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Growth response of warm season grass (*Cynodon dactylon*) to different salinity levels

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Abstract

Turfgrasses are essential natural element of any landscape, which play a dynamic role in redecoration of gardens, parks, golf course and play grounds. *Cynodon dactylon* L., cv. Tiffany is a warm season turfgrass having vibrant value and reputation because of its stunning appearance, hardy nature, soft carpet sensation, drought, salinity resistance quality, heavy traffic bearing and browning . In which Salinity is one of the major environmental factor which limits turf growth and quality because it reduces water availability for plant use. High salt levels hinder water absorption, inducing physiological drought in the plant. Scarcity of fresh water along with soil salinization has resulted in an increased need for screening of salt tolerant turfgrasses which have the ability to withstand against different salinity levels. Keeping in view, present research was laid at research area of horticulture department, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi 33.6000° N, 73.0333° E. The experiment was carried out to check growth response of warm season grass (*Cynodon dactylon*) to different salinity levels. The treatments thus formed were Control/ 0ppm; NaCl @1000ppm; NaCl @3000ppm; NaCl @5000ppm; NaCl @ 7000ppm. The qualitative and quantitative parameters were analyzed, results showed maximum quality and growth of turfgrass along with salt tolerance at NaCl @3000 ppm and minimum at NaCl @7000 ppm. Through these results it was concluded that the rate of growth was decreased in correspondence to increased salinity but plants were tolerable up to the certain level without any reduction in their growth.

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Introduction

Cynodon dactylon (Poaceae) also known as Bermuda grass, couch grass, and devil's grass is a warm season perennial, creeping type turf, which is native to South Africa (Farsani *et al*., 2012). It provides a bright green color, uniform appearance and dense environmental turf of good quality (Wherley, 2011). It has been found to be rich in proteins, carbohydrates, minerals and also possess antibacterial, antimicrobial, antiviral and wound healing properties (Asthana *et al.,* 2012; Ashok kumar *et al*., 2013). It has tendency to grow on the soils that are too salt damaged to support agricultural crops and successfully irrigated with saline water (Teutan *et al*., 2005). Soil salinity is considered as one of the major factors in many regions of the world that reduce the plant growth and salt water interference into irrigation water supplies has led to the fresh water shortage and restrictions on the use of portable water for landscape irrigation (Arizona Department of Water Resources, 1995; California State Water Resources, 1993; Peacock *et al*., 2004). Water quality and quantity are becoming major problems worldwide especially in arid and semi-arid regions of Pakistan, where rainfall is insufficient to leach salts and excess sodium ions out of the rhizosphere (Pessarakali *et al*., 2006). Growth limits at higher salinity and its detrimental effects on plant growth have been seen (Greenway and Munns, 1980; Lauchli, 1986; Cheeseman, 1988). *Cynodon dactylon* grows well with plenty of sunshine and higher temperatures, and that's why it is a good choice for drought prone and rainfed areas (Parida *et al.,* 2005).

Tolerance to salinity has been evolved naturally in numerous turfgrasses including Bermuda grass, which has demonstrated superior tolerance to salinity conditions compared to many turf grasses exhibiting salt tolerance of about 16-18 mmhos/cm (Dudeck and Peacock, 1993; Lee, 2000). Under high saline conditions, cell expansion is reduced by accumulation of salts in cell walls that would effectively reduce cell turgor and consequently reduce growth (Qian *et al*., 2001). This paper aims at analyzing the impact of salinity on the growth of bermuda grass and to check the level of salinity which can be tolerable by it without effecting its growth under controlled conditions. The results will show the conditions at which turfgrass has shown better growth response under saline conditions so that the plants can be grown successfully under salt stress in the rain fed areas and sea water can be utilized.

Materials and methods

Experimental site and planting material

The experiment was conducted in the glass house of Department of Horticulture; PMAS-Arid Agriculture University Rawalpindi. Bermuda grass cultivar named Tiffany was purchased from a reliable nursery and grass plugs were grown in pots of diameter 50.24 inches^2 and established until the carpet was made. Media used in pots consist of sand and FYM in 1:1.

Treatments and data collection

Five treatments with three replications were laid out randomly. After 2 months, when the carpet was established the shoots were maintained at the height of 3 cm and salinity treatments (0, 1000, 3000, 5000, 7000 ppm NaCl) were applied. After 45 days of treatment application, grass was harvested to collect the data. General soil properties for example, soil type, organic matter (OM), soil pH and electrical conductivity (EC) were calculated before and after turf grass establishment from Department of Soil fertility and Water analysis Rawalpindi. Dry weight of roots and shoots was measured by weighing balance. Length of shoots, roots, number of stolons, and visual parameters of turf were also measured. Na+ and Cl- concentration was measured by flame photometer (Modal; PFP 7, Jenway) and chloride analyzer (Modal, PCLM 3, Jenway).

