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## Comparative Responses of Two Kentucky Bluegrass Cultivars to Salinity Stress

Y. L. Qian,\* S. J. Wilhelm, and K. B. Marcum

### ABSTRACT

Little information is available concerning physiological responses of Kentucky bluegrass (*Poa pratensis* L.) (KBG) cultivars to salinity. Growth and physiological responses of 'Limousine' and 'Kenblue' KBG to a range of salinity levels were investigated. Grasses were grown in solution culture and exposed to salinity levels of 2.2, 5.2, 8.2, 11.2, and 14.2  $\text{dS m}^{-1}$  for 10 wk. Though both cultivars exhibited increased leaf firing with increasing salinity, Limousine exhibited less leaf firing than Kenblue at salinity levels above 5.2  $\text{dS m}^{-1}$ . In addition, salinity levels that caused 25% shoot growth reduction were 3.2  $\text{dS m}^{-1}$  for Kenblue and 4.7  $\text{dS m}^{-1}$  for Limousine, indicating that Limousine has better salinity tolerance. Under moderate (8.2  $\text{dS m}^{-1}$ ) salinity stress, Limousine produced ~50% more root growth than Kenblue. Water relations diverged between cultivars at 8.2 and 14.2  $\text{dS m}^{-1}$ , as Limousine had higher leaf water and osmotic potentials, as well as more positive turgor. While glycinebetaine was not detected in either cultivar, proline increased in leaves with increasing salinity, and was higher in Kenblue than Limousine at 8.2, 11.2, and 14.2  $\text{dS m}^{-1}$ . This suggests that compatible solute accumulation is not a salinity tolerance mechanism of KBG, and that proline accumulation is merely an indication of salt injury. Limousine maintained 52% lower shoot  $\text{Na}^+$ , 30.4% lower  $\text{Cl}^-$ , and 52% higher shoot  $\text{K}^+/\text{Na}^+$  ratio than Kenblue at the highest salinity level. These results suggest that salinity tolerance in KBG is largely attributable to maintenance of higher root growth, and more positive turgor, higher  $\text{K}^+/\text{Na}^+$  ratio, and less  $\text{Cl}^-$  accumulation in shoots. These traits may serve as useful selection criteria in breeding efforts to develop salt tolerant KBG.

**S**ALT PROBLEMS are of great concern in arid and semi-arid regions, where soil salt content is naturally high and precipitation is insufficient for leaching. With accelerated urban development in western states, turf is

increasingly grown on soils where salinity problems already exist, or may develop subsequently from the use of saline irrigation water. One of the most efficient methods of improving turfgrass growth in salt-stressed situations is to use salt tolerant species and/or cultivars. Though KBG is the most widely used cool-season turfgrass in the USA (Christians, 1998), it is considered to be salt-sensitive, reported to tolerate less than 4  $\text{dS m}^{-1}$  soil salinity (Butler et al., 1974; Harivandi et al., 1992). In previous studies, cultivar Limousine suffered substantially less leaf firing under saline conditions than did Kenblue (Qian, unpublished results). Limousine, released by Jacklin Seed in 1992, is classified as an aggressive KBG that exhibits compact vertical growth, but aggressive lateral growth. Because of its aggressive lateral growth, Limousine tolerates close, frequent mowing, and is frequently used on golf course fairways in temperate climates. Kenblue, released in 1967 by the Kentucky Agricultural Experiment Station, is a Common-type (Midwest ecotype) KBG that has a relatively fast shoot elongation rate and low density.

Salt tolerance in plants is a complex phenomenon involving morphological, physiological, and biochemical processes (Jacoby, 1999). Salinity tolerance mechanisms of KBG have not been elucidated. Comparing growth, morphological, and physiological responses of KBG cultivars having different salinity tolerances may aid in defining salt tolerance mechanisms and identifying criteria for breeding salt resistant KBG cultivars.

Objectives of the present study were to (i) compare plant growth, water potential components, ion content, and compatible solute content of a salt-sensitive (Kenblue) vs. a salt-tolerant (Limousine) KBG cultivar across a range of salinity levels and (ii) examine growth and physiological characteristics that might relate to variability in KBG salinity tolerance.

