

Growth Responses of Desert Saltgrass under Salt Stress

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Abstract

Saltgrass (Distichlis spicata), clonal accession WA-12, collected from Wilcox, Arizona was studied in a greenhouse to evaluate its growth responses in terms of shoot and root lengths, shoot fresh weight, and shoot and root dry weights under control and salt (sodium chloride) stress conditions. Plants were grown under control (no salt) and three levels of salt stress (100, 200, and 400mM NaCl equivalent to 6250, 12500, and 25,000 g L⁻¹ sodium chloride, respectively), using Hoagland solution in a hydroponics system. Plant shoots (clippings) were harvested weekly, oven dried at 60 °C, and dry weights recorded. At each harvest, both shoot and root lengths were measured and recorded. At the last harvest, plant roots were also harvested, oven dried, and dry weights were determined and recorded. The results show that the shoot and root lengths decreased with increasing the salinity levels, however, both shoot fresh and dry weights significantly increased at 200mM NaCl salinity compared with the control or the 400mM NaCl level. Root dry weights at both 200mM and 400mM NaCl salinity levels were significantly higher than the control.

Introduction

Desert saltgrass (*Distichlis spicata*), a potential turf species, grows in very poor to fair soil conditions, in both salt-affected soils and soils under drought conditions. It grows in arid and semi-arid regions. The plant is abundantly found in areas of the western parts of the United States, on the sea-shores of several Middle-Eastern countries, Africa, South and Central American. *Distichlis* can be manipulated to produce dwarf and turf type varieties as well as cultivars more tolerant to salinity and drought stresses. These characteristics can be very beneficial for turfgrass growth in arid and semi-arid regions where the soils are usually saline/sodic and water is limited for irrigation and other agricultural uses. In addition, this plant can be used in soil conservation for covering road sides and soil surfaces with high risks of erosion.

The objectives of this study were to compare growth responses in terms of shoot and root length and shoot (clippings) and root fresh and dry weights of desert saltgrass grown under control and different levels of salt stress.

Materials and Methods

Desert saltgrass, cultivar WA 12, collected from Wilcox, Arizona was used in a greenhouse experiment to evaluate its shoot and root growth as well as its fresh and dry weights under control and salt (NaCl) stress conditions, using a hydroponic technique.

The plants were vegetatively grown in cups, 9 cm diameter and 7 cm height. Silica sand was used as the plant anchor medium. Each cup was fitted into one of the 9 cm diameter 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 and supported the cups above the solution to allow for root growth, and were placed on 42 cm X 34 cm X 12 cm Carb-X polyethelene tubs containing half strength

Hoagland nutrient solution (Hoagland and Arnon, 1950). Eight replications of each treatment were used in a Randomized Complete Block design in this investigation.

Plants were allowed to grow in this nutrient solution for 42 days. During this period, the plant shoots (clippings) were harvested weekly in order to allow the saltgrass to reach full maturity and develop uniform and equal size plants. The harvested plant materials (clippings) were discarded. The culture solutions were changed biweekly to ensure adequate amount of plant essential nutrient elements for normal growth and development. At the last harvest, day 42, the roots were also cut to 2.5 cm length ensuring that all plants had uniform roots and shoots for the stress phase of the experiment.

The salt treatments were initiated by adding 50 mM, 2.925 g, of NaCl per liter of the culture solution per day. Four treatments were used, including control (no salt addition), 100, 200, and 400 mM salinity levels. The culture solution levels in the tubs were marked at the 10 liter volume level and maintained at this level by adding water as needed. After the final salinity level was reached (day 8 after the initiation of the salt treatment), the shoots (clippings) were harvested and the harvested plant materials were discarded for the last time. Then, the plant shoots (clippings) were harvested weekly for the evaluation of the fresh and dry matter production. At each weekly harvest, both shoot and root lengths were measured and recorded.

The harvested plant materials were oven dried at 60 °C and dry weights were measured and recorded. The recorded data were considered the weekly plant dry-matter production. At the termination of the experiment (after 7 weeks exposure to salt stress), the last harvest, plant roots were also harvested, oven dried at 60 °C, and dry weights were determined and recorded.

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

Results and Discussion

Root Length

The root length decreased under salt stress conditions. This decrease was more pronounced as the exposure time to salinity increased. However, for the first five harvests the reduction in root length was not statistically significant (Table 1). After six weeks exposure to NaCl stress, the reduction in root length due to salt stress was statistically significant.

Shoot Length

The shoot length was more severely affected under high level (400mM) of salt stress compared to root length (Table 1). The effect of stress on shoot length at highest level of salinity was obvious from the first harvest. At the last harvest, the effect of the medium (200mM) salinity level on the shoot length was statistically significant compared to the control and the low (100mM) level of NaCl.

