Salt Tolerance in Seashore Paspalum

Not all varieties are created equal, research shows

By Paul L. Raymer

Salinity problems have become increasingly more prevalent in managed turfgrass over the last 10 years. Emphasis on water conversation strategies that use non-potable, alternative irrigation sources has been a primary contributor (Marcum, 2004).

Alternative irrigation water sources include recycled water, storm water, saline ground water and seawater blends. Many of these alternative water sources contain much higher salt levels than traditional irrigation waters. The trend for use of more salt-laden irrigation waters on turfgrass sites is expected to continue to rise at a rapid rate and to further increase interest in the use of more salt-tolerant grasses, especially halophytes (Carrow and Duncan, 2005; Lee et al., 2005; Marcum, 2002).

Seashore paspalum, Paspalum vaginatum, is warm-season, halophytic grass that has rapidly gained popularity for use as a fine turf on golf courses and other recreational sites, especially where salt is a problem or irrigation with salt-laden alternative water sources is anticipated (Duncan and Carrow, 2000). Seashore paspalum is considered the most salt-tolerant warm-season turfgrass species and also holds great promise for reclamation and soil stabilization of unmanaged salt-affected sites (Loch et al., 2003).

The existence of salt-tolerant plants (halophytes) and differences in salt tolerance among genotypes within plant species indicates that there is a genetic basis to salt response (Yamaguchi and Blumwald, 2005). Previous research has demonstrated that seashore paspalum ecotypes vary greatly in their level of tolerance to salt (Lee et al., 2004a, Lee et al., 2004b) and range from no better than the best bermudagrass hybrids to highly salt tolerant. Therefore, it is necessary to screen potential seashore paspalum cultivars prior to their release to ensure that they have high levels of salt tolerance. Genetically controlled variability for salt tolerance among genotypes infers that it may be possible to further improve salt tolerance of this species through breeding and selection.

A prerequisite for the development of new cultivars with improved salt tolerance is an efficient and effective salt tolerance screening method suitable for evaluation of large numbers of breeding lines. Such a screening method has been developed at the University of Georgia (Raymer et al., 2005). This screening technique was used to evaluate salt tolerance of 15 genotypes in a replicated greenhouse experiment.

Materials and methods

Three ebb and flow benches were used to provide daily sub-irrigation with a solution containing soluble fertilizer, according to the procedures outlined in Raymer et al., 2005.

The fertilizer solution was monitored weekly using a compact NO_3-nitrate ion meter and maintained between 200 mg and 300 mg per kilogram NO_3 (200 to 300 parts per million). A synthetic sea salt mix was gradually added to individual benches to achieve final salt concentrations of 0, 20 and 40 dS per meter (decisemins per meter, which measures electrical conductivity often used to quantify salinity). Electrical conductivity of the irrigation solution was monitored using a portable pH/conductivity meter equipped with a conductivity electrode.

Six replications of 15 genotypes, including 14 seashore paspalum genotypes and

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TABLE 1

Visual and Growth Responses of Seashore Paspalum Genotypes to Varying Concentrations of Salt.