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## MATERIALS AND METHODS

### Plant Culture

Two greenhouse experiments were conducted from 18 Feb. to May 18 1998 (Exp. I) and 1 Dec. 1999 to 17 March 2000 (Exp. II) using a solution culture system. During both experiments, average air temperature in the greenhouse was 21°C at 0800 h, 24°C at 1400 h, and 18°C at 0200 h. Plants were grown under natural light, with photosynthetically active radiation ranging from 150  $\mu\text{mol m}^{-2}\text{s}^{-1}$  on cloudy days to 1150  $\mu\text{mol m}^{-2}\text{s}^{-1}$  on sunny days. General procedures were described in previous publications (Marcum and Murdoch, 1994; Qian et al., 2000). Briefly, sward pieces of Kenblue and Limousine, measuring 10 cm in diam. were sampled from 3-yr-old field plots. Sod pieces were hand-washed to remove soil, then planted into a hydroponic system comprised of tanks containing 38 L full strength Hoagland's solution as the nutrient medium. Grasses were clipped weekly and allowed to establish well before salinity treatments began.

### Experiment I

Salinity was increased in four tanks (each tank containing both cultivars) by daily increments of  $\sim 0.4 \text{ dS m}^{-1}$  by means of equal weights of  $\text{CaCl}_2$  and  $\text{NaCl}$  until a final salinity level of  $9.2 \text{ dS m}^{-1}$  was reached. Salinity was measured by an electrical conductivity meter (Model CO150, Hach Company, Loveland, CO). The other four tanks were maintained as control Hoagland's medium ( $\text{EC} = 2.2 \text{ dS m}^{-1}$ ) without the addition of  $\text{NaCl}$  and  $\text{CaCl}_2$ .

Grasses were exposed to final salinity treatments for a period of 10 wk. During this period, solution EC of all treatment tanks was measured every 2 to 3 d and adjusted when necessary. Leaf firing percentage was determined weekly, beginning 4 wk after initiation of salinity treatments, by visually estimating total percentage of chlorotic leaf area. Means of leaf firing over time are presented for each salinity level. Grasses were clipped weekly to a height of 2.5 cm throughout the experiment. Clipping yields were harvested weekly beginning 6 wk after the initiation of salinity treatments, and dried at 70°C for 48 h for dry weight determination. Following the final clipping harvest after 10 wk of salinity treatment, grass sward was harvested and divided into verdure and roots. Each fraction was then dried in a force-draft oven at 70°C for 48 h to determine dry mass.

### Experiment II

Salinity treatments were applied by adding equal weights of  $\text{CaCl}_2$  and  $\text{NaCl}$  gradually during a 3-d period to obtain electrical conductivity (EC) values of 5.2, 8.2, 11.2, and  $14.2 \text{ dS m}^{-1}$ . Control treatment consisted of Hoagland's medium ( $\text{EC} = 2.2 \text{ dS m}^{-1}$ ) without the addition of  $\text{NaCl}$  and  $\text{CaCl}_2$ .

Grasses were exposed to final salinity treatments for a period of 10 wk. During this period, solution EC of all treatment tanks was measured every 2 to 3 d and adjusted when necessary. Data on leaf firing percentage, clipping yield, root mass, and verdure were collected as described in Exp. I. In addition, physiological responses to salinity treatments were determined, including leaf water relations, leaf sap mineral content, and proline and glycinebetaine.

Predawn leaf water and osmotic potentials were measured 7 wk after salinity treatments were initiated, using thermocouple psychrometers (Tru Psi Water Potential Measurement System, Decagon Devices Inc., Pullman, WA). Between 0400 and 0500 h, fully emerged leaf blades were excised and sealed in stainless-steel psychrometer chambers. Sealed samples were

equilibrated at 25°C for 3.5 h before measuring water potential (Qian and Fry, 1997). For leaf osmotic potential measurement, chambers containing leaf tissues were removed from sensor heads, sealed with Parafilm (American Can Co., CT), capped, and frozen at  $-40^\circ\text{C}$  for 8 h. Chambers were then removed from the freezer, thawed at 25°C for 1 h, unsealed, and quickly returned to the thermocouple sensor heads. Leaf osmotic potential was determined after a 3.5 h equilibration period. Because only 20 thermocouple psychrometer chambers were available, samples were taken on two separate dates, each date covering two replications for each cultivar and salinity treatment.

