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Morphological responses of turfgrass species to varying levels of salinity

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Abstract
The commercial landscaping in the coastal area has raised a problem of the salinity tolerance level of the turf grass species used for laying. In order to maintain the quality outdoors in salt affected areas, the experiment was carried out in the south Gujarat region. The Plot was laid out in completely randomized design with factorial concept (FCRD) with three repetitions, comprising five salinity treatments of different saline irrigation water *viz.*, S_0 : ≈ 2.0 dS/m (Control/Best Available Water), S_1 : 4.0 dS/m, S_2 : 8.0 dS/m, S_3 : 16.0 dS/m and S_4 : 32.0 dS/m. The effect of salinity on six turfgrass genotype *viz.*, *Cynodon dactylon* (G_1), *Paspalum vaginatum* (G_2), *Zoysia japonica* (G_3), *Axonopus compressus* (G_4), *Eremochloa ophiuroides* (G_5) and *Stenotaphrum secundatum* (G_6) were studied. The pot experiment was carried out under the UV stabilized rain shelter. The treatments were imposed for the period of two month with saline irrigation water based on the moisture sensor reading on fully established turfgrasses. The morphological parameter of the grass species *viz.*, Leaf length, Leaf width and Stolon internodal length were observed during this period. As the salinity increased the morphological parameters showed a sharp reduction across all the turfgrass species, Although *Paspalum vaginatum* showed more tolerance among all, making it the best turfgrass under the high salinity stress.

Keywords: Turfgrass, salinity, morphology, genotype, stress

Introduction
Turfgrasses are plants that form a more or less continuous ground cover that persists under regular mowing and traffic (Turgeon, 1980) [13]. Turfgrass and ornamental plants are integral part of landscape ecological system and they serve both the thing of service and beauty (Robert *et al.*, 1992). They provides at least three major benefits to human activities: functional, recreational and ornamental (Beard, 1973) [1]. Functional uses include wind and water erosion control, thereby reducing dust and mud problems surrounding homes and businesses. It is also recognized for reducing glare, noise, air pollution and heat build up. Turf is extensively used along the roadsides for erosion control. Recreational use of turf is extensive throughout the world. The turfgrass species belongs to the family Poaceae which was formerly known as Gramineae under the class Monocotyledonae. More than 800 genera comprising over ten thousand species belong to Poaceae (Piperno and Sues, 2005) [10]. The grass family is of particular interest to human as our staple foods including rice, wheat and maize etc. belongs to the grass family. In addition, grasses form an important part of the urban and peri-urban landscape all over the world. However, there are also at least 12 species that are widely used as turfgrasses (Shaw, 2012) [12].
Salinity is one of the most important abiotic stresses widely affecting the plant growth around the world. Soil salinity is an escalating problem worldwide, with nearly 10 % of the earth's total land surface or 954 Mha covered with salt-affected soils and up to 100 Mha saline due to irrigation (Ghassemi *et al*., 1995 [2] and Pessarakli and Szabolics, 1999) [9]. Critical water shortages are occurring in rapidly growing urban areas, resulting in restrictions on the use of potable water for irrigating turfgrasses in varieties of landscape areas. Turfgrass landscape irrigation is typically considered a low priority use for fresh water, particularly when water shortages occur (Kjelgren *et al.*, 2000) [5]. Freshwater resource constraints are not the only issues facing many regions; salinity issues with soil and water are also getting worse. Therefore, in addition to developing saline water resources for irrigation, the turfgrass sector must also manage turfgrasses on salty locations. Salt tolerant turfgrasses are becoming essential in many areas of the world because of salt accumulation in soil, restriction on ground water especially in coastal areas (Hixson *et al.*, 2004) [3]. Turfgrass species that can withstand salt have become more and more necessary due to the growing usage of brackish water sources and sewage effluent for irrigation. Therefore, the study was done to evaluate the salinity tolerance level of the six warm season turfgrass used in the south Gujrat condition.

