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Saltgrass (*Distichlis spicata*) Project Addition - Greenhouse Tests for Relative Salinity and Drought Tolerance

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EXECUTIVE SUMMARY

Desert saltgrass (*Distichlis spicata* ssp. *stricta*), native to the Sonoran and Mohave deserts of U.S., thrives in extremely dry, saline environments, including saline and alkali salt flats. Having growth characteristics similar to bermudagrass, the species has potential for development into an alternative turfgrass for dry or saline areas, or when saline water sources are used for irrigation. Twenty one desert saltgrasses, selected for their turf characteristics, have been evaluated for salinity tolerance, relative to Midiron bermudagrass. Salinity stress imposed on plants varied from none (control) to over 71,000 ppm (full strength sea water is approximately 35,000 ppm). Overall, desert saltgrass was much more salt tolerant than the bermudagrass entry. Some saltgrass entries were truly halophytic (salt loving), surviving, and maintaining a green leaf canopy at the highest salinity level. The best saltgrass accessions were: A-55, A-48, and A-57. However, other saltgrasses were much more salt-sensitive, closer in fact to the salinity tolerance of Midiron bermudagrass, which did not survive under the higher salinity stress levels in this experiment. The least salt tolerant saltgrass entries were: C-92, C-11, A-51, C-12, A-61, C-66, and C-10. Desert saltgrass has great potential for development as an alternative turfgrass for use in saline areas, or with saline irrigation water. Some turf-type accessions are extremely salt tolerant, able to thrive in full strength seawater.

RESEARCH PROGRESS

Twenty one saltgrass accessions (7 Colorado, 14 Arizona lines) are being field-evaluated for turfgrass characteristics, and also for environmental stress (salinity and drought) tolerance. Environmental stress (salinity and drought) responses are being evaluated in controlled environment greenhouses at the U.A. Plant Sciences Greenhouse Facility. The 21 saltgrass accessions are as follows:

Arizona lines:	A-40, A-41, A-48, A-51, A-53, A-55, A-61, A-65, A-72, A-77, A-86, A-119, A-137, and A-138.
Colorado lines:	C-8, C-10, C-11, C-12, C-56, C-66, and C-92.

Hybrid bermudagrass (*Cynodon dactylon x C. transvaalensis* cv. Midiron) has also been included as a standard entry in all environmental stress tolerance experiments.

A) Salinity tolerance

Rhizome sections of these 22 entries (21 saltgrass accessions + Midiron bermudagrass) were planted on March 22, 1999 into 2.5 inch diameter pots filled with coarse, acid-washed silica sand. Pot bottoms consisted of coarse nylon screen, allowing roots to grow into hydroponics nutrient solutions. Grasses were initially established under mist, then pots were suspended over tubs containing 25 L of constantly aerated ½ strength Hoaglands #2 solution, modified with EDDHA chelate. Each entry was replicated four times in a randomized block experimental design. Treatment design consisted of a split plot, with salinity level the main effect and turfgrass entry the sub-effect.

To ensure development of mature plants, turfgrasses were allowed to grow in hydroponics for 3 months prior to initiation of salinity treatments. Throughout establishment and during experiments, saltgrasses were trimmed at 3 inches, and Midway at 1.5 inches. Salinity treatments began on June 7, 1999. One week prior to that, all roots extending into hydroponics solutions were trimmed to pot bases, which allowed monitoring of root elongation and depth during salinity stress.

Salinity was gradually raised in treatment tubs by 40 mM per day (30 mM NaCl, 10 mM $CaCl_2$). At each 200 mM level, tubs were held for three days to allow plants to equilibrate, then harvests and other data were taken. Treatment levels were 200, 400, 600, 800, and 1000 mM (14325, 28650, 42975, 57300, and 71625 ppm). For comparison, full strength seawater is approximately 35000 ppm.

Control plants (non-salinized) were measured for all variables along with treatment plants, allowing measurement variables to be expressed on a relative basis ($x_{salinized}$ / $x_{control}$ X 100). Data variables taken were as follows:

Percent green leaf canopy area (visual turf quality)- at each salinity level
Leaf clipping dry weight - at each salinity level
Root length (depth) - at each salinity level
Total root dry weight - end of experiment

B) Drought tolerance

A competitive soil moisture dry-down technique, originally developed for turfgrass by Dr. Richard White at Texas A&M University is being utilized to screen the 21 saltgrass entries, along with Midiron bermudagrass, for drought tolerance. I thank Dr. White for his advise in setting up our experimental protocol.

