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As population growth and demand for irrigation increases, available water for irrigation will decrease, and use of low-quality or effluent sources of irrigation will become more prevalent. Elevated salinity levels are a concern with use of these types of irrigation waters. Therefore, tomorrow's turfgrasses must possess increased resistance to stresses related to both drought and salinity. This greenhouse salinity screening project represents the second phase of testing in a 5-yr USDA Specialty Crops Research Initiative involving breeders and physiologists from five universities, including Texas A&M University, University of Georgia, University of Florida, North Carolina State University, and Oklahoma State University. Forty-five cultivars and experimental lines of bermudagrass (*Cynodon spp.*), zoysia grass (*Zoysia spp.*), St. Augustinegrass (*Stenotaphrum secundatum*) and seashore paspalum (*Paspalum vaginatum*) which have demonstrated superior drought tolerance in multi-location field drought screening are now being evaluated for salinity tolerance. A subsequent round of screenings will again be conducted in 2015 using a new set of drought-resistant entries from the current year's field drought testing. These screenings will contribute data needed for development of new warm-season turfgrass cultivars with improved drought and salinity tolerance. The objective of this research is to evaluate salinity tolerance in warm-season turfgrasses and identify experimental lines possessing superior salinity tolerance for advanced testing and cultivar development.

## Methodology

\*Greenhouse experiments are being conducted in the Summer 2014 and 2015 at Texas A&M University, College Station, TX and University of Georgia, Griffin, GA. Data presented are for the Texas A&M study.

\*Sod plugs (6 cm diameter x 5 cm deep) from forty-five cultivars and experimental lines of 4 warm-season turf species were used in the experiments.

\*Sod plugs were washed free of soil and transplanted into 100 cm<sup>2</sup> x 10.2 cm deep pots containing washed sand. The cultures were allowed to fully establish into pots for 60-days prior to initiating experiments.

\*During the establishment phase, grass cultures were irrigated daily with 0.6 cm of irrigation, and given liquid-fertilizer twice weekly (Peters 20-20-20). Grasses were clipped as needed, with bermudagrass, zoysiagrass, and seashore paspalum entries maintained at a 2.5 cm and St. Augustinegrass at a 5.1 cm height of cut.

\*Experiments were conducted at salinity levels of 0, 15, 30, and 45 dS m<sup>-1</sup>. Within each salinity level, entries were arranged in a completely randomized design with 4 replications per treatment.

\*Salinity treatments were provided to plants via sub-irrigation 1 to 2 times daily. This solution was created by adding synthetic sea salt (Instant Ocean Aquarium Systems, Mentor, OH) to reverse-osmosis water to create the desired salinity.

\*During acclimation, the salinity level of each treatment was gradually increased by 10 dS m<sup>-1</sup> per week until final salt concentrations 0, 15, 30, and 45 dS m<sup>-1</sup> were reached, at which time 6-week experiments were initiated. Salinity concentrations of irrigation water were monitored twice weekly using a nitrate meter (Eutech Instruments, Plainfield, IL).

\*A 13-2-13 soluble fertilizer (Miracle-Gro Professional Excel, Mansfield, OH) was added to the irrigation water as needed to maintain a solution nitrate concentration of 200 to 300 mg L<sup>-1</sup>. Nitrate levels of solutions were monitored weekly using a nitrate meter (LAQUA Twin Nitrate Meter, Spectrum Technologies, Plainfield, IL).

\*Grasses within each treatment were visually rated for leaf firing on a 1-9 scale weekly (1 = completely brown turf, 9 = perfect green turf). At week 10 (end of salinity exposure) digital image box images were taken and subjected to digital image analysis for determination of percent green cover within each pot.

\*Grasses were clipped weekly for measurement of weekly growth rate within each treatment. After 6 weeks at the target salt concentrations, grasses were harvested and washed free of sand to determine total biomass dry weights of venture, crown and roots. Percent reduction in total biomass was calculated for each entry and salinity level.

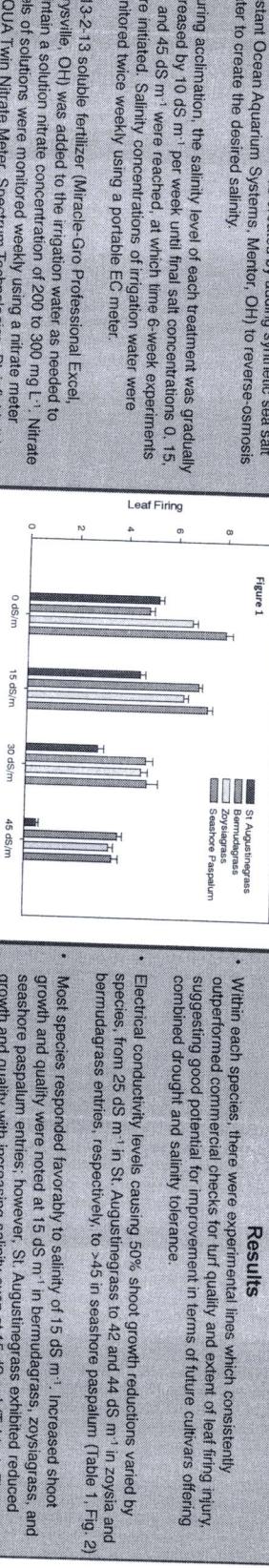
\*Data were analyzed using general linear model of SPSS. Fisher's LSD was used to compare treatment means.