Materials and methods:
A pot experiment was conducted under a UV-stabilized rain shelter at Navsari Agricultural University, Gujarat, during the period of April 2024 to December 2024, with six turfgrass genotypes, *viz.*, *Cynodon dactylon*, *Paspalum vaginatum*, *Zoysia japonica*, *Axonopus compressus*, *Eremochloa ophiuroides* and *Stenotaphrum secundatum* in order to compare their salt tolerance. Fifty sprigs of each genotype were planted in the rectangular plastic pots with dimensions 60 cm × 30 cm × 27 cm. In order to provide uniform soil conditions, all the pots were filled with a mixture of white sand and neem cake. Neem cake was mixed into the sand media at the rate of 1.0 kg/m². Each grass genotype was planted in 15 pots; likewise, a total of 90 pots with different grasses planted on them, including three repetitions, were arranged under the rain shelter based on a completely randomized design. For a period of four months, the grasses were grown under the greenhouse condition with tap water irrigation for the proper

establishment and later on the grasses were clipped to a height of 3 cm above the media level in the pots in order to maintain a dense turf before the application of the treatment.

The temperature and relative humidity were measured timely during the period of the experiment, and the mean weather data is presented in Table 1.

Table 1: Weather data during the period of experiment

Months Parameters	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature(^{0}C)	29.85	31.00	30.10	27.80	27.10	27.65	28.80	25.75	23.00
Relative Humidity (%)	59.50	68.00	79.00	90.00	90.50	88.50	78.50	60.00	61.50

The five salinity levels, *viz.,* 2.0 (BAW), 4.0, 8.0, 16.0, 32.0 dS/m, were made by diluting seawater (45.0 dS/m) with the best available water. In order to avoid the salinity shock, all the pots received the best available water (2.0 dS/m) in the first irrigation. In the second irrigation, all the pots, except for the control ones, were irrigated with 4.0 dS/m water. In subsequent irrigations, except for the control pots and 4.0 dS/m treatments, they were irrigated with 8.0 dS/m water and so on, until the maximum salinity treatments were reached. The irrigation interval was determined using the moisture sensor reading, which was installed in the experimental unit. Each pot was irrigated with 2 liters of water during each irrigation. The EC of each salinity treatment was properly checked before every irrigation using a portable EC meter. The application of the salinity treatment continued for a period of two months. The data on Leaf length, Leaf width, Stolon internodal length were recorded 4 weeks after the initiation of salinity treatment.

Leaf length (cm) Length of the third mature leaf from the growing tip was recorded with digital Vernier Calliper in 5 flattened random leaves from each pot on weekly basis and averaged. Leaf length from leaf tip to the leaf collar was measured in centimetre.

Leaf width (mm) Width of the third mature leaf from the growing tip was recorded in 5 flattened random leaves from each pot on weekly basis and averaged. Leaf width was measured at a distance of 1.0 cm from its ligule (at the widest part of the leaf blade) using digital Vernier Calliper and expressed in millimetre.

Stolon internodal length (mm) Five stolons of grasses from each pot were taken out and their third internode from top was measured as the distance between two nodes of mature stolon using digital Vernier Calliper. The observations were recorded on weekly basis and then averaged and expressed in millimetre.

Result and discussion:

It is evident from the data that, leaf length of all the turfgrass species was significantly decreased with increased salinity of irrigation water. The mean data of salinity (S0 to S4) of the different turfgrass species revealed that the salinity had significant effect on the reduction of the leaf length. Over the period of observation also, it was noticeable that the leaf length of all the turfgrass species reduced considerably. As the grasses used in this experiment belonged to different genotype, their morphological characters like leaf length, width and stolon internodal length varied widely, so that morphological characters of the genotypes was not comparable in this context. From the interaction table, it is evident that, the turfgrass genotypes recorded their normal leaf length under the control treatment of ≈2.0 dS/m (S0). It is evident from the data (Table 2) that, the leaf length of all the turfgrass species was significantly decreased with increased salinity of irrigation water and also with the period of application of treatment except for the genotype G2 (*Paspalum vaginatum*) which did not follow a gradual reduction in leaf length. The trend for the leaf length reduction followed by the six different genotypes as a result of the salinity stress imposed on them followed the order $G_6 > G_5 > G_4 > G_1 > G_3 > G_2$, in which the genotypes were *Stenotaphrum secundatum, Eremochloa ophiuroides, Axonopus compressus, Cynodon dactylon, Zoysia japonica* and *Paspalum vaginatum* respectively. The results obtained were in conformity with the previous findings of Zhang and Hu (2021) [15] in zoysia grass; Patel *et al.* (2024) [8] in Bermuda grass cultivar selection-1.