Leaves were sampled for sap mineral content analysis 4 wk after salt treatments were initiated. Intact leaves were rinsed thoroughly with distilled water to remove all external salt, and allowed to air dry prior to clipping. Approximately 10 leaf blades were excised per cup, placed into microcentrifuge tubes, and frozen at  $-40^\circ\text{C}$  for at least 8 h. Samples were subsequently thawed for 30 min., and sap expressed with a laboratory press. Twenty-microliter aliquots of expressed sap were analyzed for  $\text{Na}^+$ ,  $\text{Ca}^{++}$ ,  $\text{K}^+$ ,  $\text{Mg}^{++}$ , and other minerals (data not presented) by inductively-coupled plasma-emission spectrophotometry (Model 975 Plasma Atomcomp, Thermo Jarrell Ash Corp., Franklin, MA). Leaf sap  $\text{Cl}^-$  concentration was measured by ion chromatography (2000 I/SP, Dionex, Sunnyvale, CA).

Following 5 and 6 wk salinity treatment, fully expanded leaves were sampled for glycinebetaine and free proline analysis, respectively. Free proline concentration was determined spectrophotometrically by an acid ninhydrin procedure (Bates et al., 1973). For glycinebetaine, leaf samples were frozen on dry ice immediately after excision, thawed, and sap expressed with a laboratory press. Ten microliters of extract was dried under a stream of nitrogen, and final aliquot volume brought to 1 mL with deuterium water. Glycinebetaine was quantified by NMR methodology, after the procedure of Jones et al. (1986) with modifications. A Varian UNITY Plus 500 NMR spectrometer operating at 11.75 T (499.869 MHz for  $^1\text{H}$  NMR) was utilized, spectra being measured at 30°C with a 5-mm triple-resonance inverse detection probe. One dimensional proton spectra were acquired with 16 transients, 19.2 k data points, a pulse repetition rate of 2.0 s, a flip angle of  $60^\circ$ , and a spectral width of 8000 Hz centered on the water peak. Free induction decays were zero filled to 64 k prior to Fourier transformation.

### Data Analysis

Data from each experiment were analyzed separately. Experimental design was a split plot with four replications; salt treatment (tank) being the main plot effect and cultivars (pots) within each tank being subplot effects. Salinity and cultivar effects were determined by analysis of variance (SAS Institute, 1989). Treatment means were separated by Fisher's protected LSD. Regression analysis was performed for Exp. II to define linear relationships between each variable and the salinity level.

## RESULTS

### Experiment I

Leaf firing increased over time in salinity treatment, and was higher in Kenblue than Limousine (Table 1). Under nonsaline conditions, Kenblue produced 41% higher clipping yield than Limousine, whereas no difference was found between cultivars in salinity treatment.

**Table 1. Effect of salinity on percentage leaf firing, clipping yield, root mass, and verdure of Kenblue and Limousine Kentucky bluegrass in Experiment 1.**

Variable	Control (2.2 dS m <sup>-1</sup> )		Salinity (9.2 dS m <sup>-1</sup> )	
	Kenblue	Limousine	Kenblue	Limousine
% Leaf firing	3.0%	1.3%	53%†	12.3%
Weekly clipping (g)	0.35†	0.24	0.12	0.11
Root mass (g)	0.40	0.34	0.18	0.19
Verdure (g)	2.4	3.2	2.4†	3.3

† Indicates significant difference between two cultivars within salinity level and parameter.

