



# Effect of Salinity on Warm Season Turf Grass Species

Purushottam Kumar Nandu <sup>a\*</sup>, Samir E. Topno <sup>a</sup>,  
V. M. Prasad <sup>a</sup> and Nini R. Kuotsu <sup>b</sup>

<sup>a</sup> Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, India.

<sup>b</sup> School of Agricultural Science and Rural Development, Medziphema Campus, Nagaland, India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJPSS/2023/v35i193558

### Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/104871>

**Original Research Article**

**Received: 10/06/2023**

**Accepted: 14/08/2023**

**Published: 19/08/2023**

## ABSTRACT

The demand for salinity tolerant turf grasses is increasing due to augmented use of effluent or low-quality water for turf irrigation. Fresh water, along with soil Salinization in many locations, has raised the requirement for salt-tolerant turf grass screening. Physiological responses to salinity and relative salt tolerance of Five C4 turf grasses, two variety of *Cynodon dactylon* (Bermuda grass), *Zoysia matrella* (Manilla grass), *Zoysia japonica* (Zoysia Grass) and *Paspalum notatum* (Bahia grass) were investigated during the study at Department of Horticulture Sam Higginbottom University of Agriculture Technology and Science, Prayagraj. Turf grasses were planted in plastic pots filled with sand: cocopeat: vermiculite (2:1:1) and irrigated with different concentration of salinity levels (0.6, 5.0, 10.0, 15 dS m<sup>-1</sup>). Salinity tolerance was evaluated based on leaf length leaf Wirth leaf firing, shoots and root growth reduction, proline content, total chlorophyll content RGB content and relative water content was subjected to analysis of variance. Among the four turf grass species Bahia grass found to be most salt tolerant turf grass followed by Z. matrella while Zosia japonica was least tolerant turf grass against salt stress.

\*Corresponding author: E-mail: [nanduraj881997@gmail.com](mailto:nanduraj881997@gmail.com);

**Keywords:** *Cynodon dactylon*; *Paspalum notatum*; turfgrass; *Zoysia matrella*;  $dS\ m^{-1}$ .

## 1. INTRODUCTION

“Salinity causes major environmental factors limiting plant growth and productivity in many areas of the world. Salinity is one of the most important abiotic stresses widely distributed in both irrigated and non-irrigated areas of the world. Plants that grow on saline soils are confronted with soil solutions exhibiting a wide range of concentrations of dissolved salts. Concentrations fluctuate because of changes in water source, drainage, evapo transpiration, solute availability, and hydrostatic pressures. The leaves of glycophytic plants cannot retain high levels of salt without injury. In addition to the osmotic effect of concentrated solutes, there are ionic effects that arise from the specific composition of the solute flowing through plant tissues. Internal excesses of ions may cause membrane damage, which interferes with solute balances or causes shifts in nutrient concentrations [1-5]. Some specific symptoms of plant damage which may be recognized especially in the leaves are color change, tip-burn, marginal necrosis, and succulence. There are several potential turf grass species that may be appropriate at various salinity levels of seawater. The demand for salinity-tolerant turf grasses is increasing due to augmented use of effluent or low-quality water (sea water) for turf irrigation [6-8]. This need has been exacerbated by rapid urbanization (and associated turf grass acreage increase) in arid/semiarid regions having intense competition for limited potable water resources and in coastal areas where salt water intrusion into fresh water irrigation wells is common” [9]. “Salinity is a major a biotic environmental stress that is reported to be responsible for reducing plant growth across the globe. Salt tolerant turf grass are becoming essential in many areas of the world because of salt accumulation on soil restriction on ground water use and salt water intrusion into ground water” [10]. “Physiological response to salinity includes growth suppression and lowered osmotic potential” [11].

“ Salt tolerant plants have the ability to minimize these detrimental effects by producing a series of morphological, physiological and biochemical process” [12]. “Sodium chloride (NaCl) is the major compound contributing salinity in soils and more salt tolerant turf grasses are required to cope the problem” [13]. “Osmotic balance or osmoregulation is certainly a crucial factor for the

survival of a plant under salt – stressed condition. Generally plant has plant have developed different adaptive mechanism to mitigate salinity under salinity under saline environments” [14,15,16,17].

The goal of this review is to create greater awareness of salt-tolerant turf grasses, their current and potential uses, and their potential use in developing countries. The future for irrigating turf may rely on the use of moderate-to high-salinity water and, in order to ensure that the turf system is sustainable, will rely on the use of salt-tolerant grasses and an improved knowledge of the effects of salinity on turf grasses.