Table 2: The effect of different saline water irrigation on leaf length of various turfgrass genotypes at weekly interval

Sr. No.	Treatment combinations	Leaf length (cm)					Mean
		W_1	W_2	W_3	W_4	W_5	
1	G_1S_0	4.87	5.37	5.15	4.88	4.83	5.02
2	G_1S_1	5.13	4.91	5.01	4.81	4.79	4.93
3	G_1S_2	4.24	4.69	4.12	4.22	4.18	4.29
4	G_1S_3	4.23	4.40	4.04	4.11	3.94	4.14
5	G_1S_4	4.00	3.87	3.88	3.17	3.15	3.62
6	G_2S_0	5.29	5.03	5.17	5.74	7.15	5.68
7	G_2S_1	5.25	5.39	5.31	6.23	7.87	6.01
8	G_2S_2	4.88	4.83	4.78	5.68	7.26	5.49
9	G_2S_3	4.83	4.55	5.09	4.96	6.54	5.19
10	G_2S_4	4.95	4.71	4.85	5.70	6.59	5.36
11	G_3S_0	4.98	4.49	4.43	4.57	4.80	4.65
12	G_3S_1	4.93	4.41	4.41	4.54	4.67	4.59
13	G_3S_2	4.87	4.35	4.27	4.15	4.55	4.44
14	G_3S_3	4.24	4.19	4.10	4.07	4.24	4.17
15	G_3S_4	3.90	3.33	3.29	3.06	3.03	3.32
16	G_4S_0	7.03	8.04	5.94	5.37	6.49	6.58
17	G_4S_1	6.84	7.03	5.90	5.31	6.27	6.27
18	G_4S_2	6.77	6.80	5.47	4.53	4.91	5.70
19	G_4S_3	6.19	6.37	4.99	4.30	3.81	5.13
20	G_4S_4	4.28	4.39	4.09	3.88	3.17	3.96
21	G_5S_0	10.47	10.35	8.83	9.82	9.43	9.78
22	G_5S_1	9.64	10.24	7.91	8.91	9.09	9.16
23	G_5S_2	7.77	9.65	7.09	7.43	7.59	7.91
24	G_5S_3	7.17	7.47	6.11	7.29	6.87	6.98
25	G_5S_4	5.99	6.34	5.56	6.25	6.41	6.11
26	G_6S_0	8.35	8.21	6.98	6.84	6.89	7.45
27	G_6S_1	8.19	7.59	6.10	5.42	6.43	6.75
28	G_6S_2	6.25	6.61	5.51	4.45	4.83	5.53
29	G_6S_3	5.17	5.77	4.11	4.03	4.15	4.65
30	G_6S_4	3.25	3.31	3.09	3.27	3.31	3.25
Mean (W)		5.80	5.89	5.19	5.23	5.57	
		SEm ±		CD at 5 %		CV %	
G		0.017		0.047		2.61	
S		0.015		0.043			
W		0.016		0.044			
G × S		0.037		0.105			
G ×W		0.038		0.107		2.67	
S × W		0.035		0.098			
G × S × W		0.086		0.239			

(G-Genotypes, S-Salinity, W-week)

