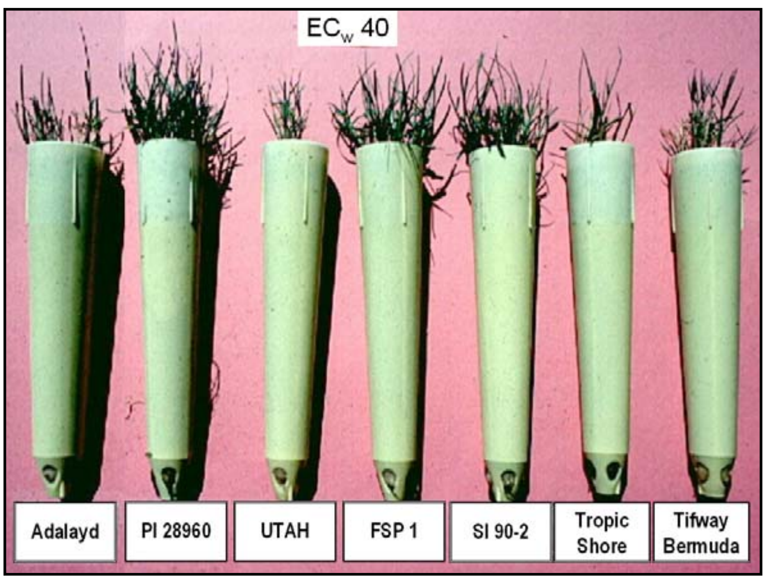
USGA

Turfgrass and Environmental Research Online

...Using Science to Benefit Golf



University of Georgia researchers are developing selections of seashore paspalum that are significantly more salt tolerant than bermudagrass.

Volume 1, Number 11
August 1, 2002

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 215 projects at a cost of $21 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

Editor

Jeff Nus, Ph.D.
904 Highland Drive
Lawrence, KS 66044
jnus@usga.org
(785) 832-2300
(785) 832-9265 (fax)

Research Director

Michael P. Kenna, Ph.D.
P.O. Box 2227
Stillwater, OK 74076
mkenna@usga.org
(405) 743-3900
(405) 743-3910 (fax)

USGA Turfgrass and Environmental Research Committee

Initial Selection of Salt-tolerant Seashore Paspalum Ecotypes

Geungjoo Lee, Ronny. R. Duncan, and Robert. N. Carrow

SUMMARY

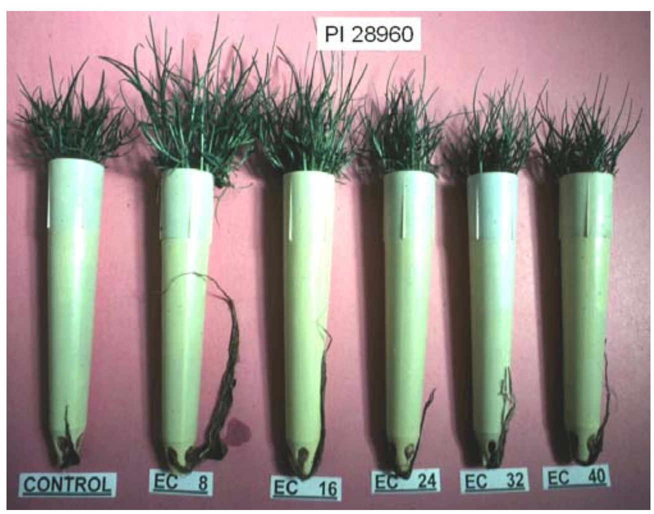
- Global water scarcity demands use of alternative water resources, and on turf, this means poor quality water with some level of salt stress (growth reduction, ion toxicity, soil degradation).
- Development of salt tolerant turfgrass cultivars is an important long-term management strategy for salt-affected sites.
- Ninety-four seashore paspalum ecotypes and four hybrid bermudagrass cultivars were screened in solution/sand culture system.
- Diverse salt tolerance (most tolerant were SI 93-1 and SI 93-3 and least tolerant was Adalayd) was found and bermudagrass cultivars generally exhibited significantly less salt tolerance than seashore paspalum.
- Salt tolerance evaluation for halophytic turfgrasses should include actual growth measurements for shoot, root, and total growth parameters at 0 and >35 dSm^{-1} salinity ranges.
- Site-specific integrated salinity management protocols must be developed in concert with cultivar development programs.