Cultivar (Cynodon dactylon)	Leaf Firing			Turf Quality			Shoot Growth Reduction		
	Check	Tifway	Celebration	Score	Zoysia grass sp.	Emory	Palmetto	Score	% of control
University of Georgia	Check	3.75	2.75	61.19	62.85	2.25	1.75	65.19	
	USG-8	3.00	2.80	59.68	58.00	2.00	1.50	63.31	
	USG-14	3.75	3.25	60.50	62.00	2.25	1.50	61.84	
	USG-42	2.50	2.00	71.82	74.24	2.75	3.00	76.82	
	USG-70	4.50	4.00	74.24	76.54	3.00	3.50	58.75	
	OSU11-1	3.50	2.75	78.32	78.32	3.00	2.50	41.52	
	OSU11-17	3.75	3.00	94.06	94.06	3.25	2.75	82.75	
	OSU11-31	3.75	3.00	94.06	94.06	3.25	3.00	62.12	
	OSU11-56	3.75	3.00	94.06	94.06	3.25	3.00	77.08	
Oklahoma State University	Mean	3.70	3.00	73.75	73.75	3.00	2.50	76.61	
	LSD	0.67	0.80	3.23	—	0.71	0.50	61.53	
	Std Error	2.74	—	—	—	2.87	2.47	66.58	

St. Augustinegrass ( <i>Stenotaphrum secundatum</i> )	Leaf Firing			Turf Quality			Shoot Growth Reduction		
	Check	St. Augustine	Bermudagrass	Score	Seashore Paspalum ( <i>Paspalum vaginatum</i> )	Check	Zoysia grass sp.	Score	% of control
Texas A&M Aprilite	Check	0.25	0.25	99.35	St. Augustine	2.50	2.00	49.04	
	Palmetto	0.75	0.75	97.18	Palmetto	2.00	2.20	31.46	
	DALSA-115	0.50	0.50	97.18	UGP-1	4.50	3.75	38.72	
	DALSA-1316	0.75	0.75	97.17	UGP-3	5.25	4.75	42.92	
	DALSA-1317	0.25	0.25	98.10	UGP-10	2.75	2.25	47.81	
	DALSA-1318	0.25	0.25	98.15	UGP-28	2.50	3.75	30.74	
	DALSA-1319	0.25	0.25	97.74	UGP-73	3.75	2.75	39.25	
North Carolina State University	Mean	1.00	0.50	98.00	Mean	3.54	2.80	39.08	
	NC-17	0.25	0.25	96.24	LSD	0.71	0.82	34.42	
	NC-25	0.00	0.00	95.50	Std Error	2.95	—	—	
	NC-40	0.25	0.25	97.00	—	—	—	—	
	NC-50	0.35	0.35	97.97	—	—	—	—	

Table 1 Leaf firing, turf quality, and % shoot growth reduction relative to controls for experimental lines and commercial checks at 45 dS m<sup>-1</sup> electrical conductivity at the conclusion of the salinity stress experiment, prior to recovery.



## Results

• Within each species, there were experimental lines which consistently outperformed commercial checks for turf quality and extent of leaf firing injury suggesting good potential for improvement in terms of future cultivars offering combined drought and salinity tolerance.

• Electrical conductivity levels causing 50% shoot growth reductions varied by species, from 25 dS m<sup>-1</sup> in St. Augustinegrass to 42 and 44 dS m<sup>-1</sup> in zoysia and bermudagrass entries, respectively, to >45 in seashore paspalum (Table 1, Fig. 2).

• Most species responded favorably to salinity of 15 dS m<sup>-1</sup>. Increased shoot growth and quality were noted at 15 dS m<sup>-1</sup> in bermudagrass, zoysiagrass, and seashore paspalum entries; however, St. Augustinegrass exhibited reduced growth and quality with increasing salinity even at 15 dS m<sup>-1</sup> (Table 1, Figs. 1&2). Entries maintaining the highest quality at 45 dS m<sup>-1</sup> treatment included UGP-3 and B11-1, OSU B11-31, and Celebration bermudagrass (Table 1).

These results demonstrate considerable interspecific and intraspecific species differences in salinity tolerance among the warm-season experimental lines tested. Given the previously determined drought resistance of these entries, there appears to be strong potential in these lines for development of cultivars with improved drought and salinity tolerance.

Future research will address mechanisms of salinity tolerance among these entries, with particular emphasis on St. Augustinegrass.

## Conclusions

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Future research will address mechanisms of salinity tolerance among these entries, with particular emphasis on St. Augustinegrass.