Similarly, the data for the character leaf width of six different turfgrass genotype used for this experiment, as influenced by different levels of saline irrigation water,

period of exposure and their interaction effect have been presented in Table 3. Over the period of observation, five-week data were collected in which leaf width of all the six turfgrass species was decreased due to increase in the period of exposure to saline irrigation water (W0 to W5) in which the maximum overall leaf width (2.41 mm) was recorded in the first week (W1) and the minimum leaf width (1.84 mm) was observed at the fifth week (W5). Here also the least difference in the leaf width over the weeks and across the salinity was observed in the genotype G_2 -*Paspalum vaginatum*. The order of leaf width reduction followed by the genotypes are $G_4 > G_6 > G_5 > G_1 > G_3 > G_2$ in which the genotypes were *Axonopus compressus*, *Stenotaphrum secundatum*, *Eremochloa ophiuroides*, *Cynodon dactylon*, *Zoysia japonica* and *Paspalum vaginatum*, respectively. Hence it is evident that, for the character leaf width, genotype G_2 (*Paspalum vaginatum*) was least affected by salinity, followed by G_3 (*Zoysia japonica*) and G_1 (*Cynodon dactylon*). Earlier, similar trends were also reported by Zhang and Hu (2021) [15] in zoysiagrass; Keyikoglu *et al.* (2019) [4] in four turfgrass species; Li *et al.* (2018) in centipedegrass;

Table 3: The effect of different saline water irrigation on leaf width of various turfgrass genotypes at weekly interval

Sr. No.	Treatment combination	Leaf width (mm)					Mean
		W_1	W_2	W_3	W_4	W_5	
1	G_1S_0	1.60	1.12	1.15	1.12	1.07	1.21
2	G_1S_1	1.45	1.08	1.03	1.02	1.04	1.12
3	G_1S_2	1.09	0.95	0.82	0.89	0.89	0.93
4	G_1S_3	0.87	0.97	0.83	0.82	0.83	0.86
5	G_1S_4	0.96	0.99	0.84	0.78	0.78	0.87
6	G_2S_0	1.97	1.11	1.52	1.47	1.49	1.51
7	G_2S_1	1.64	1.11	1.59	1.57	1.48	1.48
8	G_2S_2	1.45	1.01	1.26	1.24	1.36	1.26
9	G_2S_3	1.04	1.11	1.24	1.22	1.27	1.18
10	G_2S_4	1.12	1.15	1.33	1.17	1.23	1.20
11	G_3S_0	1.45	0.79	0.84	0.82	0.81	0.94
12	G_3S_1	0.90	0.80	0.75	0.74	0.79	0.79
13	G_3S_2	0.73	0.67	0.66	0.71	0.77	0.71
14	G_3S_3	0.71	0.64	0.64	0.67	0.71	0.67
15	G_3S_4	0.67	0.62	0.61	0.60	0.67	0.63
16	G_4S_0	9.50	5.25	3.39	4.14	5.11	5.48
17	G_4S_1	5.53	5.08	3.59	4.06	4.79	4.61
18	G_4S_2	4.59	4.74	3.58	4.00	4.63	4.31
19	G_4S_3	4.24	4.28	3.54	3.93	4.42	4.08
20	G_4S_4	4.42	4.05	3.40	3.48	3.32	3.73
21	G_5S_0	2.50	2.03	1.58	1.54	1.50	1.83
22	G_5S_1	1.74	1.83	1.77	1.57	1.54	1.69
23	G_5S_2	1.53	1.78	1.56	1.44	1.48	1.56
24	G_5S_3	1.21	1.61	1.47	1.31	1.45	1.41
25	G_5S_4	1.48	1.51	1.39	1.26	1.31	1.39
26	G_6S_0	5.76	4.10	3.77	3.31	3.39	4.06
27	G_6S_1	4.09	3.59	3.33	2.94	3.32	3.45
28	G_6S_2	2.69	2.95	3.06	2.81	2.87	2.88
29	G_6S_3	2.43	2.48	2.36	2.45	2.55	2.45
30	G_6S_4	2.96	2.40	2.31	2.12	2.10	2.38
Mean		2.41	2.41	2.06	1.84	1.84	
		SEm ±		CD at 5 %		CV %	
G		0.008		0.022		3.13	
S		0.007		0.020			
W		0.007		0.019		3.13	
G × S		0.017		0.048			
G × W		0.016		0.046			
S × W		0.015		0.042			
G × S × W		0.037		0.102			