Genotype	Leaf[1] Firing	Total Clip Wt.	Verdure	Crown & Roots	Total Biomass	Biomass[2] Reduction
	Score	*grams*	*Grams*	*grams*	*Grams*	*%*
Fresh Water						
Adalayd	8.7	1.7	4.9	3.4	10.0	-
Excalibur	8.7	1.6	4.3	3.5	9.3	-
HI 10	8.6	1.9	4.0	3.5	9.4	-
HI 101	8.8	1.9	4.5	3.5	9.8	-
K 3	8.6	1.7	3.8	2.7	8.1	-
KC 8	8.7	2.2	4.5	3.5	10.2	-
SPS K1	9.0	2.1	4.5	3.0	9.6	-
SeaIsle 1	8.6	2.1	5.4	4.3	11.7	-
SeaIsle 2000	9.0	1.7	3.8	4.6	10.1	-
Salam	8.7	1.8	4.3	3.2	9.3	-
SeaSpray	8.8	1.9	4.0	3.4	9.3	-
SeaIsle Supreme	8.9	1.6	4.6	3.4	9.6	-
SI 99	8.6	1.7	4.6	2.8	9.1	-
TifEagle (Cynodon)	9.0	2.2	5.1	5.3	12.6	-
Tropic Shore	8.1	3.1	4.4	3.9	11.3	-
Mean	**8.7**	**1.9**	**4.4**	**3.6**	**10.0**	**-**
LSD 0.05	**0.2**	**0.5**	**0.9**	**0.8**	**1.6**	**-**
Std. Err.	**0.1**	**0.2**	**0.3**	**0.3**	**0.6**	**-**
20 dS m^{-1} Salt						
Adalayd	5.7	1.0	3.4	3.1	7.5	24.6
Excalibur	6.3	0.7	2.7	3.0	6.5	30.1
HI 10	6.2	1.0	3.1	3.2	7.3	22.3
HI 101	6.1	0.8	2.7	3.0	6.5	33.5
K 3	6.9	1.0	2.8	3.4	7.2	11.6
KC 8	6.0	1.3	3.7	3.8	8.8	13.7
SPS K1	7.0	0.9	3.6	3.1	7.6	20.6
SeaIsle 1	6.3	1.0	3.2	3.6	7.8	33.3
SeaIsle 2000	7.2	0.9	3.1	3.7	7.6	24.5
Salam	6.7	0.8	3.4	2.7	6.8	26.6
SeaSpray	6.5	0.9	2.8	2.6	6.3	32.8
SeaIsle Supreme	8.0	1.1	3.6	4.2	8.9	7.2
SI 99	8.1	1.2	4.8	4.2	10.1	-10.9
TifEagle (Cynodon)	5.1	0.8	3.4	3.7	7.8	37.5
Tropic Shore	3.3	1.0	2.1	2.5	5.6	50.3
Mean	**6.4**	**1.0**	**3.2**	**3.3**	**7.5**	**24.7**
LSD 0.05	**0.5**	**n.s.**	**0.9**	**0.8**	**1.2**	**-**
Std. Err.	**0.2**	**0.7**	**0.3**	**0.3**	**0.4**	**-**
40 dS m^{-1} Salt						
Adalayd	3.4	0.5	1.5	2.0	4.0	59.7
Excalibur	3.6	0.6	1.3	2.0	3.9	58.5
HI 10	3.4	0.8	1.5	2.8	5.1	46.2
HI 101	3.7	0.3	1.7	2.8	4.8	51.2
K 3	4.3	0.6	1.9	2.0	4.5	44.9
KC 8	3.6	1.0	2.1	2.7	5.8	43.7
SPS K1	4.3	0.4	1.7	2.0	4.2	56.2
SeaIsle 1	4.5	0.8	2.1	3.4	6.3	46.4
SeaIsle 2000	4.6	0.7	1.6	3.1	5.3	46.8
Salam	3.4	0.4	1.5	2.3	4.1	55.3
SeaSpray	3.9	0.8	1.4	2.5	4.7	49.5
SeaIsle Supreme	6.7	0.7	2.7	4.5	7.9	17.8
SI 99	6.3	0.6	2.4	3.9	7.0	23.3
TifEagle (Cynodon)	2.0	0.5	1.6	3.7	5.8	54.0
Tropic Shore	1.5	0.5	1.4	1.8	3.8	66.9
Mean	**3.9**	**0.6**	**1.8**	**2.8**	**5.1**	**48.4**
LSD 0.05	**0.7**	**0.3**	**1.0**	**0.8**	**1.2**	**-**
Std. Err.	**0.2**	**0.1**	**0.3**	**0.3**	**0.4**	**-**

1. Rated on a 1-9 scale with 9 = no leaf firing. 2. Reduction in total plant biomass when compared to the freshwater treatment. 3. dS m^{-1} (decisemins per meter)

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one ultra-dwarf bermudagrass genotype, TifEagle, were simultaneously evaluated at each of the three salt concentrations.

Ten genotypes previously evaluated for salt tolerance (Lee et al., 2004a, Lee et al., 2004b) and shown to range from sensitive to tolerant were included along with five genotypes with unknown tolerance levels. Plants for evaluation were grown in washed

Large genotypic differences were observed for all traits measured.

play sand in 10 centimeter pots on the ebb and flow tables and maintained by daily sub-irrigation with fertilizer solution for 30 days prior to initiating salt treatments.

After the 30-day grow-in period, all plants were clipped to a standard height of one-half inch and salt concentration increased in 6 dS per meter steps at four-day intervals until target concentrations were reached. All tables were sub-irrigated simultaneously using a single electronic timer. Sub-irrigation frequency was once per day for the first three weeks of the experiment and increased to twice per day thereafter. After reaching target salt concentration, all plants were scored for leaf firing and clipped to determine top growth dry weight at two-week intervals.

After six weeks at the target salt concentrations, plants were harvested, washed free of sand and verdure, and crown/root dry weights were determined.