Rhizome sections of the 22 entries were planted into 2.5 inch diameter X 5 inch deep PVC pipes filled with medium grade fritted clay on January 11, 2000. Plants were initially established under mist, and then grasses, including PVC pipes were planted into large, 1.5 ft. diameter X 2.5 ft. deep metal cans filled with medium grade fritted clay on March 21, 2000. All 22 entries were planted into a single metal can, comprising one replicated block. There are four replicated blocks in the experiment. Data taken will include:

Percent green leaf canopy area (indicator of turfgrass quality)
Percent leaf curling
Relative clipping dry weight
Shoot osmotic adjustment

For the soil moisture dry-down technique to work properly, turfgrass roots must have totally filled the containers (cans must be root-bound). This required long-term establishment. Throughout establishment, turfgrasses were fed with ½ strength Hoagland's #2 solution once per week, and clipped weekly at 3 inches (saltgrasses) or 1/5 inches (bermudagrass).

Initial osmotic potential measurements were made on October 5, 2000. Shoot samples of each pot (entry & rep) were taken and immediately sealed in water vials and transported to the lab. To allow measurement of osmotic potential at full turgor, tissue was allowed to fully hydrate in a lighted refrigerator. Sap was extracted, and osmotic potential subsequently measured with a vapor pressure osmometer. Osmotic adjustment will soon be measured again on the same plants during a period of severe drought stress.

Following initial osmotic potential measurement, water was withheld for initial drought acclimation, beginning November 20, 2000. Plants are now being watched closely. When initial leaf curling/wilt is noted, rootzones (cans) will be recharged with water, and dry-down will begin. Data (above) will be taken during dry-down. When stress reaches a moderate level, indicated by leaf curling, final osmotic potential measurements will be made. Osmotic adjustment is equal to (final/initial osmotic potential) X 100.

RESULTS

A) Salinity tolerance

Turfgrass quality and green leaf area declined as salinity level increased. Figure 1 shows the responses of six representative entries, including the best (A-55) and worst (Midiron). All saltgrass accessions were more salt tolerant than Midiron, though there was a large range in salt tolerance among accessions (Table 1). Green leaf area among saltgrass lines ranged from 81% in A-55 to 11% in C-91. In contrast, Midiron was completely dead (0% green) at this salinity.

Relative leaf clipping dry weight declined as salinity level increased. Figure 2 shows the responses of six representative entries. Once again, Midiron was least salt tolerant, with death occurring under moderate salinity. In contrast, all saltgrass accessions remained alive at the highest salinity level. However, differences in relative clipping dry weights were relatively slight, compared to the large differences noted for green leaf area (Table 1). This was perhaps due to the slow growth rate observed in saltgrass. Though differences in growth rate were slight, there were large differences in green leaf area, and resulting turf quality and survival.

Rooting depth increased under moderate salinity, relative to control, in several saltgrasses and also slightly in Midiron (Figure 2). However, there was a general decrease in rooting depth with increasing salinity. Entries with deep roots at high salinity included A-42, C-91, and A-53 (Table 2). However, root weight was greater at high salinity than control plants in nearly half of saltgrass lines, but not in Midiron bermudagrass (Table 2). This increase in root mass, relative to control, in salt-stressed plants is commonly found in halophytic (salt loving) plants.

Although there was not a strong relationship between shoot growth (relative leaf clipping dry weight) and percent green leaf area, there was a slightly significant correlation between them across all salinities (Table 3). There was also a slight correlation between relative leaf clipping dry weight and rooting depth. However, there was no correlation between rooting variables depth and relative dry weight.

The data reveals that saltgrass is more salt tolerant than Midiron bermudagrass. Further, there are large differences in salt tolerance among saltgrass accessions, the more tolerant of which are truly halophytic. Other saltgrass accessions studied are more salt-sensitive, being closer to bermudagrass in salt tolerance.

B) Drought tolerance

Unfortunately, the drought tolerance work is not yet completed. However, the experiment has begun (after a long establishment period), and data collection will begin next month. All data collection will be finished within 6 to 8 months, and a final report will be sent to the USGA at that time.

Table 1. Percent green leaf canopy (% Green Leaf) and relative leaf clipping dry weight (Leaf D.W.)† of twenty one desert saltgrass accessions and 'Midiron' bermudagrass at 71,625 ppm total salinity.