(G-Genotypes, S-Salinity, W-week)

The stolon internodal length of the six turfgrass species to the salt stress of five different saline irrigation treatment for a continuous five-week period as well as their interaction effect were found significant, which have been presented in Table 4.0. The mean data from the shows that the maximum stolon internodal length was observed in the control treatment (S0 ≈2.0 dS/m) for all the grass species and thereby reduced significantly with a minimum growth recorded at the highest salinity treatment S4 (32.0 dS/m). The maximum stolon internodal length for all the turfgrass were recorded in the control treatment S0 (≈2.0 dS/m), except for the genotype G_1 (*Cynodon dactylon*) and G_2 (*Paspalum vaginatum*), in which the maximum growth was recorded in the salinity treatment S1 (4.0 dS/m). This increase in growth was probably aided by the nutrients present in the sea water that used for making the saline irrigation water. The trend shown by the genotypes based on the reduction in their stolon internodal growth was $G_6 > G_1 > G_4 > G_5 > G_3 > G_2$, in which the genotypes were *Stenotaphrum secundatum*, *Cynodon dactylon*, *Axonopus compressus*, *Eremochloa ophiuroides*, *Zoysia japonica* and *Paspalum vaginatum*, respectively. The results obtained were in conformity with the previous research of Kumar *et al.* (2021) [6] in *Melia dubia* and Wang *et al.* (1997) [14] in *Atriplex prostrata*.

Table 4: The effect of different saline water irrigation on stolon internodal length of various turfgrass genotypes at weekly interval

Sr. No.	Treatment combinations	Stolon Internodal Length (mm)					Mean
		W1	W2	W3	W4	W5	
1	G_1S_0	16.41	16.55	16.22	16.17	16.00	16.27
2	G_1S_1	16.72	19.28	18.05	17.14	15.41	17.32
3	G_1S_2	14.74	16.47	16.24	14.01	13.87	15.06
4	G_1S_3	11.76	14.60	15.45	12.42	12.14	13.27
5	G_1S_4	10.57	12.60	11.16	10.39	9.61	10.87
6	G_2S_0	10.70	9.07	8.79	8.44	8.16	9.03
7	G_2S_1	12.49	8.57	8.53	8.35	8.10	9.21
8	G_2S_2	8.99	8.33	8.30	8.27	7.64	8.31
9	G_2S_3	9.71	7.99	6.56	6.65	6.41	7.46
10	G_2S_4	9.68	7.70	6.46	6.62	6.44	7.38
11	G_3S_0	12.54	7.88	7.83	7.71	7.25	8.64
12	G_3S_1	10.49	7.46	7.29	7.09	6.05	7.68
13	G_3S_2	9.63	7.39	7.08	6.81	5.35	7.25
14	G_3S_3	8.68	7.31	6.81	6.65	6.16	7.12
15	G_3S_4	8.28	6.27	5.94	6.30	5.13	6.38
16	G_4S_0	13.53	13.67	11.64	10.19	9.93	11.79
17	G_4S_1	14.39	13.00	10.63	9.65	9.86	11.51
18	G_4S_2	11.61	12.06	10.79	9.42	9.12	10.60
19	G_4S_3	9.45	9.84	9.31	8.08	7.69	8.87
20	G_4S_4	9.92	9.15	7.21	6.80	4.74	7.57
21	G_5S_0	15.60	12.62	11.43	8.47	8.26	11.27
22	G_5S_1	15.88	11.03	9.40	8.33	8.03	10.53
23	G_5S_2	11.95	10.68	8.27	6.98	6.90	8.95
24	G_5S_3	11.53	9.03	8.42	6.75	6.15	8.38
25	G_5S_4	10.38	8.92	7.98	6.63	6.07	8.00
26	G_6S_0	24.03	18.10	14.76	12.59	12.30	16.36
27	G_6S_1	18.55	15.51	13.33	11.07	10.45	13.78
28	G_6S_2	17.61	14.74	13.95	10.23	9.89	13.28
29	G_6S_3	15.21	11.46	9.32	9.31	8.68	10.79
30	G_6S_4	13.36	10.87	8.47	7.41	6.24	9.27
Mean (W)		12.81	11.27	10.19	9.16	8.60	
		SEm ±		CD at 5 %		CV %	
G		0.079		0.225		6.60	
S		0.072		0.205			
W		0.077		0.216			
G × S		0.177		0.503			
G × W		0.190		0.528		7.05	
S × W		0.173		0.482			
G × S × W		0.424		1.181			

