Growth Responses and Nitrogen Uptake of Saltgrass under Salinity Stress

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Abstract

Various saltgrass (Distichlis spicata) clones were studied in a greenhouse to evaluate their growth responses in terms of shoot and root lengths and shoot and root dry matter (DM) weights under salt stress. Plants were grown hydroponically using Hoagland solution No. 1. Treatments included control plants and plants grown with salt (NaCl) at EC of 20 dSm^{-1}*. Twelve different clones were grown with four replications of each variety. Plants were grown in a randomized complete block (RCB) design. Plant shoots (clippings) were harvested weekly, oven-dried at 60º C and DM weights were recorded. At the last harvest, plant roots were also harvested, oven-dried at 60ºC and DM weights were determined and recorded. The results show increased shoot length in control plants, increased root length in most of the plants grown in saline conditions, greater shoot dry weight in control plants and greater root dry weight in saline plants. All results for shoots are based on a weekly average for six weeks and for roots are based on an average of the four replicated clones at the end of the study.*

Introduction

Saltgrass (*Distichlis spicata*) is a warm season turfgrass species that has the ability to grow under highly saline conditions and with limited available water sources (Kopec et al., 2001a, 2001b, and 2005; Marcum et al, 2005; Pessarakli et al., 2001a and 2001b; Pessarakli, 2007; Pessarakli and Kopec, 2008; Pessarakli et al., 2005). This characteristic could prove to be beneficial in certain turfgrass areas requiring low maintenance in arid regions with saline soils and limited water available. Growth of this species could be important to aid in conservation of water and use of salt-affected soils. Test of the species' ability to grow under highly saline conditions and with low available water sources are needed before it can be applied to a turfgrass system.

The objective of this study was to compare the growth responses of saltgrass in terms of shoot and root lengths and dry weights (shoot clippings weight) grown under salt stress condition. Nitrogen^{15} was also added to this experiment to determine saltgrass' ability to take up nitrogen under salt stress. The results of this portion of the study are pending on the completion of the ^{15}N analysis, therefore, will not be included in this paper.

Materials and Methods

Saltgrass (*Distichlis spicata*) genotypes (A37, A49, A50, A60, 72, A86, A107, A126, A136, A138, 239 and 240) collected from several southwestern states of the United States (Kopec et al., 2000) were studied in a greenhouse to evaluate their growth in terms of shoot and root lengths and dry mater (DM) weights (shoot clippings weight) grown under saline (NaCl) conditions at EC of 20 dSm^{-1} using a hydroponic technique.

The plants were vegetatively grown in cups, 9 cm diameter and 7 cm height, followed procedures by Marcum et al. (2005), Pessarakli et al. (2001b, 2005), Pessarakli (2007), and Pessarakli and Kopec (2008) outlined here. Silica sand was used as the plant anchor medium. Each cup was fitted in to one of the 9 cm holes cut in a rectangular plywood sheet 46 cm x 37 cm x 2 cm. The plywood sheets served as lids for the hydroponic tubs supported the cups above the solution to allow for root growth and were placed on 42 cm x 34 cm x12 cm Carb-X polyethylene tubs containing half strength Hoagland solution No. 1 (Hoagland and Arnon, 1950). Plants were grown in a randomized complete block (RCB) design in this experiment. Four replications of each genotype and each treatment were grown in this experiment. During this period, the plant shoots (clippings) were harvested weekly in order to allow the grass to reach full maturity and develop uniform and equal size plants. The harvested plant materials (clippings) were discarded. One week prior to the first harvest, all roots and shoots were cut to have uniform roots and shoots prior to the initiation of the salt stress study.

Each week the plant shoots (clippings) were harvested for the evaluation of the dry matter (DM) production. At each harvest, both the shoot and root lengths were measured and recorded. The harvested plant materials were oven-dried at 60ºC and DM weights were measured and recorded. Six harvests were included in the experiment. At the termination of the experiment plant roots were also harvested, oven-dried at 60ºC and DM weights were measured and recorded.

The data were subjected to Analysis of Variance, using SAS statistical package (SAS Institute, 1991). The means were separated, using Duncan Multiple Range test.

Results and Discussion

The results for the average weekly growth responses are presented in Tables 1- 5.