Entry	% Green Canopy	Relative Clipping Wt.
A-55	81	3.1
A-48	77	1.8
A-77	70	3.6
A-138	66	1.4
A-137	62	2.5
A-40	52	2.4
A-119	48	3.0
A-65	47	3.1
A-53	46	2.3
A-86	40	1.5
A-41	38	3.2
C-8	38	2.5
C-56	32	2.7
A-72	27	1.5
C-10	20	2.2
C-66	17	3.0
A-61	17	3.0
C-12	15	2.5
A-51	15	8.2
C-11	12	3.9
C-92	11	4.9
Midiron	0	0.0
$LSD_{0.05}$	14	2.2

†Relative leaf clipping dry weight = (salinized treatment value ÷ control treatment value) x 100.

Table 2. Relative root dry weight and relative rooting depth of twenty one desert saltgrass accessions and 'Midiron' bermudagrass at 1000 m*M* total salinity. Relative variables are percentages: (salinized treatment value ÷ control treatment value) x 100.

Entry	Root Wt.	Root Depth
A-65	211	65
C-10	140	69
A-53	127	86
C-92	126	87
A-41	122	97
A-72	119	68
A-86	117	75
A-55	114	54
A-138	102	67
C-66	99	71
A-51	98	64
C-12	95	63
A-77	95	52
C-56	91	81
C-11	85	64
A-137	80	57
A-40	80	72
Midiron	75	81
A-119	72	53
A-48	72	57
C-8	70	56
A-61	63	47
$LSD_{0.05}$	70	20

Table 3. Pearson correlation coefficients, across all salinities, for percent green leaf canopy (GL), relative leaf clipping dry weight (LW), relative rooting depth (RD), and relative root dry weight (RW), of twenty one desert saltgrass accessions and 'Midiron' bermudagrass. Relative variables were calculated as salinized treatment values ÷ control treatment values.

Parameter	LW	RD	RW
GL	0.64**	0.11NS	-0.07NS
LW		0.48*	0.16NS
RD			0.35NS

*, **Correlations significant at the 0.05 and 0.01 level of probability; NS = not significant.

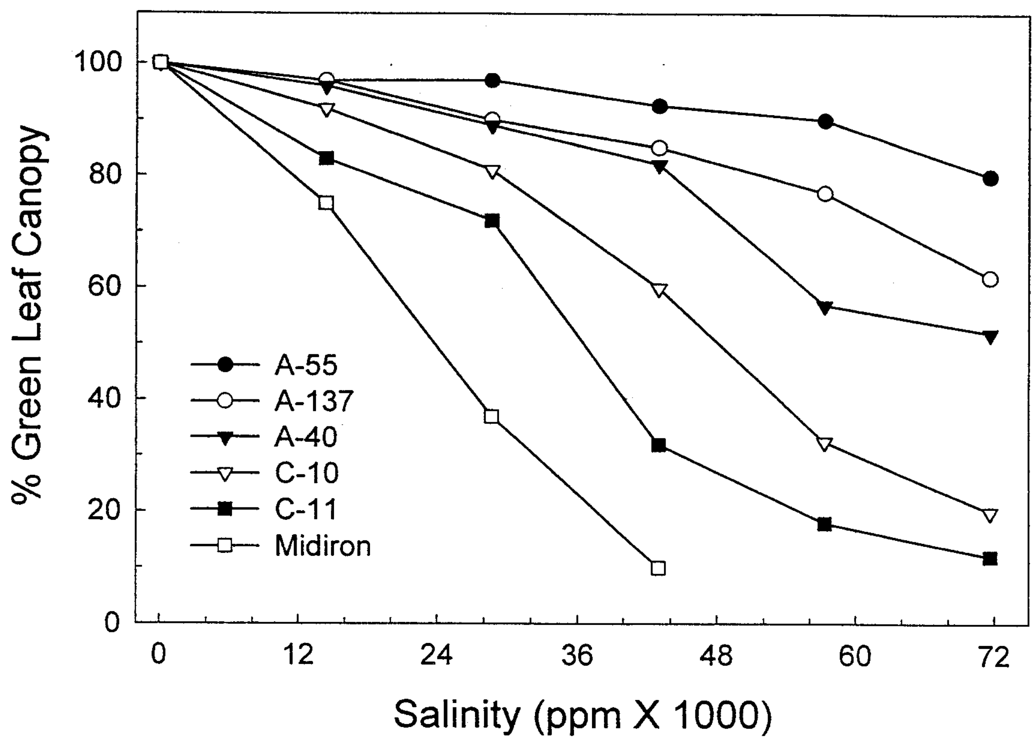

Figure 1. Effects of salinity on percent green leaf canopy area of six saltgrass accessions and Midiron bermudagrass.

