species.

Kentucky bluegrass and tall fescue were seeded under a gradient of salinity and under various temperature regimes in growth chambers. Seed germination was counted daily to calculate the germination speed. Total germination percentage was determined 28 days after treatments. Germination speed and percentage were compared to surface regression models to determine the temperature window to achieve 50-percent germination for each salinity treatment.

Kentucky bluegrass seeds need to be seeded in a narrow temperature window to achieve acceptable germination under saline conditions.

As the salinity increased, the temperature window for germination narrowed. This trend was more pronounced in Kentucky bluegrass than tall fescue (Table 1). Kentucky bluegrass seeds, emerging slowly and exhibiting great sensitivity to salinity during germination, need to be seeded in a narrow temperature window to achieve acceptable germination under saline conditions.

For example, under a ratio of 16 hours of warm temperatures to 8 hours of cool temperatures (encompassing one full day) and in the absence of salinity, the temperature window to achieve 50-percent germination of Kentucky bluegrass was 57 degrees F to 84 degrees F (Table 1). As salinity increased to 4 mmho/cm, the window narrowed to 65 degrees F to 80 degrees F. At 6 mmho/cm, the window narrowed to 71 degrees F to 74 degrees F for Nustar Kentucky bluegrass.

For tall fescue, the temperature window to achieve 50 percent germination only narrowed from 52 degees F to 105 degrees F to 51 degrees F to 100 degrees F as salinity increased from .3 to 6 mmho/cm. Compared to tall fescue, Kentucky bluegrass has a much narrower window within which to achieve successful germination under saline conditions.

TABLE 1

Temperature window that resulted in 50 percent germination

Salinity level	Kentucky bluegrass	Tall fescue
0.3 mmho/cm	57-84 °F	52-105 °F
4.0 mmho/cm	65-80 °F	51-102 °F
6.0 mmho/cm	71-74 °F	51-100 °F

Predictive models, such as those generated in our study (Qian and Suplick, 2001), may be used in conjunction with long-term local climatic data to optimize germination. For example, assuming a soil salinity level of 3 to 4 mmho/cm and examining 50-year mean temperature data for this area of northern Colorado, the appropriate seeding times for Nustar Kentucky bluegrass would generally be the first week of June and the last two weeks of August.

Additionally, cultural practices such as irrigation and use of artificial cover may be used to keep soil-surface temperatures at optimum levels to maximize germination.

To confirm our lab results, we conducted a field experiment. Bluegrass and fescue were seeded in field plots with two different soil salinity levels [electrical conductivity of the saturated soil paste was 4 mmho/cm and .8 mmho/cm (control), respectively].

Kentucky bluegrass and tall fescue were seeded in September and May. Establishment was rated eight weeks after seeding. We observed that establishing Kentucky bluegrass in mid-September in northern Colorado, under saline field conditions, was 14 percent lower than late-May seeding. In contrast, tall fescue appeared unaffected by seeding date (Fig. 1)

Temperatures and stress

Environmental factors, including aeration, water present, soil type, temperature, relative humidity, nutrient balance and the length of exposure to salt stress all affect the salt tolerance of established bluegrass.

We conducted two identical experiments in a greenhouse using hydroponics. Fully established

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TABLE 2

Salinity levels that caused 25 percent shoot and root growth reduction and percent leaf firing (at 6 mmho/cm) of nine Kentucky bluegrasses in two greenhouse experiments with different temperatures

	Mean min temp. (°F)	Mean max temp. (°F)	$EC_{25\% root}$* (mmho/cm)	$EC_{25\% shoot}$** (mmho/cm)	Leaf firing***(%) (damage)
Experiment I	70.7	81.5a	7.4a	5.2	15.9a
Experiment II	72.5	92.2b	3.4b	6.7	33.8b

*$EC_{25\%root}$, electrical conductivity of 25% root growth reduction

**$EC_{25\%shoot}$, electrical conductivity of 25% shoot growth reduction

***Leaf firing percentage was determined by visually estimating the total percentage of chlorotic turf canopy area

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Kentucky bluegrasses were subjected to constant salinity treatments at the control plot and at the other plots at 3, 5, 7, and 9 mmho/cm levels for 10 weeks to determine tolerance to salt stress (Suplick et al., 2002). Accumulated clippings were weighed, and total root weights were taken at the end of the experiment.

Leaf firing percentage was determined for each cultivar under each salinity treatment by visually estimating the total percentage of chlorotic turf.

Experimental procedures in Experiment I and II were the same, but Experiment I was conducted during winter and spring. Experiment II was conducted throughout summer into fall when daily warm temperatures were higher. Their duration prolonged creating an environment less favorable to Kentucky bluegrass growth (Table 2). We found that the magnitude of salinity stress were significantly differerent between the two experiments. Compared to Experiment I, average leaf firing across cultivars was much higher in Experiment II. The salinity level that caused 25-percent root growth reduction was 7.4 in Experiment I and 3.4 in Experiment II, although the temperature that resulted in 25-percent shoot growth reduction did not follow the same trend.

To confirm the lab results, researchers conducted a field experiment comparing bluegrass and fescue.

The higher percentage of leaf firing and low salinity level that cause 25 percent root growth reduction indicated that bluegrass is more sensitive to salinity under summer temperatures. Summer conditions will increase Kentucky bluegrass susceptibility to salt stress.

Our findings with respect to the effect of high temperature conditions on the expression of salinity tolerance suggested the importance of temperature in evaluating the salt tolerance of bluegrass. Summer heat stress can escalate salinity damage to the root system of Kentucky bluegrass. Management strategies can be critical in reducing salt accumulation in the root-zone.

Water injection, which minimizes surface disturbance but boosts infiltration and reduces salt built up, would also likely mitigate salinity problems in cool-season turf.

Cultivar differences

Although Kentucky bluegrass is generally ranked as a salt-sensitive turfgrass, variability in salt tolerance has been shown to exist among cultivars (Qian et al., 2001).

Horst and Taylor (1983) examined germination and initial growth in saline solution culture, and reported significant differences in salt tolerance during germination and initial growth among 44 Kentucky bluegrass cultivars. Rose-Fricker and Wipff (2001) studied relative salinity tolerance of many bluegrass cultivars and also found significant differences.

We have conducted salinity screening studies. Cultivars of Kentucky bluegrass were sodded into shallow pots containing coarse sand. Pots were suspended over tanks containing 32 liters of con-

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TABLE 3

Relative salinity tolerance of Kentucky bluegrass cultivars

Good	Fair	Poor
Moonlight	Nuglade	Kenblue
Northstar	Midnight	Park
SR-2000	Blacksburg	Huntsville
Limousine	Abbey	Challenge
Eclipse	Award	Livingston

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stantly aerated and balanced nutrient solution. The pots had coarse nylon-screen bottoms, allowing root systems to grow into the nutrient solutions.

Different Kentucky bluegrass cultivars were subjected to constant salinity treatment to determine tolerance to salt stress. Table 3 lists the cultivars tested and their relative salinity tolerance. We have found few newly released cultivars exhibited greater salinity tolerance.

If saline conditions are expected in the soil or irrigation water, use of a more salt-tolerant Kentucky bluegrass may mean the difference between success and failure. Nevertheless, Kentucky bluegrass is still salt-sensitive compared with other species such as tall fescue and creeping bentgrass (Carrow and Duncan, 1998). Selecting salt-tolerant Kentucky bluegrass cultivars is beneficial for sites where salinity level is marginally high.

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