“Among these, salt exclusion is considered to be the most important adaptive feature of non halophytic plants, whilst most tolerant halophytes are salt accumulators” [18]. “Salt-accumulating halophytes are very crucial for osmotic adjustment. It could be achieved in the following ways: (i) by accumulating inorganic osmolyte (K<sup>+</sup>) and/or (ii) accumulating organic osmolytes such as proline. Therefore, salt-tolerant halophytic plants have the capability to minimize the detrimental effects by morphological means and physiological or biochemical processes” [12]. “Some of the turf grass species are halophytic in nature. So salt-tolerant turf varieties would allow landscape development in saline environments and would be ideal in such environments, where limited or no fresh water is available for irrigation and saline water is the only option for irrigation practices. Interestingly, the development of turf grass industry especially in the coastal areas of India is an emerging field. To the best of our knowledge, published literatures are very scanty on salt tolerance studies in turf grass species, which have been or being conducted in India [19-23]. Therefore, this study was framed to determine the relative salinity tolerance and growth response of five important turf grass species to salinity. The relative salt tolerance among most of the widely used turf grass species and cultivars has not been adequately studied. Those species possessing some level of salt tolerance could provide more acceptable turf in areas where only low quality irrigation water is available or saline soil conditions exist. Many plants can be grown using land and water unsuitable for conventional crops and can provide food, fuel, fodder, fiber, resin, essential oils, and pharmaceutical products and can be

used for landscape reintegration. There are a number of potential turf grass species that may be appropriate at various salinity levels” [24,25-27].

This study was carried out into response of warm season turf grasses on different levels of salinity and the study of the performance of different warm season turf grasses.

## 2. MATERIALS AND METHODS

The present study entitled Effect of Salinity on Warm season turf-grass species was carried out at Department of Horticulture, Naini agriculture Institute, Sam Higginbottom university of Agriculture Technology and Science Naini Prayagraj U.P. during July to December 2022. The objective was finding the most salt tolerant turf grass species and most suitable turf grasses in Prayagraj agro climatic condition. The detail of various material used and the method employed in carrying out the experiment and described in the detailed in this chapter under appropriate heading.

**Table 1. Turf grass species used in this study**

SI No.	Variety
1	Manila grass ( <i>Zoysia. Matrella</i> )
2	Bermuda grass Tift-Dwarf-419
3	Bahia Grass ( <i>Paspalum notatum</i> )
4	Bermuda grass Selection-1 ( <i>Cynodon dactylon</i> )
5	Zoysia /Japanese lawn grass ( <i>Zoysia. japonica</i> )

**Visual Appeal of Turf:** -The colour of individual green leaves recorder with RHS colour chart and corresponding colour was recorded for visual appeal of turf.

**Fresh weight of Shoot:** - “At the end of experiment (four weeks after salt initiation), shoots above the soil surface were harvested and washed with tap water and then distilled water to remove all potting mixture particles” [24].

**Dry weight of Shoots:** - “After harvesting the shoots, roots were removed from the pots, washed with tap water, and rinsed with distilled water. The shoot and root samples were then oven-dried to a constant weight at 70°C for 3 days. The dry weight (g/pot) was recorded for each treatment” [24].

**Dry weight of Roots:-** “At the end of experiment (four weeks after salt initiation), shoots above the soil surface were harvested and washed with tap water and then distilled water to remove all potting mixture particles then weighted is estimated. The root samples were then oven-dried to a constant weight at 70°C for 3 days. The dry weight (g/pot) was recorded for each treatment” [24].

**Leaf Length:** - Leaf length was taken before application of treatment and after application of treatment on weekly basis.

**Leaf Width:** - Leaf width is taken before application of treatment and after application of treatment on weekly basis.

**Firing of Leaves:** -“Leaf firing was estimated as total percentage of chlorotic leaf area, with 0% corresponding to no leaf firing and 100% for total brown leaves” [24].

**Chlorophyll Content:** - The leaves were collected from few randomly selected plants for estimating chlorophyll content, Chlorophyll meter SPAD 502 plus were used to know the chlorophyll content in leaves. It measures the absorbance of the leaf in the Red and near-infrared region. Using this two absorbance the meter calculation a numerical SPAD value is proportional to the amount of chlorophyll present in leaves.