Global issues of water quality and quantity are becoming increasingly important. In turfgrass areas, good quality and ample water resources have decreased over the last decade due to priority allocation to urban sites and extreme climatic changes (temperature increases, unexpected periodic and prolonged drought seasons). Use of low quality water is an alternative source and can include drainage water, saline groundwater, and recycled water. When seawater is included with these alternative resources, they encompass more than 98 % of the total global water supply (5). The use of marginal quality water is directly related to salinity problems from accumulation of total salts or toxic salt ions, which leads to decline of turf growth and eventually soil degradation (1).

GEUNGJOO LEE, Ph. D. (joo@arches.uga.edu) is a postdoctoral associate, Dept. of Crop and Soil Sciences, Univ. of Georgia, Athens, GA 30602; RONNY R. DUNCAN, Ph.D. (rduncan@gaes.griffin.peachnet.edu) and ROBERT. N. CARROW, Ph.D. (rcarrow@gaes.griffin.peachnet.edu) are professors, Dept. of Crop and Soil Sciences, Univ. of Georgia, Georgia Experimental Station, Griffin, GA 30223-1797.

One way to alleviate salt stress is to develop turfgrass cultivars with enhanced salt tolerance. Application of site-specific management protocols on salt-affected areas is also necessary for both short- and long-term water conservation strategies. The University of Georgia turf team where Drs. Ronny Duncan and Robert Carrow are principle researchers has contributed to development of salt management packages through comprehensive communication such as books (1, 4), articles (2, 3, 5, 6, 8), educational management workshops at various turfgrass conferences, and websites (www.georgiaturf.com/seashorepaspalum and www.seaisle1.com).

Seashore paspalum ecotypes were evaluated under salt regimes, because fine-textured seashore paspalum (SP; *Paspalum vaginatum*) cultivars exhibit better salinity tolerance than any other warm season turfgrasses (1).



Salt tolerance evaluation for halophytic turfgrasses should include actual growth measurements for shoot, root, and total growth parameters at 0 and >35 dSm-1 salinity ranges.

Glossary

EC_e = a measure of soil salinity based on the electrical conductivity of a saturated soil paste extract. This value is used to classify salt-affected soils and to rank salinity tolerance of plants. Units are usually dSm^{-1} (decisiemens per meter).

1 dSm^{-1} = 1 mmhos cm^{-1} = 1000 micromhos cm^{-1} = 0.1 Sm^{-1}

EC_w= Electrical conductivity of irrigation water as a measure of total soluble salts. Seawater is 54 dSm^{-1}.

Threshold EC_e = The EC_e at which growth starts to decline in response to increasing salinity. For halophytes, maximum growth occurs at threshold EC_e. Unit is usually dSm^{-1}.

Leaf firing (LF) = the percentage of leaves exhibiting visual symptoms of chlorosis or actual tissue desiccation.

Issues on assessment of salinity tolerance

Two essential parameters for evaluation of salt tolerance have traditionally been used: (a) soil threshold electrical conductivity (EC_e) (the maximum allowable soil salinity level without yield reduction relative to growth vs. a nonsaline control), and (b) growth reduction (%) per unit salinity increase or the slope of the relative growth curve (9). Based on this concept, Type 2 plants (moderately tolerant glycophyte) exhibit higher salinity tolerance than Type 1 plants (salt-sensitive glycophyte) since a Type 2 plant has a higher threshold EC_e (dSm^{-1}) and less growth reduction (Fig. 1).

This method has been applied in the evaluation of relative salt tolerance among various crops species (which are almost always Type 1 or Type 2 plants). Most crops have been screened under limited (EC_e <30 dSm^{-1}) salinity levels, which is essentially a glycophytic or salt-sensitive plant growth response. This plant group seldom grows well at ECe > 20 dSm^{-1} (i.e. ocean water EC_w=54 dSm^{-1}). Assessment of salinity tolerance for halophytic (salt-tolerant) seashore paspalum turfgrasses (Type 3 in Fig. 1) should be conducted using new criteria (7). From the perennial turfgrass viewpoint, maintenance of high relative growth rates with increasing salinity levels (EC_e >30 dSm^{-1}) can provide acceptable recoverability from traffic or other injuries since these plants maintain more shoot photosynthetic area and higher carbohydrate storage.