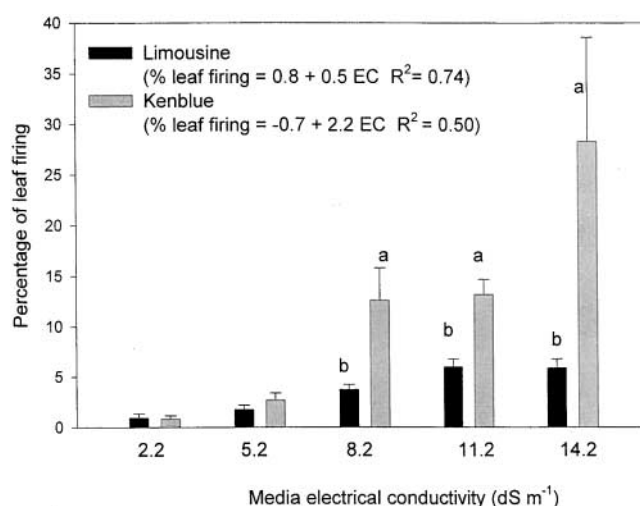
Salinity reduced clipping yield by 66% in Kenblue, and 54% in Limousine, relative to control. However, salinity did not affect verdure of either cultivar. Salinity reduced root mass by 55% in Kenblue and 45% in Limousine, relative to control.

## Experiment II

Analysis of variance revealed significant effects of salinity, cultivar, and their interaction in affecting percent leaf firing (Table 2). With increasing salinity, both cultivars exhibited increased leaf firing, though leaf firing increased more rapidly in Kenblue than Limousine (Fig. 1). Differences were not apparent until 8.2 dS m<sup>-1</sup>, at which point Limousine had significantly lower percent leaf firing.

Clipping yields were influenced by salinity, cultivar, and their interaction (Table 2). Mean weekly clipping yield decreased linearly with increasing salinity for both cultivars (Fig. 2). Regressions were strongly linear, with slope more negative in Kenblue than Limousine. Under nonsaline and low-saline conditions (i.e., control and 5.2 dS m<sup>-1</sup>), Kenblue produced 27 to 48% higher clipping yield than Limousine, whereas at the highest salinity level, Limousine produced 53% higher clipping yield than Kenblue. Regression predicted that 25% shoot growth reduction occurred at 3.2 dS m<sup>-1</sup> for Kenblue, and at 4.7 dS m<sup>-1</sup> for Limousine.

Root growth of Limousine and Kenblue responded differently to increasing salinity, being linear in Kenblue, but curvilinear in Limousine (Fig. 3). As salinity level increased from control (2.2 dS m<sup>-1</sup>) to 5.2 dS m<sup>-1</sup> Limousine exhibited a trend of increasing in root mass. With further increasing in salinity, root growth decreased. In contrast, root growth of Kenblue decreased linearly with increasing salinity. At 8.2 and 14.2 dS m<sup>-1</sup>



**Fig. 1. Effect of salinity between 2.2 and 14.2 dS m<sup>-1</sup> on percentage leaf firing of Kenblue and Limousine Kentucky bluegrass in experiment II. Vertical lines represent standard errors. Columns labeled with different letters are significantly different, within a given salinity level, at 0.05 probability using Fisher's LSD test.**

salinity levels, Kenblue produced 50 and 40% lower root mass than Limousine, respectively. Regression analysis predicted 25% root growth reduction occurred at 3.8 dS m<sup>-1</sup> for Kenblue and at 6.2 dS m<sup>-1</sup> for Limousine.

Salinity, cultivar, and salinity × cultivar interaction significantly affected leaf water potential components. Leaf water potential components were similar between Kenblue and Limousine under nonsaline conditions. Mean leaf water, osmotic, and pressure potentials for the two cultivars were -0.98, -1.49, and 0.51 MPa, respectively. Water, osmotic, and pressure potentials diverged between cultivars as salinity level increased. At 8.2 dS m<sup>-1</sup>, the water, osmotic, and pressure potentials of Kenblue were 0.90, 0.56, and 0.28 MPa lower than that of Limousine, respectively. At 14.2 dS m<sup>-1</sup>, leaf water potential and pressure potential of Kenblue were -0.48 and -0.14 MPa lower than that of Limousine. Regression analysis indicated significant linear relationships between salinity and water potential components, except for leaf osmotic potential of Limousine (Fig. 4). Analysis of variance indicated a significant replication effect on water potential components (Table 2). This likely occurred because different replications were sampled on different dates with varying environmental conditions.