**Relative water content:** - Relative water content (RWC) was estimated using formula given by Barr [28] and expressed in percentage. 100 mg of leaf tissue was taken and placed in Petridis for four hours and turgid weight measured. Relative water content was then calculated using the following formula:

$$\text{RWC (\%)} = \frac{(\text{Fresh weight}) - (\text{Dry weight})}{(\text{Turgid weight}) - (\text{Dry weight})} \times 100$$

**Determination of Proline content:** - Proline was estimated by following method of [29]. “Fresh leaf tissue (0.5 g) was homogenized in 10ml of 3% sulfosalicylic acid, and the homogenate was filtered through Whatman no. 2 filter paper. Two milliliters of the filtrate were brought to reaction with 2ml acid ninhydrin solution (1.25 g ninhydrin in 30ml glacial acetic acid), 20mL ortho-phosphoric acid (6-M), and 2ml of glacial acetic acid for 1 h at 100°C. The

reaction was terminated in an ice bath. The reaction mixture was extracted with 4mL toluene, mixed vigorously by passing a continuous stream of air for 1-2 min. The chromophore containing toluene was aspirated from the aqueous phase, warmed at room temperature, and the absorbance was recorded spectrophotometrically at 520 nm [24]. The proline concentration was determined from a standard curve and calculated on fresh weight basis as follows:

$$\frac{\mu\text{mol proline/g fresh weight} = \mu\text{g proline/ml} \times \text{ml of toluene}}{115.5 \times 100}$$

### 3. RESULTS AND DISCUSSION

**1. Determination of visual appeal of Turf Grass (RGB Content before Treatment):** -The data presented in Table 2 in relation to leaf colour of different turf grasses recorded different colour according to RHS colour chart before or after treatment. After the NaCl treatment the different turf grasses exhibited colour which ranged from green group N 144 A in Manila grass, N144 B was found in Bermuda grass Var. Tif- Dwarf N144 D was found in Hybrid Bermuda grass Var. Selection- 1 and 145 D was found in Zoysia grass. During the month of December significant variation in leaf colour among different turf grasses could be attributed to their genetic makeup resulting in different pigments and their proportion leading to different colour in turf grasses.

**2. Fresh Weight of Shoot (g):** It is clear from the data presented in Table 3 that the effect of treatment, species and interaction was found in significant with respect to fresh shoot weight. Among the different turf grass species, it was found in maximum fresh shoot weight in Bahia grass (90.64 g/pot) followed by Hybrid Bermuda var. Selection -1 (88.24 g/pot), i.e., 6.24 % and 4.3% reduction in fresh shoot weight. Among the concentration of NaCl it was observed that

Maximum fresh shoot weight recorded in T<sub>0</sub> i.e., Control (5.16 g/pot) and Minimum was recorded in treatment T<sub>4</sub> at 15 dSm<sup>-1</sup> (4.14 g/pot). The interaction data show that the fresh shoot weight of all the species significantly decreases with respect to increase salinity effect.

**3. Dry Shoot weight (g):** "It is clear from the data presented in Table 4 that the effect of treatment, species and interaction was found in

significant with respect to Dry shoot weight. Among the different turf grass species, it was found in maximum dry shoot weight in Bahia grass (4.15 g/pot) followed by Hybrid Bermuda var. Selection -1 (2.87 g/pot), i.e., 33.33% and 25% reduction in fresh shoot weight. Among the concentration of NaCl it was observed that maximum fresh shoot weight recorded in T<sub>0</sub> i.e., Control (3.14 g/pot) and Minimum was recorded in treatment T<sub>4</sub> at 15 dSm<sup>-1</sup> (2.24 g/pot). The interaction data show that the fresh shoot weight of all the species significantly decreases with respect to increase salinity effect. A common response of plant of plants to salinity in shoot dehydration and loss of cell turgor, resulting in reduced growth rate" [30]. "High shoot growth rate of Bahia grass at the highest salinity may have resulted from maintenance of shoot tissue succulence. Rather than comparing absolute growth rates under salt stress, salinity tolerance is better expressed as relative shoot growth reduction with increased salinity, which is an indication of relative plant vigor under stress" [31].