The objectives of this study were: (a) to evaluate the salinity tolerance of seashore paspalum (SP) ecotypes compared to selected bermudagrasses, and (b) to develop selection criteria for classification of high salinity tolerance among all turfgrasses.

Materials and Methods

Ninety-four seashore paspalum (SP) ecotypes plus four bermudagrass cultivars ('Tifgreen', 'Tifway', TifSport', 'TifEagle') were initially evaluated in Griffin, GA in 1997. After each entry was uniformly established as five-cm diameter plugs in 20-cm deep cone-shaped pots filled with sand, they were immersed up to the turfgrass crown in a non-saline nutrient solution for maximum root volume establishment. Salt mixtures were gradually added every day to the solution to achieve selected salinity levels based on electrical conductivity of water (EC_w)=1, 9, 17, 25, 33, and 41 dSm^{-1} and to facilitate the grasses slowly adapting to increasing salinity levels. The nutrient solutions were aerated continuously, changed weekly, and maintained at a constant volume.

Shoot clippings were collected three times every two weeks. Crown (crown plus stem up to 2.5 cm mowing height) and root tissues were also harvested at the end of experiment. The tissues were dried at 70C for 48 hrs and weighed. Those shoot, crown, and root tissues were combined to determine total plant biomass yield.

The proposed criteria to assess salinity tolerance of halophytic seashore paspalums included: (a) absolute shoot, root and total yield (g dry weight) at EC_w of 1, 25, 33, and 41 dSm^{-1}; (b) threshold ECw (dSm^{-1}) for shoot, root, and total yield and the maximum total biomass yield at that salinity level, (c) shoot and root $EC_w25\%$ indicating salinity level for 25% growth reduction compared to the growth at the non-saline EC_w1, and (d) shoot leaf firing at $EC_w=41dSm^{-1}$. One approach to evaluate relative salinity tolerance among these grasses was to include all measured traits and to determine the frequency in the top (best) statistical ranking for the parameters exhibiting a significant F-test.

Result and Discussion

Shoot, root, and total growth responses of five seashore paspalum ecotypes and two bermudagrasses to increasing salinity levels are presented in Tables 1, 2, and 3, respectively. Salinity tolerance responses were very diverse among ninety-eight entries (94 seashore paspalums and four bermudagrasses). Most shoot, root, and total growth parameters exhibited a significant F-test among 98 grass entries except for threshold EC_w (Table 1, 2, and 3). Growth responses of salt-tolerant seashore paspalum SI

	Shoot yield (g dry weight)							
Grass	EC_w1	EC_w25	EC_w33	EC_w41	**Threshold EC_w** (dSm^{-1})^z	**$EC_w25\%$** (dSm^{-1})^y	**Leaf firing at EC_w41** (%)^x	**Times in top ranking**§
SI 93-1	0.71	0.56	0.48	0.30	9 (0.90)	18	9	6/6
SI 93-3	0.43	0.51	0.43	0.30	10 (0.71)	24	8	5/6
Sea Isle 2000	0.61	0.42	0.39	0.26	6 (0.83)	14	8	2/6
Sea Isle 1	0.70	0.45	0.42	0.22	11 (0.80)	17	9	4/6
Tifgreen	0.20	0.21	0.25	0.13	6 (0.33)	12	33	0/6
Tifway	0.11	0.23	0.13	0.09	7 (0.23)	12	36	0/6
Adalayd	0.24	0.11	0.10	0.08	4 (0.26)	8	25	0/6
LSD (.05)	0.25	0.14	0.12	0.08	7	9	7	-
F-test	***	***	***	***	0.39	†	***	-

^{z} Threshold ECw indicating the maximum allowable salinity level without growth reduction compared to growth at the nonsaline control. The value in parenthesis, therefore, represents the maximum shoot growth in g dry weight.

^{y} ECw 25% is the salinity level exhibiting 25 % growth reduction from the growth with EC_w1 (control).

^{x} Leaf firing is the percentage of leaves exhibiting visual symptoms of chlorosis or actual tissue desiccation at EC_w41dSm^{-1}.

§ denotes the numbers of times for a ecotype ranked in the highest (best) statistical category.
*** and † significant differences among 98 entries at the 0.001 and 0.10 probability levels, respectively.