Table 2 Shoot growth reduction as influenced by electrical conductivity at the conclusion of the study. Error bars denote standard error.

Cultivar (Cynodon dactylon)	Leaf Firing			Turf Quality			Shoot Growth Reduction		
	Check	Tifway	Celebration	Score	Zoysia grass sp.	Emory	Palmetto	Score	% of control
University of Georgia	Check	2.75	2.75	61.19	62.85	2.25	1.75	65.19	
	USG-8	3.00	2.80	59.68	58.00	2.00	1.50	63.31	
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	USG-42	2.50	2.00	71.82	74.24	2.75	3.00	76.82	
	USG-70	4.50	4.00	74.24	76.54	3.00	3.50	58.75	
	OSU11-1	3.50	2.75	78.32	78.32	3.00	2.50	82.75	
	OSU11-31	3.75	3.00	94.06	94.06	3.25	3.00	62.12	
	OSU11-56	3.75	3.00	94.06	94.06	3.25	3.00	77.08	
Oklahoma State University	Mean	3.70	3.00	73.75	73.75	3.00	2.50	76.61	
	LSD	0.67	0.80	3.23	—	2.87	2.47	66.58	
	Std Error	2.74	—	—	—	2.87	2.47	66.58	

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**Table 1.** Leaf firing, turf quality, and % shoot growth reduction relative to controls for experimental lines and commercial checks at 45 dS m<sup>-1</sup> electrical conductivity at the conclusion of the salinity stress experiment, prior to recovery.

		Leaf firing score	Turf Quality score	Shoot Growth Reduction % of control			Leaf firing score	Turf Quality score	Shoot Growth Reduction % of control
Bermuda ( <i>Cynodon dactylon</i> ) Checks					Zoysia grass sp. Checks				
University of Georgia	Tifway	3.75	2.75	61.19	Empire	2.25	1.75	65.19	
	Tifway	5.25	4.50	65.41	Palisades	2.50	1.26	63.51	
	UGB-8	3.50	2.75	55.68	Zeon	1.50	2.26	69.04	
	UGB-14	3.75	3.25	60.23	FAES 1303	6.25	2.00	61.97	
	UGB-42	3.25	2.50	84.22	FAES 1304	3.75	3.00	79.52	
	UGB-70	2.50	2.50	71.82	FAES 1305	3.75	3.00	55.75	
Oklahoma State University	UGB-79	1.50	1.00	68.24	FAES 1306	3.00	3.00	41.52	
	OSUB11-1	4.50	4.00	86.54	FAES 1307	2.50	1.75	82.49	
	OSUB11-17	3.50	2.75	79.50	DALZ 1310	3.25	2.75	62.12	
	OSUB11-31	6.75	5.75	74.32	DALZ 1311	3.50	3.00	77.09	
	OSUB11-56	3.75	3.00	94.06	DALZ 1312	4.50	3.50	76.61	
	OSUB11-63	3.00	2.25	83.90	DALZ 1313	5.50	4.75	74.01	
	Mean	3.75	3.08	73.76	DALZ 1314	3.00	2.25	61.79	
	Std Error	0.67	0.80	3.23	Mean	0.72	0.71	66.98	
	LSD	2.74			Std Error	2.89	2.87		
		Leaf firing score	Turf Quality score	Shoot Growth Reduction % of control			Leaf firing score	Turf Quality score	Shoot Growth Reduction % of control
St. Augustinegrass ( <i>Stenotaphrum secundatum</i> ) Checks					Seashore Paspalum ( <i>Paspalum vaginatum</i> ) Checks				
Texas A&M AgriLife		Raleigh	0.25	0.25	99.35	Seaside 1	2.50	2.00	49.04
		Floratam	0.75	0.75	97.45	Seaside Star	3.50	2.50	31.46
		Palmetto	0.00	0.00	97.18	UGP 1	4.50	3.75	35.72
		DALSA 1315	0.50	0.50	99.07	UGP 3	5.25	4.75	43.92
		DALSA 1316	0.75	0.75	95.33	UGP 10	2.75	2.25	47.91
		DALSA 1317	0.25	0.25	89.45	UGP 38	2.50	1.75	30.74
		DALSA 1318	0.25	0.25	94.88	UGP 73	3.75	3.25	38.25
		DALSA 1319	1.50	1.50	98.74	Mean	3.54	2.89	39.58
North Carolina State University		NCS-17	1.00	0.75	100.00	Std Error	0.71	0.82	
		NCS-43	0.25	0.25	96.95	LSD	2.95	3.42	
		NCS-45	0.00	0.00	96.24				
		NCS-72	0.25	0.25	100.00				
		NCS-80	0.25	0.25	97.97				
		Mean	0.46	0.44	97.36				
		Std Error	0.36	0.35					
		LSD	1.45	1.40					

Leaf firing (0-9), 0 = completely fired turf and 9 = no leaf firing

Turf quality (0-9), 0 = completely fired turf and 9 = optimum color density and uniformity