Shoot proline content increased with increasing salin-

**Table 2. Analysis of variances with mean square and treatment significance for Experiment II.**

Variable	Salt	Block	Salt × Block	Cultivar	Salt × cultivar
Leaf firing (%)	342**	47ns	55ns	762***	178**
Clipping yield (g)	0.080****	0.004ns	0.002ns	0.010*	0.011**
Root mass (g)	0.29****	0.02ns	0.01ns	0.04ns	0.09*
Verdure (g)	0.51*	0.34ns	0.28ns	7.7****	0.14ns
Leaf water potential (MPa)	0.61**	0.90****	0.16**	0.75***	0.21***
Leaf osmotic potential (MPa)	0.13*	0.33**	0.10ns	0.36***	0.15*
Pressure potential (MPa)	0.15****	0.17****	0.01ns	0.03*	0.03*
Proline (μmol/g FW)	342****	2.8ns	11.6ns	45*	29*

\* Indicates significance at  $P = 0.05$ .

\*\* Indicates significance at  $P = 0.01$ .

\*\*\* Indicates significance at  $P = 0.001$ .

\*\*\*\* Indicates significance at  $P = 0.0001$ .

ns, not significant.

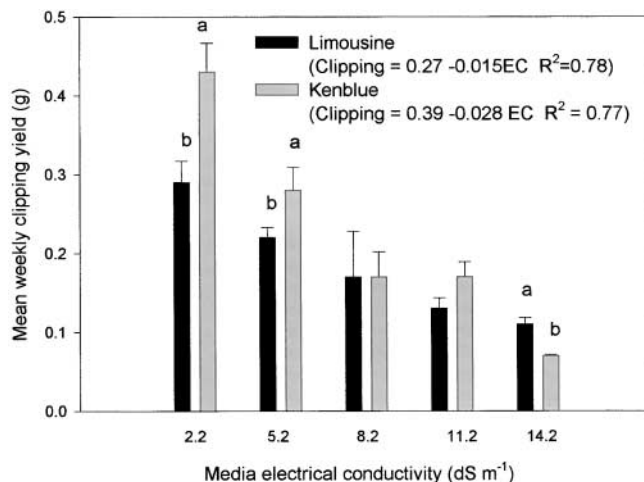


Fig. 2. Mean weekly clipping yield of Kenblue and Limousine Kentucky bluegrass as influenced by salinity from 2.2 to 14.2 dS m<sup>-1</sup> in experiment II. Vertical lines represent standard errors. Columns labeled with different letters are significantly different, within a given salinity level, at 0.05 probability using Fisher's LSD test.

ity in both cultivars (Fig. 5). Proline content increased rapidly at 8.2 dS m<sup>-1</sup> in Kenblue and at 11.2 dS m<sup>-1</sup> in Limousine. Sixty-four percent less proline was found in Limousine than Kenblue at 8.2 dS m<sup>-1</sup>. Glycinebetaine was not found in shoots of either cultivar, nor did it accumulate under salinity.

Leaf sap Na<sup>+</sup> and Cl<sup>-</sup> concentrations increased with increasing salinity for both cultivars (Table 3). Though Na<sup>+</sup> concentration in Limousine was 61% higher than that of Kenblue under nonsaline conditions, it was 52% lower than Kenblue at high salinity (14.2 dS m<sup>-1</sup>). Similarly, Cl<sup>-</sup> content in Limousine was 48.8 and 30.4% lower than in Kenblue at 5.2 and 14.2 dS m<sup>-1</sup>, respectively. Potassium was invariably the major ion present in leaf sap (Table 3). Leaf K<sup>+</sup> concentration decreased linearly in Kenblue with increasing salinity but not in Limousine. This, together with lower leaf Na<sup>+</sup> concentration, resulted in a 52% higher K/Na ratio in Limousine than in Kenblue at high salinity levels. Even though salts added to salinity treatments had an equal weight of NaCl:CaCl<sub>2</sub>, Ca<sup>++</sup> concentration in leaf sap did not increase with increasing salinity levels in either cultivar (Table 3). Kenblue had higher leaf Ca<sup>++</sup> concentrations than Limousine at 5.2, 8.2, and 14.2 dS/m. Leaf sap Mg<sup>++</sup> concentration decreased as salinity increased, with Limousine averaging 54% lower than Kenblue.