Table 1. Shoot yield, threshold EC_ws, leaf firing to threshold EC_w, $EC_w25\%$, and number of times in the top statistic categories for five seashore paspalums and two bermudagrasses.

Grass	Root yield (g dry weight) EC_w1	EC_w25	EC_w33	EC_w41	Threshold EC_w (dSm^{-1})[z]	EC_w 25% (dSm^{-1})[y]	Times in top ranking §
SI 93-1	0.60	0.37	0.44	0.48	6 (0.67)	32	3/5
SI 93-3	0.40	0.44	0.40	0.39	9 (0.52)	36	4/5
Sea Isle 2000	0.40	0.31	0.50	0.36	7 (0.54)	34	2/5
Sea Isle 1	0.42	0.32	0.42	0.32	4 (0.49)	36	2/5
Tifgreen	0.30	0.26	0.27	0.24	5 (0.36)	38	1/5
Tifway	0.22	0.35	0.29	0.23	10 (0.42)	39	1/5
Adalayd	0.20	0.11	0.13	0.13	5 (0.21)	25	0/5
LSD (.05)	0.15	0.11	0.12	0.11	8	12	-
F-test	***	***	***	***	0.83	***	-

[z] Threshold ECw indicating the maximum allowable salinity level without growth reduction compared to growth at nonsaline control. The value in parenthesis, therefore, represents the maximum shoot growth in g dry weight.

[y] EC_w 25% is the salinity level exhibiting 25 % growth reduction from the growth with EC_w1 (control).

§ denotes the numbers of times for a ecotype ranked in the highest (best) statistical category.

*** significant differences among 98 entries at the 0.001 probability levels.

Table 2. Root yield, threshold EC_ws, EC_ws causing 25% root growth reduction, and number of times in the top statistical category for five seashore paspalums and two bermudagrasses.

Grass	Total yield (g dry weight) ECw1	ECw25	ECw33	ECw41	Threshold EC_w (dSm^{-1})[z]	EC_w 25% (dSm^{-1})[y]	Times in top ranking §
SI 93-1	2.23	1.69	1.64	1.63	9 (2.52)	35	4/5
SI 93-3	1.44	1.81	1.48	1.42	10 (2.00)	36	3/5
Sea Isle 2000	1.92	1.51	1.64	1.17	7 (2.18)	36	1/5
Sea Isle 1	1.82	1.56	1.75	1.36	6 (2.11)	35	4/5
Tifgreen	1.10	0.89	1.04	0.85	7 (1.29)	29	0/5
Tifway	0.72	1.02	0.84	0.73	9 (1.07)	34	1/5
Adalayd	1.00	0.55	0.54	0.52	4 (1.06)	18	0/5
LSD (.05)	0.54	0.44	0.37	0.32	8	12	-
F-test	***	***	***	***	0.41	***	-

[z] Threshold EC_w indicating the maximum allowable salinity level without growth reduction compared to growth at nonsaline control. The value in parenthesis, therefore, represents the maximum shoot growth in g dry weight.

[y] ECw 25% is the salinity level exhibiting 25 % growth reduction compared to the growth with EC_w1 (control).

§ denotes the numbers of times for a ecotype ranked in the highest (best) statistical category.

*** significant differences among 98 entries at the 0.001 probability levels.

Table 3. Total yield (shoot + root + crown), threshold EC_ws, EC_ws causing 25% total yield reduction, and number of times in the top statistical category for five seashore paspalums and two bermudagrasses.

93-1 showed a yield increase with increasing salinity up to the threshold EC_w (Fig. 2).

High inherent growth rate (growth at EC_w1 or no salinity) was an important selection parameter for high salt tolerance capabilities. Among 98 entries, five seashore paspalums remained in the highest EC_w41 group out of the sixteen seashore paspalums in the top statistical ranking of shoot growth at EC_w1 and four out of nine in root growth (data not shown). Since enhanced growth occurs at the moderate salinity levels (EC_w 10 to 30 dSm^{-1}) in halophytes, growth at EC_w25 and EC_w33 was considered. The more salinity tolerant SI 93-1 and SI 93-3 had the highest shoot, root, and total growth across all salinity levels (Tables 1, 2, and 3).