**4. Determination of dry root weight:** It is clear from the data presented in Table 5 that the effect of treatment, species and interaction was found to be significant with respect to root dry weight. Root dry weight of all turf grass species was significantly influenced by salinity. Among the different turf grass species, it was found that the maximum root dry weight observed in Hybrid Bermuda var. selection - 1(0.6g/pot) followed by Bermuda grass var. Tif- dwarf 419 (0.57 g/pot) i.e., 7.98% and 3.78% reduction in root dry weight respectively with respect to control whereas minimum root dry weight was recorded in Manila grass (0.20 g/pot) i.e., 39.37% reduction in root dry weight. Among the concentration of salt (NaCl mM) it was observed that maximum root dry weight recorded in T<sub>0</sub>, i.e., Control (0.56 g/pot) and minimum was recorded at T<sub>4</sub>, 15 dS m<sup>-1</sup>(0.33 g/pot) NaCl salt concentration which represent 36.75% reduction in root dry weight. The interaction data shows that the roots dry weight of all the species significantly decreasing with respect to the increasing salt concentration.

**5. Determination of Leaf Length:** The data presented in Table 6 and revealed that the effect of treatment, species and interaction was found to be significant with respect to leaf length. Leaf length of all turf grass species was significantly influenced by salinity. Among the different species and effect of different salinity for leaf

length was recorded high in Bahia grass (14 cm) followed by Tif – Dwarf 419 (4.52 cm) and lowest leaf length found in zoysia grass (4.19).

**6. Determination of Leaf width:** The data presented in Table 7 revealed that the effect of treatment, species and interaction was found to be significant with respect to leaf Wirth. Leaf Wirth of all turf grass species was significantly influenced by salinity. Among the different species and effect of different salinity for leaf Wirth was recorded high in Bahia grass (0.43 cm) followed by Selection- 1 (0.35 cm) and lowest leaf length found in Tif – Dwarf (0.18).

**7. Determination of Leaf firing (%):** It is evident from the data in Table 8 that the effect of treatments, species and interaction of salinity and species had significant effect on leaf firing percent. Regardless of salt concentration minimum leaf firing (%) was recorded among the species in Manila grass (17.41) while maximum leaf firing (%) was found in Hybrid Bermuda grass var. Selection -1 (25.73%). However, there was less noticeable salinity injury in Manila grass and Bermuda grass var. Tif- Dwarf 419 at all salinity levels compared to other grasses. Among the treatments of salt concentration (NaCl mM) it was observed that maximum leaf firing (%) recorded (40.5) in T<sub>4</sub>, 15 dS m<sup>-1</sup> i.e., salt level and minimum was recorded (0.00%) in treatment T<sub>0</sub> (control). At the highest salinity level of 15 ds m<sup>-1</sup> the least leaf firing was observed in Manila grass (32.13%) compared to (44.26%) leaf firing in Bahia grass. Thus, leaves firing of different varieties increases in respect to increasing concentration of salt, these findings are in accordance with the earlier report by Uddin et al. [32]. Assessment of salinity tolerance using percent leaf firing has been reported in previous studies also [33]. In fact, leaf firing has been considered as an important criterion of turf grass assessment under salt stress because leaf firing is easily noticed on turfs and also easily measured.

**8. Determination of Chlorophyll content (SPAD Value):** It is clear from the data presented in Table 9 that the effect of treatment, species and interaction was found to be significant with respect to total chlorophyll content. Chlorophyll content of all turf grass species was significantly influenced by salinity. As salinity increased, chlorophyll content decreased. Among the different turf grass species it was found that the maximum chlorophyll content (SPAD Value) observed in

Zoysia grass (18.40 mg/g) followed by Bahia grass (18.40 mg/g) and minimum was found in Hybris Bermuda var. selection - 1 (17.06 mg/g). “Among the concentration of salt (NaCl mM) it was observed that maximum chlorophyll content recorded in control (21.2 mg/g) and minimum was recorded in T<sub>4</sub> 15 dS m<sup>-1</sup>(14.62 mg/g). Perusal of data in Table 5. 2 shows that interaction among species and NaCl concentration resulted and species were ranked at the highest level of salinity in the treatment T<sub>4</sub>. Thus, Bahia grass and Zoysia matrella maintained comparatively higher amounts of total chlorophyll under salt stress with marginal reductions compared to other turf species. The NaCl induced decrease in chlorophyll level is widely reported in both glycophytes and halophytes” [9,34]. “Salinity-induced chlorophyll reduction may be related either to Mg deficiency and/or chlorophyll oxidation since reactive oxygen species (ROS) generation is common in salinity stressed conditions” [35].