Results

Large genotypic differences were observed for all traits measured (Table 1). Higher ratings of visual appearance of turf quality (presented as leaf firing ratings) and higher biomass production (clip weight,

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verdure weight, crown and root weight, and total biomass weight) are positive indicators of salt tolerance. Salt- tolerant cultivars are expected to have the ability to maintain growth and thereby have minimal reduction in total biomass when exposed to salt. The salt treatments used in this experiment were 20 and 40 dS per meter. As a reference, consider that the salinity level of ocean water is approximately 54 dS per meter.

At the moderate salt level of 20 dS per meter, leaf firing ratings averaged 6.4 for all genotypes tested, and ranged from 8.1 for the variety SI 99 to 3.3 for the salt-sensitive line, Tropic Shore. Total biomass values averaged 7.5 grams for all entries and ranged from a high of 10.1 grams for SI 99 to a low of 5.6 grams for Tropic Shore. SI 99 and SeaIsle Supreme formed the top statistical group at 20 dS per meter.

At the higher salt level of 40 dS per meter, leaf firing ratings averaged only 3.9 for all genotypes tested, and ranged from 6.7 for SeaIsle Supreme to 1.5 for the salt-sensitive line, Tropic Shore. Total biomass values averaged 5.1 grams for the 15 entries and ranged from a high of 7.9 grams for SeaIsle Supreme to a low of 3.8 grams for Tropic Shore. SI 99 and SeaIsle Supreme were in the top statistical group for all traits measured at 40 dS per meter. When the total biomass produced at 40 dS per meter was compared to that produced under freshwater conditions, biomass reductions for the 15 genotypes tested averaged 48.4 percent. The paspalum genotypes Adalayd, Excalibur, Salam and Tropic Shore as well as TifEagle bermudagrass all had biomass reductions of greater than 50 percent at the 40 dS per meter level.

In contrast, the total biomass values of SeaIsle Supreme and SI 99 were reduced by 17.8 percent and 23.3 percent, respectively.

In summary, two new genotypes, SeaIsle Supreme and SI 99, with salt tolerance levels superior to any previous reports were identified. SeaIsle Supreme was released by the Georgia Experiment Stations in 2004 and is now available for commercial sale by licensed growers.

Discussion

The genotypic variability among ecotypes demonstrated in this experiment combined with the development of a screening method to efficiently identify ecotypes with superior salt tolerance offers great promise for continued improvement of the level of salt tolerance within this halophytic species.

In our breeding program, we plan to exploit the observed genetic variability by recombining superior genotypes and selecting for further improvements in salt tolerance. Breeding efforts will be focused on development of cultivars for use as fine turf as well as on the development of cultivars for use in forage production and stabilization of salt affected areas.

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REFERENCES

Carrow, RN and RR Duncan. 2005. Salinity and Turfgrasses: Issues and Research Status. Proc. Inter. Salinity Forum. 25-27 April, 2005. Riverside, CA.

Duncan, RR and RN Carrow. 2000. Seashore Paspalum—The Environmental Turfgrass. John Wiley and Sons Inc., Hoboken, NJ.

Loch, DS, E. Barrett-Lennard, and P. Truong. 2003. Role of salt tolerant plants for production, prevention of salinity and amenity values. Proc. of 9th National Conf. of Productive Use of Saline Lands (PUR$L). 29 Sept.-Oct. 1, Rockhampton, QLD, Australia

Lee, G., RN Carrow, and RR Duncan. 2004a. Salinity tolerance of selected seashore paspalums and bermudagrasses: root and verdure responses and criteria. HortSci. 39(5):1143-1147.

Lee, G., RR Duncan, and RN Carrow. 2004b. Salinity tolerance of seashore paspalum ecotypes: shoot growth responses and criteria. HortSci. 39(5): 1138-1142.

Lee, G., RR Duncan, and RN Carrow. 2005. Criteria for assessing salinity tolerance of the halophytic turfgrass seashore paspalum (Paspalum vaginatum). Crop Sci. 45:251-258.

Marcum, KB. 2002. Growth and physiological adaptations of grasses to salinity stress. In M. Pessaraki (ed.) Handbook of Plant and Crop Physiology: 623-626. Marcel Dekker, NY.

Marcum, KB. 2004. Use of saline and non-potable water in the turfgrass industry: Constraints and developments. Proc. 4th International Crop Science Congress. Brisbane, Australia, 26 Sep-1 Oct 2004. www.cropscience.org.au.

Raymer, PL, RN Carrow, and DA Wyatt. 2005. Screening for salt tolerance in seashore paspalum. Proc. Inter. Salinity Forum. 25-27 April, 2005. Riverside, CA. p. 129-133.

Yamaguchi, T., and E. Blumwald. 2005. Developing salt-tolerant crop plants: challenges and opportunities. Trends in Plant Sci. 10:12 p. 615-620.