Threshold EC_w values with nonsignificant F-tests were not included in evaluations of the top statistical categories. However, these maximum potential yield values can be used for determining leaching requirements of saline irrigation water (1, 3). In the study, 25% growth reduction occurred around EC_w20 dSm^{-1} for shoot and > EC_w33 dSm^{-1} for root and total growth (Tables 1, 2, and 3).

The more salinity tolerant SI 93-1 and SI 93-3 seashore paspalums exhibited <10 % leaf firing at the highest EC_w41 dSm^{-1}. Leaf firing (leaf chlorosis and necrosis) at EC_w41 indicated the tolerant seashore pasplums (SI 93-1, SI 93-3, Sea Isle 2000, Sea Isle 1) maintained shoot density and chlorophyll concentration at 80 % of seawater salinity (54 dSm^{-1}; Table 1).

After assessing yield results from different tissue parts, the most tolerant ecotypes were SI 93-1 and SI 93-3, followed by Sea Isle 1 and Sea Isle 2000 (within the intermediate group).

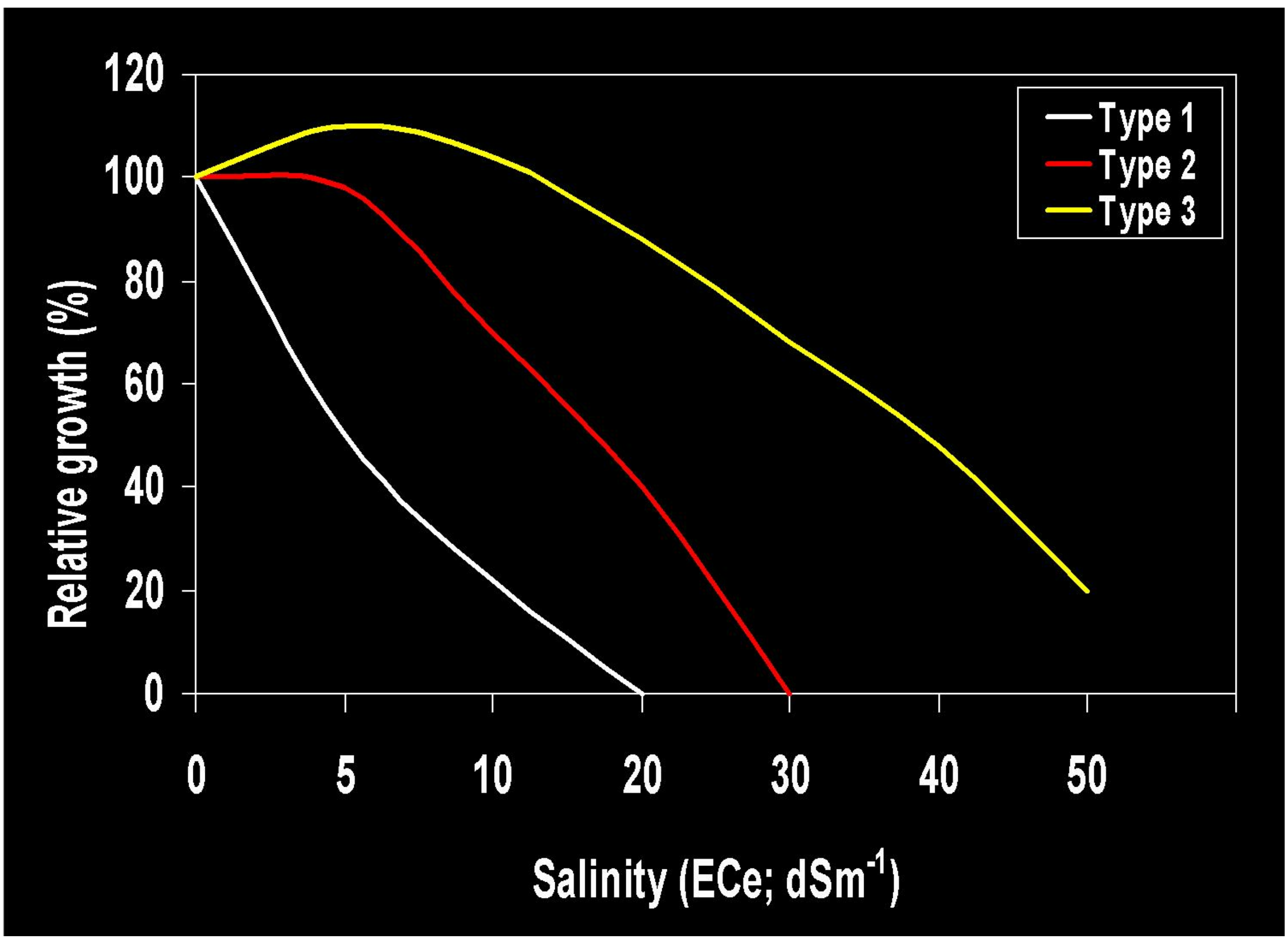


Figure 1. Growth response curves to determine salinity tolerance of agronomic crop plants (Type 1 or Type 2) and salt-tolerant halophytes (Type 3).

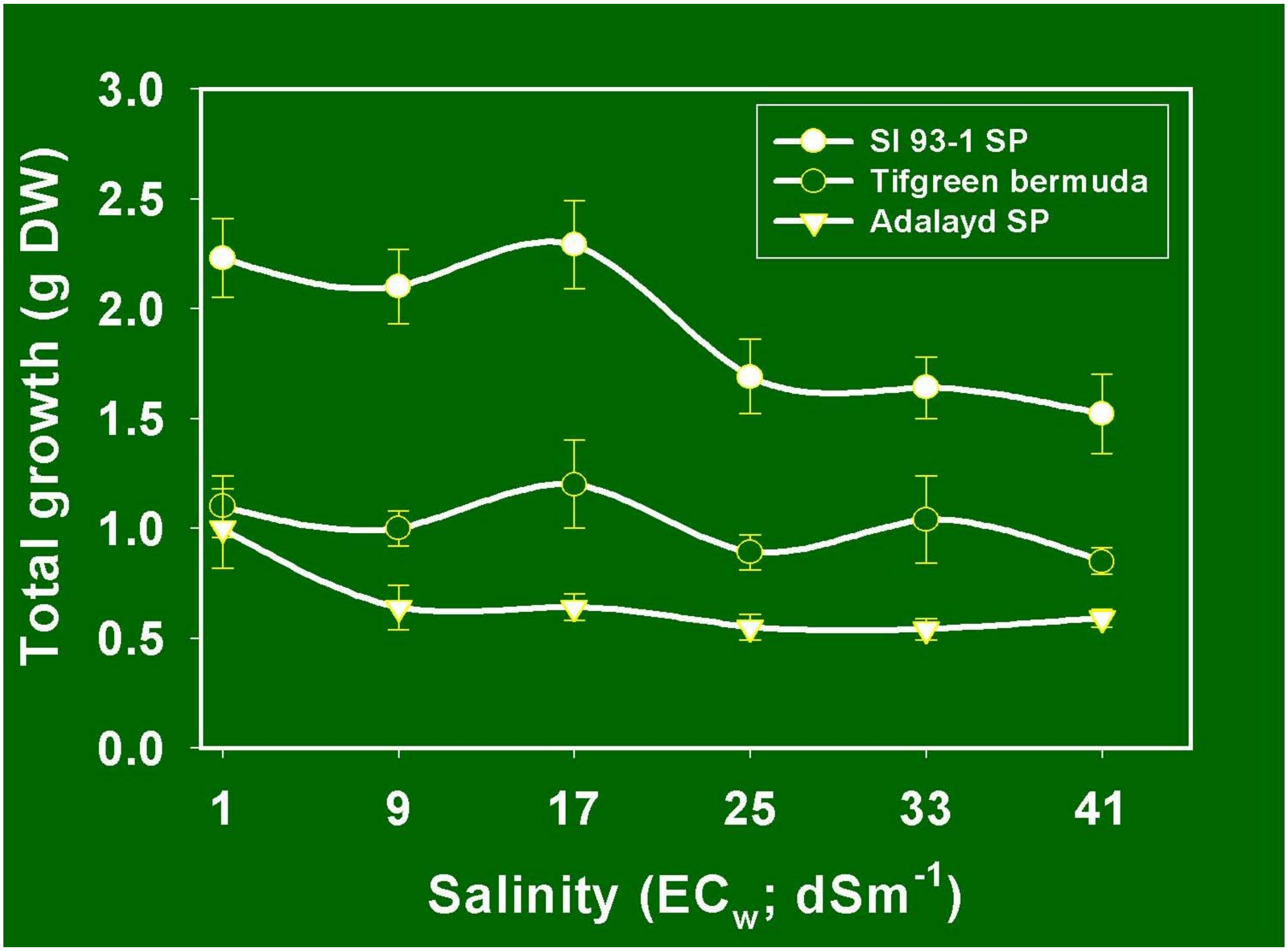


Figure 2. Newer selections of seashore paspalum (e.g., SI 93-1) are more salt tolerant than Tifgreen bermudagrass and Adalayd seashore paspalum (an older cultivar). Bars represent standard errors of the mean (n=6).