Shoot length

The data from the average shoot length per week showed a decrease in all varieties of plants grown under saline conditions compared to control plants Table 1).

Root length

The data from the total root length for the duration of the experiment showed increased root growth of eight of the twelve varieties grown under saline conditions when compared to control plants (Table 1). These eight varieties were A60, A86, A107, A126, A136, A138, 239 and 240.

Shoot fresh weight

The results showed that all varieties, except variety A86, produced a higher weekly average fresh weight for control plants than those grown under saline conditions (Table 2).

Root fresh weight

The results of the final fresh weight of the roots showed an increase in six of ten of the varieties A49, A86, A107, A126, A136 and 240, for the plants grown under saline conditions (Table 2). As shown in Table 2, two of the varieties, A138 and 239, did not produce recordable results for root fresh weight.

Shoot dry matter (DM) weight

The average DM weight showed an increase in ten of the twelve varieties, A37, A50, A60, 72, A107, A126, A136, A138, 239, and 240, in the control plants in comparison to those grown under saline conditions (Table 3). However, the percent DM weight of the shoots (average dry weight/average fresh weight) showed an increase in nine out of the twelve varieties, A49, A50, A60, 72, A86, A107, A126, 239 and 240, in the plants grown under saline conditions in comparison to control plants, with variety A136 being equal under the two conditions.

Root dry matter (DM) weight

Dry weight averages showed an increase in eight of the ten varieties, A49, A50, 72, A86, A107, A126, A136 and 240, grown under saline conditions (Table 3). The percent root dry matter (average dry weight/average fresh weight) showed increased dry matter production in seven of the ten varieties, A37, A50, A60, 72, A86, A126 and 240, grown under saline conditions (Table 4).

Shoot to root dry matter

The results showed an increase in shoot to root dry matter (average shoot dry weight/average root dry weight) in eight of the ten varieties, A37, A49, A50, 72, A107, A126, A136 and 240, of the control plants compared to the varieties grown under saline conditions (Table 5). Note, two of the varieties (A138 and 239) did not produce recordable results for root dry matter (DM), Tables 2, therefore no values for the shoot to root DM weight (Table 5).

Shoot succulence

The results showed, except for variety 72, increased in succulence (average shoot fresh weight/average shoot dry weight) of the other eleven varieties under control conditions compared to those grown under saline conditions (Table 5).

Conclusion

Based on the results of this experiment, it can be concluded that saltgrass has a high salt tolerance. The results show increased average shoot length, average shoot fresh weight, average shoot dry weight, shoot/root dry matter and succulence in the plants grown under control conditions. However, the results also show increased average root length, average root fresh weight, average root dry weight, percent shoot dry matter and percent root dry matter in the plants grown in the saline, EC of 20 dS/m, conditions. This indicates high salt tolerance because the results pertaining to root growth were all increased under the saline conditions. This shows the plant's ability to produce sufficient root growth under saline conditions in order to support adequate shoot growth.

The amount of dry matter produced is the most significant results as they are a direct representation of saltgrass' ability to grow under highly saline conditions. As shoot and root lengths were recorded based on the longest shoot or root present, they are not an accurate representation of how tolerant each of the varieties is. The recorded dry matter results show saltgrass' tolerance to salt stress because it represents the total shoot and root mass produced by the plants from each treatment. Therefore, based on the results of this experiment it is concluded that each of the tested varieties has a high salt tolerance.

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Table 1. Average shoot and root growth of saltgrass under control & NaCl salinity.

	Average Shoot Length (cm)		**Average Root Length (cm)**	
	Treatment		**Treatment**	
Grass Species ID	**Control**	**EC 20 dS/m**	**Control**	**EC 20 dS/m**
A 37	14.49	12.57	9.48	6.00
A 49	13.30	12.05	8.60	6.72
A 50	13.28	11.26	13.84	5.26
A 60	12.65	12.15	12.62	13.44
72	12.18	10.39	15.90	13.16
A 86	12.22	11.70	7.96	12.08
A 107	11.65	10.95	3.76	4.30
A 126	12.99	11.29	6.08	7.38
A 138	11.34	9.90	7.10	9.60
239	7.23	6.09	10.10	12.85
240	7.86	7.08	8.40	17.85

Shoot values are an average of six harvests
Root values are average at final harvest

Table 2. Average shoot and root fresh weight production of saltgrass under control and NaCl salinity.