(G-Genotypes, S-Salinity, W-week)

Conclusion

From study it was notable that, across all the salinity treatments, G_2 - *Paspalum vaginatum* was the genotype that maintained the morphological characters *viz.*, leaf length, leaf width and stolon internodal length over the period of experiment. Although the genotypes used in the study has their own morphological character, their changes according to the salinity treatment over time was successfully analyzed and found that the G_2-*Paspalum vaginatum* makes best result under saline areas for better landscaping. Based on the results of the present study, Seashore paspalum (*Paspalum vaginatum*) proved to be the most salt tolerant genotype with excellent turf quality and stability even at the highest salinity level of 32.0 dS/m. In conclusion, *Paspalum vaginatum* is the best option for keeping the turf healthy and green even under saline irrigation.

References

1. Beard JB. Turfgrass: Science and Culture, Englewood Cliffs, New Jersey, U.S.A., 1973, 658.
2. Ghassemi F, Jakeman AJ, Nix HA. Salinisation of Land and Water Resources; Human Cause, Extent, Management and Case Studies, CABI, Wallingford, 1995, 526.
3. Hixson AC, Crow WT, McSorley R, Trenholm RE. Saline irrigation affects *Belonolaimus longicaudatus* and *Hoplolaimus galeatus* on seashore paspalum. J. Nematol.,2004:37(1):37-44.
4. Keyikoglu R, Aksu E, Arslan M. Effects of salinity stress on the growth characteristics of four turfgrass species. Fresenius Environmental Bulletin,2019:28:2942–2948.
5. Kjelgren R, Rupp L, Kilgren D. Water conservation in urban landscapes. Hortic. Sci.,2000:35(6):1037–1040.
6. Kumar R, Banyal R, Singh A, Yadav RK, Sharma PC. Salinity stress effects on the growth, morphological, physiological and biochemical properties of melia (*Melia dubia* Cav.) plant. Dendrobiology,2021:86:56-68.
7. Li J, Ma J, Guo H, Zong J, Chen J, Wang Y, et al. Growth and physiological responses of two phenotypically distinct accessions of centipede grass [*Eremochloa ophiuroides* (Munro) Hack.] to salt stress. Plant Physiology and Biochemistry,2018:126:1-10.
8. Patel MA, Patel MA, Italiya AP, Tandel YN, Chawla SL. Response of Bermuda grass (*Cynodon dactylon* (L.) Pers) cv. Selection 1 to varied levels of saline irrigation water. Progressive Horticulture,2024:56(1):1.
9. Pessarakli M, Szabolics I. Soil salinity and sodicity as particular plant/crop stress factors, In: “Handbook of Plant and Crop Stress”. New York: Marcel Dekker Inc. (First edn.), 1999, 1-15.
10. Piperno DR, Sues HD. Dinosaurs dined on grass. Science,2005:310(5751):1126-1128.
11. Roberts EC, Huffine WW, Grau FV, Murray JJ. Turfgrass science-Historical overview. Turfgrass,1992:32:1-27.
12. Shaw RB. "Guide to Texas Grasses", Texas A&M University press, Texas, U.A.S., 2012, 10.
13. Turgeon AJ. "Turfgrass Management", Reston publishing company, Virginia, U.S.A., 1980, 391.
14. Wang LW, Showalter A, Ungar A. Effect of salinity on growth, ion content and cell wall chemistry in *Atriplex prostrata*. American Journal of Botany,1997:84(9):1247-1255.
15. Zhang Z, Hu H. Comparative study on growth traits and ions regulation of zoysiagrasses under varied salinity treatments. Open Life Science,2021:16:785-792.