Adalayd SP and two bermudagrass cultivars (Tifgreen and Tifway) exhibited the lowest salt tolerance. A diverse range of salinity tolerance was exhibited across all 94 seashore paspalum entries.

Evaluation of overall salinity tolerance among turfgrass cultivars revealed that absolute growth at EC_w1 (nonsaline condition) and at the highest salinity level (EC_w41) for shoot, root and total grass parts should be evaluated. Percentage of leaf injury (leaf firing at EC_w41) could also provide salinity assessment information. The lowest salinity tolerant seashore paspalum (i.e., Adalayd) and both bermudagrasses tolerated up to 10 to 15 dSm^{-1} and the most tolerant seashore paspalum ecotypes (i.e., SI 93-1, SI 93-2, SI 93-3) exhibited good turf quality and growth at >30 to 35 dSm^{-1}. The improved seashore paspalum ecotypes had more salinity tolerance than any of the bermudagrasses (Tifgreen, Tifway, TifEagle, Tifsport) (Tables 1, 2, and 3; Fig. 1). The less salinity tolerant grasses assessed in this study still rank as very tolerant by the traditional evaluation method outlined by Maas and Hofmann (9).

Regardless of salt-tolerance level in turfgrass cultivars, successful long- term management programs must include a comprehensive management strategy to minimize buildup of excess salts in the soil profile. The most fundamental checkpoints to properly manage grasses subjected to long term salinity stress include soil physical information (fine or coarse type, soil profile), irrigation water quality (chemical and biological), an appropriate leaching program (adequate percolation), and good nutrition management.

Acknowledgments

Funding from the U.S. Golf Association and Georgia Turfgrass Foundation Trust is gratefully acknowledged.

Literature Cited

1. Carrow, R.N., and R.R. Duncan. 1998. Salt-affected turfgrass sites: assessment and treatment. Ann Arbor Press, Chelsea, MI. 185p. (TGIF Record 43045)

2. Carrow, R.N., R.R. Duncan, and M. Huck. 1999. Treatment the cause, not the symptoms. Irrigation water treatment for better infiltration. *USGA Green Section Record* 37(6):11-15. (TGIF Record 62493)

3. Carrow, R.N., M. Huck, and R.R. Duncan. 2000. Leaching for salinity management on turfgrass sites. *USGA Green Section Record* 38 (6):15-24. (TGIF Record 70760)

4. Duncan, R.R., and R.N. Carrow. 2000. Seashore Paspalum: The Environmental Turfgrass. Ann Arbor Press. Chelsea, MI. 281p. (TGIF Record 64879)

5. Duncan, R.R., R.N. Carrow, and M. Huck. 2000. Effective use of seawater irrigation on turfgrass. *USGA Green Section Record* 38 (1):11-17. (TGIF Record 63021)

6. Duncan, R.R., R.N. Carrow, and M. Huck. 2000. Understanding water quality and guidelines to management. An overview of challenges for water usage on golf courses for 21st century. *USGA Green Section Record* 38(5):14-24. (TGIF Record 68198)

7. Lee, G. J. 2000. Comparative salinity tolerance and salt tolerance mechanisms of seashore paspalum ecotypes. PhD Dissertation (Abstract No. AAT9994109). The University of Georgia. 264p. (TGIF Record 78711)

8. Lee, G.J., R.R. Duncan, and R.N. Carrow. 2000. Salinity tolerance of *Paspalum vaginatum* and *Cynodon spp.* genotypes. *Aust. Turf. Management* 2(3):30-32. (TGIF Record 65750)

9. Maas, E.V., and G. J. Hoffman. 1977. Crop salt tolerance-current assessment. *J. Irrig. Drainage* Div., ASCE 103 (IR2); 115-134.