Similar results were reported by Babita et al. [24] in salinity effect of different turf grass species.

**9. Determination of Proline content (μmole/gfw):** The data for proline content was analyzed and presented in Table 10. It is clear from data that the shoot proline content of all grasses increased with increasing salinity. Regardless of salt concentration maximum proline content was recorded among the species in Bahia Grass (7.61 μmole/gfw) while minimum was found in manila grass (13.52 μmole/gfw). Among the treatments of salt concentration (NaCl mM) it was observed that maximum proline content recorded (7.5 μmole/gfw) in 15 dS m<sup>-1</sup> salt level and minimum was recorded (2.83 μmole/gfw) in control. The interaction data shows that the proline concentration of all the species significantly increasing in respect to the increasing salt concentration. All the grasses exhibited lower proline content at control condition but it increased as salinity level increased from control to 15 ds m<sup>-1</sup> salt concentration. The maximum proline content observed in Bahia grass (10.2 μmole/gfw) followed by Zoysia grass (8.4 μmole/gfw) at 15 dS m<sup>-1</sup> salt concentration while minimum was recorded in Mania grass (25.47 μmole/gfw). “Some compatible solutes that show an increase in concentration under salinity stress may also play significant role in osmotic adjustment, and these include proline, glycine betaine, and sugars” [36]. “Glycine betaine and proline protect enzymes (proteins) from damages caused by

salinity or dehydration stress” [37,38] “interestingly, significant proline accumulation generally occurs only after exceeding a threshold of drought or salt stress” [39]. In the current study, salinity triggered proline synthesis in response to salinity to turgor maintenance (Table 9).

**10. Determination of Relative water content:** It is clear from the data presented in Table 11 that the effect of treatment, species and interaction was found to be significant with respect to relative water content (RWC). Relative water content of all turf grass species was significantly influenced by salinity. As salinity increased, RWC decreased. Among the different turfgrass species it was found that the maximum relative water content (%) observed in case of Bermuda grass var. Tif – Dwarf 413 (33.36%) followed by Zoysia matrella (30.34%) and minimum RWC found in case of Bahia Grass (27.68%). Among the concentration of salt (NaCl mM) it was observed that maximum RWC (%) recorded in T<sub>0</sub>, i.e., control (35.38%) and minimum was recorded in treatment T<sub>4</sub> at 15 dS m<sup>-1</sup>(25.76%) NaCl salt concentration. Perusal of data in Table 5. 4 shows that interaction among species and NaCl concentration resulted and species were ranked at the highest level of salinity in the treatment T<sub>4</sub> at 15 dS m<sup>-1</sup> as Bermuda grass var. Tif- Dwarf 419 (30.1%), Zoysia matrella (25.5%), Manila

grass (25.1%) than Hybrid Bermuda var. selection- 1 (25.1%) and Bahia grass (23.1%). “The percentage relative water content (RWC) was determined as an indicator of osmotic status of turfgrass species studied. Salinity stressed plants certainly face osmotic challenges. This is in agreement with several previous reports” [14,40] “which concur that osmotic adjustment is the main mechanism for survival and growth of plants under salinity stress. Plants osmotic adjustment subjected to salt stress can occur by the accumulation of high concentration of either inorganic ions or low molecular weight organic solutes. Our studies indicated that salinity tolerance in relation to relative water content was better in Bahia grass followed by Zoysia matrella. These new salt tolerant species provide an opportunity to use very brackish sources of water” [41,28].

**Table 2. Effect of salinity of warm season turf grass species of RGB color chart**

Sl. No	Varieties	Leaf colour of turf grass
1	Manila Grass	N144A
3	Bahia Grass	N144D
4	Selection 1	144D
5	Zoysia Grass	145 D

**Table 3. Effect of salinity on warm season turf grass species of fresh shoot weight**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	4.43	4.03	3.93	3.63	3.4	3.884
Tif-Dwarf	4.46	4.26	4.1	3.93	3.4	4.03
Bahia Grass	6.73	6.46	6.2	6.06	5.9	6.27
Selection-1	4.76	4.63	4.26	4.13	3.83	4.322
Zoysia Grass	5.42	4.9	4.63	4.5	4.1	4.71
MEAN	5.16	4.86	4.62	4.45	4.13	
CD% (0.05)						
Species (S)	0.15					
Treatment (T)	0.15					
Interaction (A*B)	0.32					