	Average Shoot Fresh Weight (g)		**Average Root Fresh Weight (g)**	
	Treatment		**Treatment**	
Grass Species ID	**Control**	**EC 20 dS/m**	**Control**	**EC 20 dS/m**
A 37	1.2386	0.8577	0.9891	0.4632
A 49	1.0172	0.8616	0.0723	0.3427
A 50	1.3231	0.8825	0.5838	0.2406
A 60	1.2156	0.9028	0.7684	0.4957
72	1.9460	1.7347	1.6159	1.2031
A 86	0.7728	1.0894	0.6699	0.7866
A 107	0.9455	0.7553	0.4060	0.4629
A 126	1.2113	0.9221	0.1121	0.1851
A 136	2.5426	1.0075	0.0876	1.1340
A 138	1.8153	0.7446	n/a*	n/a*
239	1.3514	0.6938	n/a*	n/a*
240	1.6929	1.1498	0.1674	0.8198

Shoot values are an average of six harvests
Root values are average at final harvest
*Note: Varieties A 138 and 239 did not produce recordable results for root dry matter

Table 3. Average shoot and root dry matter production of saltgrass under control and NaCl salinity.

	Average Shoot Dry Matter (g)		Average Root Dry Matter (g)	
	Treatment		Treatment	
Grass Species ID	Control	EC 20 dS/m	Control	EC 20 dS/m
A 37	0.4723	0.3417	0.0841	0.0760
A 49	0.3859	0.4103	0.0309	0.1370
A 50	0.5558	0.4390	0.4730	0.0740
A 60	0.4631	0.4236	0.0498	0.0074
72	0.7156	0.5049	0.0848	0.1393
A 86	0.3082	0.4690	0.0675	0.0819
A 107	0.3900	0.3612	0.0723	0.0771
A 126	0.5501	0.4529	0.0173	0.0478
A 136	0.8292	0.3720	0.2520	0.0813
A 138	0.9620	0.2873	n/a*	n/a*
239	0.4542	0.2856	n/a*	n/a*
240	0.5894	0.4681	0.0066	0.0723

Shoot values are an average of six harvests
Root values are average at final harvest
*Note: Varieties A 138 and 239 did not produce recordable results for root dry matter

Table 4. Percent shoot and root dry matter production of saltgrass under control and NaCl salinity.

	Percent Shoot Dry Matter (%)		Percent Root Dry Matter (%)	
	Treatment		Treatment	
Grass Species ID	Control	EC 20 dS/m	Control	EC 20 dS/m
A 37	44	40	9	16
A 49	42	44	43	31
A 50	45	53	8	27
A 60	42	47	6	26
72	42	47	5	11
A 86	41	45	7	12
A 107	46	51	21	12
A 126	50	52	7	12
A 136	34	34	29	7
A 138	39	35	n/a*	n/a*
239	34	38	n/a*	n/a*
240	35	42	4	46

Table 5. Ratio of shoot dry weight to root dry weight and shoot succulence of saltgrass under control and NaCl Salinity.

	Shoot Dry Weight/Root Dry Weight		Succulence	
	Treatment		Treatment	
Grass Species ID	Control	EC 20 dS/m	Control	EC 20 dS/m
A 37	5.6	4.5	2.6	2.5
A 49	12.5	3.0	2.6	2.1
A 50	11.7	5.9	2.4	2.0
A 60	9.3	57.6	2.6	2.1
72	8.4	3.6	2.7	3.4
A 86	4.6	5.7	2.5	2.3
A 107	5.4	4.7	2.4	2.1
A 126	31.9	9.5	2.2	2.0
A 136	32.9	4.6	3.1	2.7
A 138	n/a*	n/a*	3.0	2.4
239	n/a*	n/a*	3.0	2.4
240	89.3	6.5	2.9	2.5

Shoot values are an average of six harvests
Root values are average at final harvest
*Note: Varieties A 138 and 239 did not produce recordable results for root dry matter