## DISCUSSION

With increasing salinity, Kenblue exhibited higher percent leaf firing, greater reduction in shoot and root growth, more negative leaf water potential components, higher leaf Na<sup>+</sup> and Cl<sup>-</sup> concentrations, and lower leaf K<sup>+</sup>/Na<sup>+</sup> ratios than Limousine. Growth responses are in agreement with the physiological parameters, indicating that Limousine is more salt tolerant than Kenblue. In previous salt tolerance studies involving KBG, Greub et al. (1985) reported that shoot salt injury was less for 'Nugget' than 'Fylking', 'Park', 'Pennstar', 'Newport',

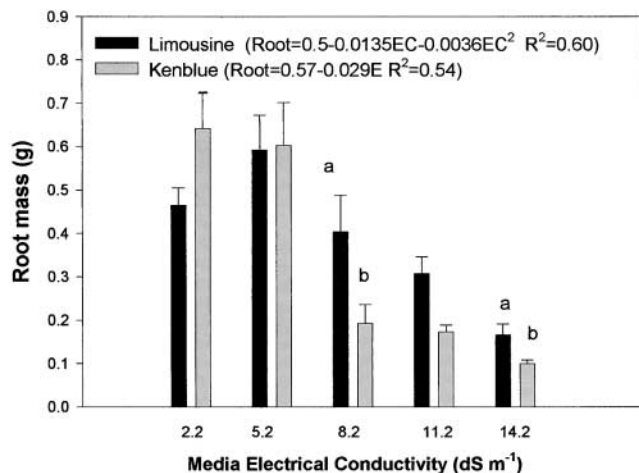


Fig. 3. Root mass of Kenblue and Limousine Kentucky bluegrass as affected by salinity from 2.2 to 14.2 dS m<sup>-1</sup> in experiment II. Vertical lines represent standard errors. Columns labeled with different letters are significantly different, within a given salinity level, at 0.05 probability using Fisher's LSD test.

and 'Merion'. Gibeault et al. (1977) reported that Fylking performed better than Merion Kentucky bluegrass in field plots having an average EC of 11.4 dS m<sup>-1</sup>. Among 23 KBG cultivars in a greenhouse pot experiment, cultivars Park, 'South Dakota Certified', 'Adelphi', 'Vantage', 'Pennstar', and Merion were relatively salt-sensitive (Ahti et al., 1977). Suplick et al. (2000) found 'Huntsville' KBG less salt tolerant than A-34 KBG. Park, South Dakota Certified, and Huntsville are classified as common type or Midwest ecotype KBG, as is Kenblue in this study. It appears that established common type KBG has been consistently ranked as salt sensitive. However, this pattern was not observed during germination and initial growth (Horst and Taylor, 1983).

In this experiment, differences in salinity tolerance between Kenblue and Limousine were associated with maintenance of root growth and positive shoot turgor. As indicated by leaf water and pressure potentials, our results demonstrated that salt-sensitive Kenblue experienced more severe water stress than did salt-tolerant Limousine under high salinity conditions. The positive water status of Limousine could be related to the development and maintenance of a more extensive root system under saline conditions.

Relative salinity tolerance was also related to restricted shoot Na<sup>+</sup> and Cl<sup>-</sup> levels, in conjunction with maintenance of high shoot K<sup>+</sup> concentrations. At high salinity, Limousine accumulated significantly less shoot Na<sup>+</sup> and Cl<sup>-</sup> than did Kenblue, resulting a higher K/Na ratio. Salinity tolerance among several cool season turfgrass species was associated with exclusion of Na<sup>+</sup> from shoot (Torello and Rice, 1986). Similarly, salinity tolerance among warm season turfgrass species has been associated both Na<sup>+</sup> and Cl<sup>-</sup> exclusion (Marcum, 1999). Storey and Wyn Jones (1979) suggested that the capacity to maintain high shoot K/Na is an important element of salt tolerance, especially in species which lack foliar salt-excretion mechanisms. The lower Cl<sup>-</sup> concentration in Limousine may also in part account for the lower leaf firing observed.