Data analysis

The collected data was analyzed through appropriate statistical package i.e. MSTAT-C. Statistical significance was compared with LSD. Quality parameters were analyzed through SPSS and significance was compared with Chi-square.

Results

Shoot length (SL), root length (RL), leaf firing (LF), no. of stolons, shoot fresh weight (SFW) under salinity

The response of turfgrass to all the salt treatments was highly significant. Salinity had a direct impact on shoot and root length, leaf firing, number of stolons along with their fresh weight. They all decreased to the corresponding increased concentration of salinity at ($p<0.05$) (Table 1).

Table 1. Shoot length (SL), root length (RL), leaf firing (LF), no. of stolons, shoot fresh weight (SFW) under salinity.

Treatments	Salt conc. (ppm)	SL (cm)	RL (cm)	LF (%)	No. of stolons	SFW (mg)
T_0	0	10.400 A	11.600 A	9.6667 E	7.2233 A	275.97 A
T_1	1000	7.9667 B	10.300 B	24.723 D	6.6667 AB	218.63 B
T_2	3000	6.7667 C	9.9000 B	43.333 C	5.8900 BC	176.73 C
T_3	5000	4.5000 D	6.6333 C	74.557 B	5.4433 CD	136.90 D
T_4	7000	3.2667 E	4.1667 D	89.667 A	4.8867 D	97.376 E

Table 2. Root fresh weight (RFW), shoot dry weight (SDW), root dry weight (RDW), root shoot ratio for fresh weight (RSFW), root shoot ratio for dry weight (RSDW) under salinity.

Treatments	Salt conc. (ppm)	RFW (mg)	SDW (mg)	RDW (mg)	RSFW (mg)	RSDW (mg)
T_0	0	301.93 A	165.97 A	186.67 A	1.0867 D	1.1200 D
T_1	1000	259.73 B	108.63 B	128.63 B	1.1433 CD	1.1800 CD
T_2	3000	207.03 C	96.733 C	121.63 B	1.1733 BC	1.2533 C
T_3	5000	164.47 D	43.567 D	63.833 C	1.2267 AB	1.4600 B
T_4	7000	3.2667 E	24.033 E	43.800 D	1.2700 A	1.8333 A

Root fresh weight (RFW), shoot dry weight (SDW), root dry weight (RDW), root shoot ratio for fresh weight (RSFW), root shoot ratio for dry weight (RSDW) under salinity

Data regarding shoot growth indicated a descending trend regarding shoot length if proceed towards T_4. At 3000 ppm, it was tolerable level for the plants and the level above it was not tolerable and seriously damaged the plants. Root growth was decreased by 14.65 % at 3000 ppm (T_2), but 64.65% at 7000 ppm (T_4). Best results were obtained at T_2, while at T_1 growth was not stable to determine the effect of stress.

Table 3. Effect of salinity on uniformity of turfgrass.

Treatments	Uniformity				
	Highly uniform	Mod. uniform	Uniform	Uneven	Highly uneven
T_0	77.78 %	22.22 %	0.00 %	0.00 %	0.00 %
T_1 (1000 ppm)	0.00 %	77.78 %	22.22 %	0.00 %	0.00 %
T_2 (3000 ppm)	0.00 %	0.00 %	77.78 %	22.22 %	0.00 %
T_3 (5000 ppm)	0.00 %	0.00 %	0.00 %	66.67 %	33.33 %
T_4 (7000 ppm)	0.00 %	0.00 %	0.00 %	0.00 %	100 %

The results showed that root dry weight (RDW) significantly ($P < 0.05$) decreased with increasing salinity. It was decreased gradually from T_1 (128.63) to T_2 (121.63), but the rate was accelerated from T_2 to T_3 (63.833) and onwards. Shoot dry weight was maintained at 3000 ppm (96.73 mg) but reduced till 7000 ppm (24.03 mg). Stable growth of the above mentioned parameters was observed at T2, while the growth was badly effected in T3 and T4 respectively. Percentage of leaf firing increased when proceeding towards T1 to T4, because the number of brown or dead leaves can be directly related to the increased salinity. Fresh and dry weights and their ratio were decreased in comparison with increased salinity (Table 2) as overall plant biomass was reduced.

Effect of salinity on uniformity and density of turfgrass

Data analyzed regarding visual parameters showed significant results ($p<0.05$) i.e. reduction in the quality of different parameters when the amount of salinity given to plants was increased. Grading of grass was done and different grades were given according to the visual observation of different treatments regarding uniformity.