Shoot Fresh Weight

For the first two harvests, the high (400mM) level of NaCl significantly reduced the shoot fresh weight compared to the other levels of salinity (Table 1). However, starting from harvest 3 to the last harvest, there was no significant differences detected on the shoot fresh weights between the high (400mM) salinity level compared with the low (100mM) NaCl stress and the control. As the stress period progressed, the medium (200mM) sodium chloride stress enhanced the shoot fresh weight. This beneficial effect of NaCl on the shoot fresh weight was statistically significant at harvests 5 and 6 (Table 1). This phenomenon is probably due to the fact that saltgrass is a true halophyte and the true halophytes use Na as an essential nutrient element. Pessaraki and Tucker's (1985) and Pessaraki's (1994 and 2001) findings of the enhancement of cotton (*Gossypium hirsutum* L.), a salt tolerant plant, growth and protein synthesis by this plant under low level of NaCl stress supports this result. At the last harvest, harvest 7, despite the higher numerical values of the shoot fresh weight for the medium (200mM) stressed plants, there was no statistically significant difference between any of the treatments. This is probably because as the plants grew older, they physiologically developed more tolerance by adjusting themselves to the imposed stress. This observation was recorded

by Pessaraki and Tucker (1985) and by Pessaraki (1994 and 2001) for cotton and by Al-Rawahy et al. (1992) for tomatoes (*Lycopersicon esculentum* Mill.).

Shoot Dry Weight

The shoot dry weights of the plants followed essentially the same pattern as the shoot fresh weights (Table 1). For both

fresh and dry weights of the shoots, except for the last harvest, the difference between the average shoot (clippings) weights of the medium (200mM) stressed plants and the other treatments was wider as the exposure time to stress progressed.

Root Dry Weight

Although the root dry weight was enhanced at the medium (200mM) and the high (400mM) salinity levels, there was no statistically significant difference detected between the average root dry weights of the different treatments. Sagi et al. (1997) also found the adverse effects of salinity stress was more pronounced on shoot than the root growth.

Conclusion

Shoot and root lengths severely decreased with increasing salinity for the first 5 weeks after salt treatment. However, both shoot fresh and dry weights significantly increased at 200mM salinity stress compared with the control after 5 weeks of exposure to the final salinity level. Root dry weights at both 200 and 400mM salinity were significantly higher than the control.

At the last harvest, the complete plant harvest showed that a general increase in root weight of ranging 23% at 200 or 400 mM salinity stress over that of the control.

References

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Table 1. Root and shoot length, shoot fresh and dry weights, and root dry weight (only for the last harvest) of seven weekly harvests of desert saltgrass under four salinity levels.

Harvest	Salinity (mM)	Length (cm)		Shoot weight (g)	
		Root	Shoot	Fresh	Dry
1	Control (0)	21.3a	11.4a	0.487a	0.201a
	100	19.3a	10.6a	0.457a	0.197a
	200	20.0a	8.1ab	0.281ab	0.124ab
	400	20.2a	5.9b	0.137b	0.068b
2	Control (0)	28.0a	10.2a	0.484a	0.211a
	100	26.2a	10.1a	0.444a	0.193a
	200	24.5a	9.0a	0.529a	0.222a
	400	26.2a	5.8b	0.187b	0.086b
3	Control (0)	32.0a	12.8a	0.563ab	0.252ab
	100	32.8a	12.1a	0.536ab	0.240ab
	200	28.9a	11.1a	0.742a	0.304a
	400	31.7a	6.7b	0.350b	0.168b
4	Control (0)	37.6a	12.7a	0.801ab	0.309ab
	100	34.7a	12.6a	0.740ab	0.281a
	200	34.1a	12.1a	0.961a	0.349a
	400	35.0a	7.8b	0.501b	0.202b
5	Control (0)	42.5a	9.5a	0.386b	0.199b
	100	37.2a	10.0a	0.447b	0.203b
	200	37.0a	9.7a	0.651a	0.282a
	400	36.7a	6.5b	0.420b	0.193b
6	Control (0)	48.4a	7.8a	0.296b	0.129b
	100	42.4ab	7.8a	0.396b	0.162b
	200	39.7ab	7.6a	0.525a	0.206a
	400	37.1b	5.8b	0.384b	0.157b
7	Control (0)	50.8a	7.3a	0.301a	0.164a
	0.441a				
	100	43.9ab	7.2a	0.310a	0.166a
	200	40.6b	6.5b	0.454a	0.205a
	400	38.2b	5.6c	0.404a	0.183a
				0.549a	
				0.376a	
				0.539a	

The values are means of eight replications.

All the values followed by the same letter in each column are not statistically different at the 0.05 probability level.