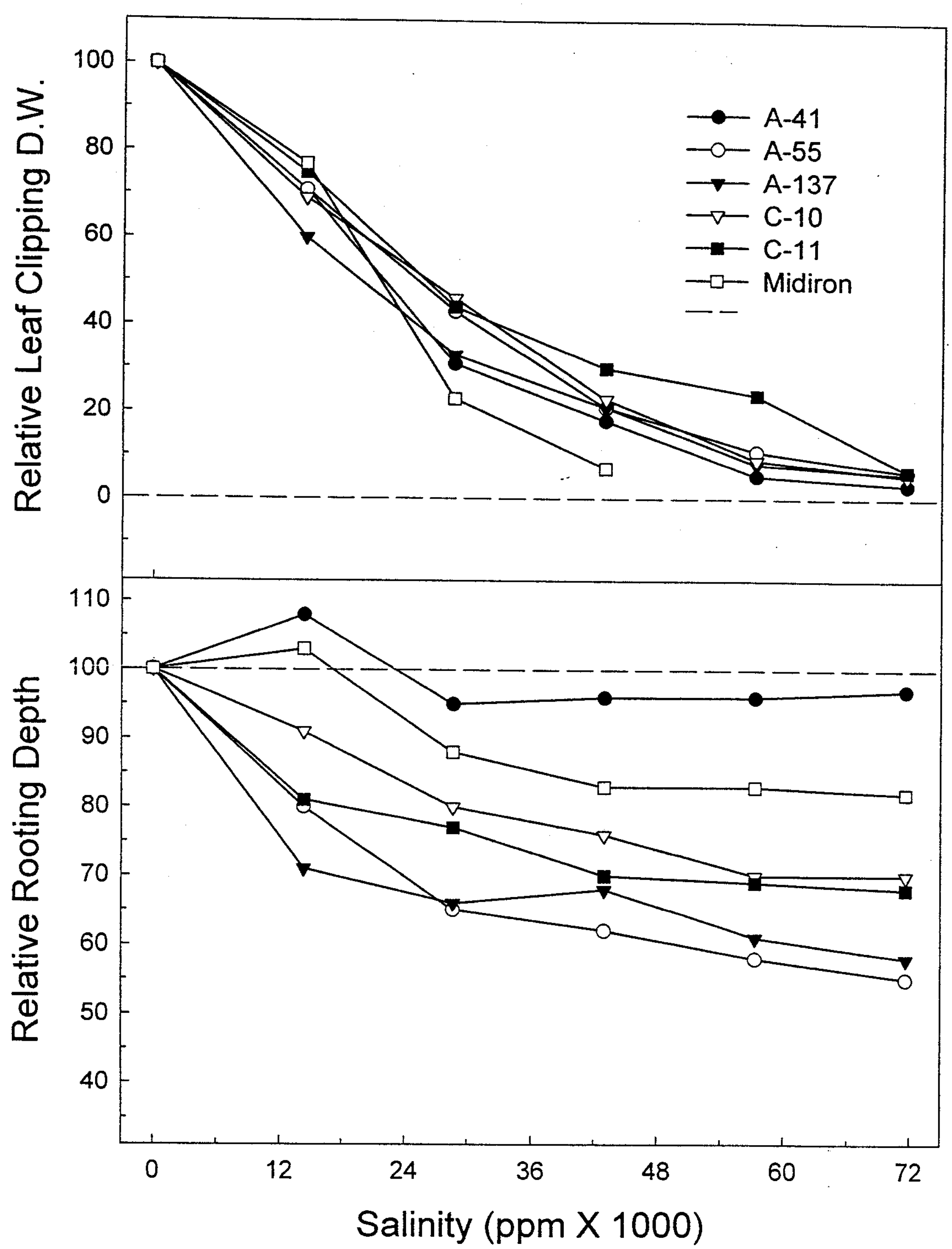

Figure 2. Effects of salinity on relative leaf clipping dry weights, and relative rooting depth of six saltgrasses and Midiron bermudagrass.