Uniformity was decreased slowly till T_2 but it decreased drastically from T_3 to T_4 (Table 3). Grass with good density was thickest followed by the thicker, thick, thin and thinnest as the salinity was increased from 0 to 7000 ppm (Table 4). It is evident from the table that control treatment.

Table 4. Effect of salinity on density of turfgrass.

Treatments	Density				
	Thickest	Thicker	Thick	Thin	Thinnest
T_0	22.22 %	77.78 %	0.00 %	0.00 %	0.00 %
T_1 (1000 ppm)	0.00 %	33.33 %	66.67 %	0.00 %	0.00 %
T_2 (3000 ppm)	0.00 %	0.00 %	44.44 %	55.56 %	0.00 %
T_3 (5000 ppm)	0.00 %	0.00 %	0.00 %	33.33 %	66.67 %
T_4 (7000 ppm)	0.00 %	0.00 %	0.00 %	0.00 %	100 %

Effect of salinity on texture of turfgrass

It showed maximum density that was 22.22 % thickest. Most stable result was confirmed at 3000 ppm, which was 44.44 % thick. Best texture was observed in control treatment that was 100 % highly fine where as other treatments like T3 showed 22.22 % moderately fine and 77.78 % fine at salt concentration of 3000 ppm. Poor texture was observed at 7000 ppm salt concentration as it fall 33.33 % under course and 66.67 % under highly course categories (Table 5).

Table 5. Effect of salinity on texture of turfgrass.

Treatments	Texture				
	Highly fine	Mod. Fine	Fine	Course	Highly coarse
T_0	100 %	0.00 %	0.00 %	0.00 %	0.00 %
T_1 (1000 ppm)	22.22 %	77.78 %	0.00 %	0.00 %	0.00 %
T_2 (3000 ppm)	0.00 %	22.22 %	77.78 %	0.00 %	0.00 %
T_3 (5000 ppm)	0.00 %	0.00 %	44.44 %	55.56 %	0.00 %
T_4 (7000 ppm)	0.00 %	0.00 %	0.00 %	33.33 %	66.67 %

Effect of salinity on color of turfgrass

Color was 100 % dark green at T1 (1000 ppm) , and 11.11 % green and 88.89 % light green at salt concentration of 3000 ppm (T3) , at 5000 ppm the color fall 11.11 % under light green and 88.89 % under yellow green categories whereas at 7000 ppm salt concentration it fall 100 % under straw brown category (Table 6).

Effect of salinity on smoothness of turfgrass

Smoothness decreased linearly from T_0 to T_2 (3000 ppm), but drastically from T_3 (5000 ppm) to T_4 (7000 ppm) as it changed from 88.89 % smoothest to 77.78 % smoother and ultimately dropped to 100 % higly rough category (Table 7).

Effect of salinity on Na+ and Cl- concentration

Na^+ and Cl^- concentrations in the leaves and shoots showed an increasing trend with increased concentration of NaCl. It significantly increased in treatments with 5000 ppm (48.84 mg/g) and 7000 ppm (53.41 mg/g) concentration and showed poor growth.

Table 6. Effect of salinity on color of turfgrass.

Treatments	Color				
	Dark green	Green	Light green	Yellow green	Straw brown
T_0	100 %	0.00 %	0.00 %	0.00 %	0.00 %
T_1 (1000 ppm)	0.00 %	100 %	0.00 %	0.00 %	0.00 %
T_2 (3000 ppm)	0.00 %	11.11 %	88.89 %	0.00 %	0.00 %
T_3 (5000 ppm)	0.00 %	0.00 %	11.11 %	88.89 %	0.00 %
T_4 (7000 ppm)	0.00 %	0.00 %	0.00 %	0.00 %	100 %

The salts quickly accumulated in the leaves with each respective treatment. Best result was observed at 1000 ppm (T_1) and 3000 ppm (T_2) with maximum salt tolerance (Table 8).

Discussion

Increase in salinity effected the growth of turfgrass as compared to controlled conditions. Salinity has caused a decline in shoot and root lengths along with their fresh and dry weights, leaf growth and development. Photosynthetic system of plant was badly effected due to decrease in overall growth, because in the stress conditions stomata does not open properly and photosynthates are not formed in the desired amount (Schaan *et al.,* 2003; Pessarakeli *et al*., 2008).

Table 7. Effect of salinity on smoothness of turfgrass.