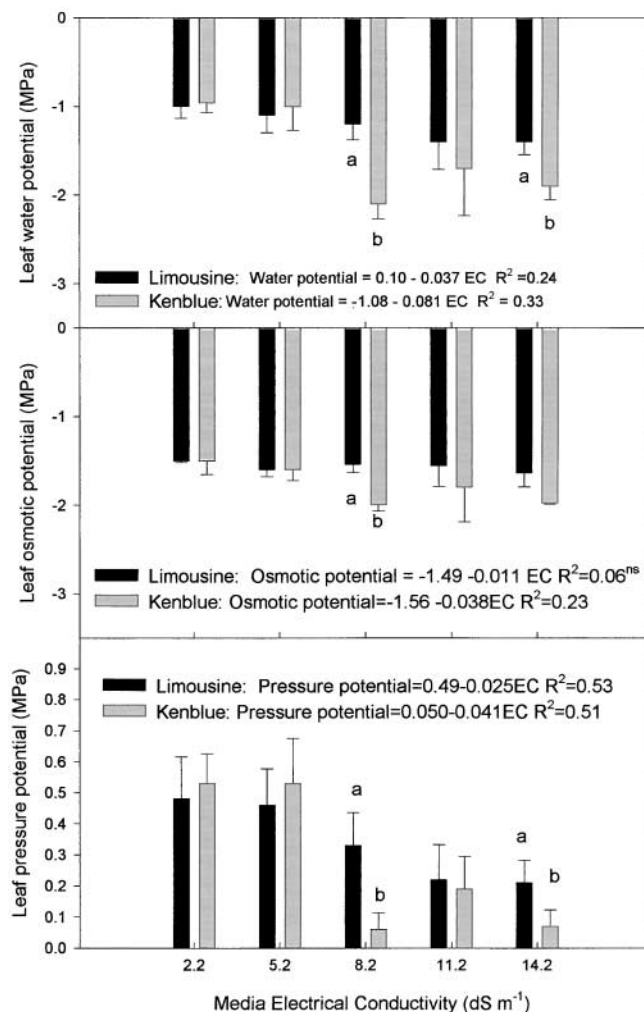


Fig. 4. Leaf water potential, osmotic potential, and pressure potential of Kenblue and Limousine Kentucky bluegrass grown under five salinity treatments. Vertical lines represent standard errors. Columns labeled with different letters are significantly different at the 0.05 probability level using Fisher's LSD test.

Interestingly, Limousine exhibited no significant changes in leaf osmotic potential with increasing salinity, suggesting that osmotic adjustment is not an important mechanism contributing to Limousine's better salinity tolerance than Kenblue. Major osmotica that increased

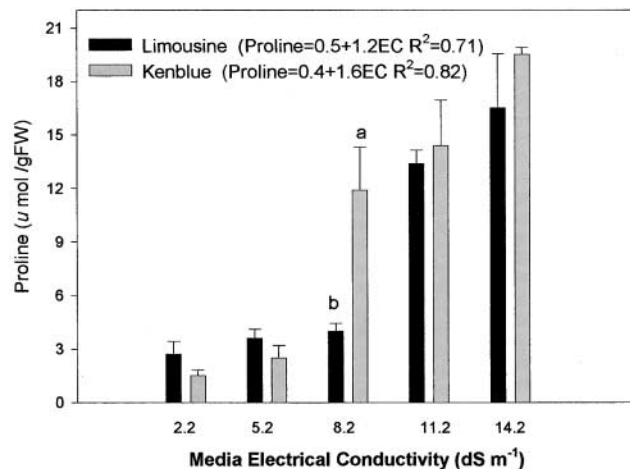


Fig. 5. Proline content in Kenblue and Limousine Kentucky bluegrass shoot tissues under five salinity levels. Vertical lines represent standard errors. Columns labeled with different letters are significantly different at the 0.05 probability level using Fisher's LSD test.