Treatments	Smoothness				
	Smoothest	Smoother	Smooth	Rough	Highly rough
T_0	88.89 %	11.11 %	0.00 %	0.00 %	0.00 %
T_1 (1000 ppm)	0.00 %	77.78%	22.22 %	0.00 %	0.00 %
T_2 (3000 ppm)	0.00 %	0.00 %	66.67 %	33.33 %	0.00 %
T_3 (5000 ppm)	0.00 %	0.00 %	0.00 %	55.56 %	44.44%
T_4 (7000 ppm)	0.00 %	0.00 %	0.00 %	0.00 %	100 %

Dudeck (2005) observed a decline of 10% in shoot growth in warm season turfgrass (Bermudagrass). Shoot dry weight also decreased in response to corresponding increasing salinity as reported in the case of Tifway and Dacca under salt stress (Taylor, 2003; Munns and Tester, 2008). Shoot DM weights decreased straight with expanded amount of NaCl for both bermudagrass and seashore paspalum (Pessarakeli *et al*., 2008). In both of these species, at the abnormal state (21,000 mg L-1) of NaCl, the decreases in shoot lengths were noteworthy. Root growth was overall decreased as salinity alters the dimension, shape, volume of epidermal and cortical cells; they become bigger in size because intercellular spaces are created between them and results in damaged root structure (Alshammary, 2004). Root growth of BS (*C. dactylon*) and KG (*Z. teneuifolia*) was good while that of SG (*D.dadactyla*), TD (*C. dactylon*), BG (*P. notatum*) and PB (*A. compressus*) were among the least tolerant group with lowest root growth as reported by (Sairam *et al*., 2002). Same results were presented by (Uddin *et al*., 2011) in the case of *P. vaginatum*, *C. dactylon*, *Z. japonica*, and *Z. matrella* decrease in root dry weight was observed. The turf quality was probably affected by burning of tissues due to absorption of high concentration of salts and imbalance of Na+: K+ across the cell membrane (Brugnoli and Lauteri, 1991). These results are also in confirmation with the findings of Dean *et al.* (1996). However, salinity causes lower osmotic potential, loss of turgor potential, ion toxicity, and nutritional disturbances. Color of the turfgrass was shifted from dark green to straw brown color due to the effects of salinity on chlorophyll contents (Ashraf *et al*., 2005). It impacts the chlorophyll like closing of stomata as a consequence of drought due to high salt concentration (Kawasaki *et al*., 2001).

Table 8. Effect of salinity on Na+ and Cl- concentration.

Treatments	Salt conc. (ppm)	Na^+ conc.	Cl^- conc.
T_0	0	32.727 D	5.9833 E
T_1	1000	33.810 D	9.3400 D
T_2	3000	47.013 C	13.837 C
T_3	5000	48.840 B	15.373 B
T_4	7000	53.417 A	17.577 A

Smoothness decreased linearly and roughness appeared as interveinal stains and deformed leaves which turned yellow and brown as the slat concentration increased. Similar results have been also found in the many grass species evaluated for salt tolerance showing deformation of tissues with the increase in stress and accumulation of salt that caused inferior quality parameters of turf grasses (Sivritepe *et al.*, 2008). Increased Na^+ and Cl^- concentrations showed poor growth. Best result was observed at 1000 ppm (T1) and 3000 ppm (T2) with maximum salt tolerance due to the ability of plants to store and accumulate the salts in salt glands and then pass it on to the leaves (Duncan, 2005; Adavi *et al.*, 2006; Lee *et al.*, 2007).

As the level of Na+ increased, the salt water potential get disturbs and effects the plant growth. Same results were also studied earlier by Chen *et al.* (2009), in which Na+ concentration increased significantly in 'Diamond' and 'Z080', but significant increase was observed at 180 and 360 mM in 'Adalayd' and 'C291' respectively. Shoot Na+ and Cl- concentrations increased with increased salinity in St. Augustine grass at 400 Mm and Japanese lawn grass accumulated high levels of shoot Na+ and Cl- at 200 mM, while centipede accumulated high Na+ and Cl- levels at 100 Mm (Munns *et al.*, 1993; Marcum *et al.*, 1994).

Conclusion

On the basis of conducted research it is concluded that different salinity levels have significant effect on the growth of turfgrass. Salinity tolerance was supreme at 3000 ppm. Shoot and root length, fresh and dry weight and number of stolons were maintained at 3000 ppm but decreased at 7000 ppm. Leaf firing, concentration of Na^+ and Cl^- was found to be increased till 7000 ppm. Salinity is a hurdle for the development of turfgrass industry because of unavailability of pure water for irrigation. Salt tolerant grasses are needed to secure the future in terms of pure water and food. Bermudagrass (*Cynadon dactylon*) has shown good salt tolerance under stress conditions.

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