under salinity were proline, Na<sup>+</sup>, and Cl<sup>-</sup>, all being higher in Kenblue than Limousine. Using the van't Hoff equation (Salisbury and Ross, 1992), we calculated the relative contributions of proline, Na<sup>+</sup>, and Cl<sup>-</sup> to leaf osmotic potential. Proline accounted for only 0.007 to 0.05 MPa, which is about 0.4 to 2.5% of the total leaf osmotic potential. As less proline was found in the salt tolerant cultivar, and a rapid proline accumulation appeared to coincide with a sharp increase in leaf firing, proline accumulation may be a result of salt injury in KBG, rather than an adaptive metabolic response. A similar pattern has been reported in warm season turfgrasses (Marcum, 1999). Sodium and Cl<sup>-</sup> contributed 4% of leaf osmolality in the control treatment of both Limousine and Kenblue. This fraction increased to 19 and 13% under highest salinity treatment, for Kenblue and Limousine, respectively.

Enzymes of salt-tolerant and salt-sensitive plants are similarly sensitive to saline (Na<sup>+</sup> and Cl<sup>-</sup>) ions (Flowers, 1985). Under saline conditions, salt tolerant plants generally (i) compartmentalize accumulated Na<sup>+</sup> and Cl<sup>-</sup> in vacuoles, and (ii) accumulate certain organic *compatible solutes* in sufficient concentrations in the cytoplasm to achieve cytoplasmic osmotic adjustment without affecting

Table 3. Leaf mineral concentration of Limousine and Kenblue Kentucky bluegrass as influenced by salinity levels (dS m<sup>-1</sup>) in Experiment II.

Salinity level	Na <sup>+</sup>		Ca <sup>++</sup>		Cl <sup>-</sup>		K <sup>+</sup>		Mg <sup>++</sup>	
	Kenblue	Limousine	Kenblue	Limousine	Kenblue	Limousine	Kenblue	Limousine	Kenblue	Limousine
	meq/L									
Control	1.74c†‡	2.8c	34.3b	24.0ab	23.7b	20.6b	228.0a	202.2ns	38.5a‡	21.7a
5.2	16.1c	15.6bc	47.8ab‡	25.0ab	51.4ab‡	26.3b	228.0a	180.5	35.7ab‡	15.2ab
8.2	39.6b	30.8ab	58.5a‡	18.8b	54.0ab	34.6b	221.4a	216.3	40.6a‡	12.7ab
11.2	34.8b	43.6a	34.3b	47.8a	64.2a	50.2a	174.1b	218.9	27.1bc	16.4ab
14.2	74.1a‡	36.1ab	53.5a‡	28.8ab	74.9a‡	52.1a	186.0b	150.0	23.0c‡	10.3b
Linear salinity effect	***	***	ns	ns	*	***	*	ns	**	*

\* Indicates significance at P = 0.05.

\*\* Indicates significance at P = 0.01.

\*\*\* Indicates significance at P = 0.001.

ns, nonsignificant.

† Means followed by same letter within the same column are not significantly different at the 0.05 probability level using Fisher's LSD test.

‡ Indicates significant difference between two cultivars within salinity level and parameter.

enzyme function (Gorham, 1996). Proposed compatible solutes glycinebetaine and proline typically accumulate in salt tolerant grasses growing under saline conditions (Rhodes and Hanson, 1993). Glycinebetaine has been reported to accumulate at sufficient levels to effect osmotic adjustment of a number of warm season turfgrasses, and accumulated levels were positively correlated with salinity tolerance (Marcum, 1999). However, using a sensitive NMR technique, we did not find glycinebetaine in either KBG cultivar, under control or salinized conditions. Though proline was found in both cultivars, accumulation patterns were not related to salinity tolerance, and accumulated concentrations were very low. Evidence suggests that glycinebetaine and proline accumulation is not a salinity tolerance mechanism in KBG.

In this paper, we have documented differential growth and physiological responses of a relative salt tolerant (Limousine) and salt sensitive (Kenblue) KBG to different salinity levels. Differences in growth response and salinity tolerance between cultivars was attributed largely to maintenance of higher root growth, more positive turgor, higher K/Na ratio, and less Cl accumulation in shoots. These criteria might effectively be utilized in breeding programs to develop salt resistant KBG cultivars.

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