**Table 4. Effect of salinity on warm season turf grass species of Dry shoot weight**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	2.4	2.2	2	1.8	1.5	1.98
Tif-Dwarf	2.4	2.1	2	1.7	1.4	1.92
Bahia Grass	4.66	4.2	4.2	4	3.7	4.152
Selection-1	3.26	3.1	2.9	2.7	2.4	2.872
Zoysia Grass	3	2.8	2.6	2.3	2.2	2.58
MEAN	3.144	2.88	2.74	2.5	2.24	

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
CD% (0.05)						
Species (S)	0.126					
Treatment (T)	0.126					
Interaction (A*B)	0.289					

**Table 5. Effect of salinity on warm season turf grass species of Dry root weight**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	0.14	0.16	0.17	0.16	0.38	0.202
Tif-Dwarf	0.87	0.27	0.9	0.44	0.41	0.578
Bahia Grass	0.43	0.34	0.94	0.65	0.36	0.544
Selection-1	0.84	0.44	0.55	0.97	0.24	0.608
Zoysia Grass	0.54	0.58	0.3	0.76	0.28	0.492
MEAN	0.564	0.358	0.572	0.596	0.334	
CD% (0.05)						
Species (S)	0.027					
Treatment (T)	0.027					
Interaction (A*B)	0.061					

**Table 6. Effect of salinity on warm season turf grass species of Leaf Length**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	Mean
Manila Grass	5	4.3	4.4	5	4.2	4.58
Tif-Dwarf	5	4.3	5	3.9	4.4	4.52
Bahia Grass	15.3	13.4	14	13.9	13.4	14
Selection-1	4	5.1	5	4.2	4.2	4.5
Zoysia Grass	4.2	4	4.3	4.2	4	4.14
MEAN	6.7	6.22	6.54	6.24	6.04	
CV	3.09					
CD% (0.05)						
Species (S)	0.16					
Treatment (T)	0.25					
Interaction (A*B)	0.559					

**Table 7. Effect of salinity on warm season turf grass species of Leaf width**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	0.18	0.23	0.22	0.17	0.18	0.20
Tif-Dwarf	0.16	0.18	0.18	0.19	0.18	0.18
Bahia Grass	0.43	0.44	0.41	0.44	0.43	0.43
Selection-1	0.43	0.35	0.30	0.35	0.33	0.35
Zoysia Grass	0.22	0.22	0.24	0.24	0.25	0.23
MEAN	0.28	0.28	0.27	0.28	0.27	
CD% (0.05)						
Species (S)	0.011					
Treatment (T)	0.011					
Interaction (A*B)	0.024					

**Table 8. Effect of salinity on warm season turf grass of Leaf firing**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	0	13.96	18.16	22.8	32.13	17.41
Tif-Dwarf	0	13.63	18.3	28.3	39.4	19.92
Bahia Grass	0	17.1	22.1	32.06	44.26	23.1
Selection-1	0	22.6	27.33	35	43.73	25.73
Zoysia Grass	0	20.33	26.53	35.36	43	25.04
MEAN	0	17.52	22.48	30.7	40.5	
CV						
CD% (0.05)						
Species (S)	1.68					
Treatment (T)	1.68					
Interaction (A*B)	3.77					

**Table 9. Effect of salinity on warm season turf grass of Chlorophyll content (SPAD Value)**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	20.3	16.7	14.2	11.6	11.1	14.78
Tif-Dwarf	21.7	19.9	18.2	16.7	15.3	18.36
Bahia Grass	22.6	20.3	18	16.1	15	18.4
Selection-1	20.8	18.8	18.2	16.3	15.2	17.86
Zoysia Grass	20.6	19.3	18.6	17.4	16.5	18.48
MEAN	21.2	19	17.44	15.62	14.62	
CV	5.94					
CD% (0.05)						
Species (S)	0.766					
Treatment (T)	0.766					
Interaction (A*B)	1.712					

**Table 10. Effect of salinity on warm season turf grass of Proline content**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	2.13	4.46	4.8	5.26	5.6	4.45
Tif-Dwarf	2.16	4.86	5.16	5.63	6.53	4.868
Bahia Grass	4.63	6.43	7.9	8.9	10.2	7.612
Selection-1	2.76	3.66	4.7	5.9	6.67	4.738
Zoysia Grass	2.5	4.9	6.5	8	8.5	6.08
MEAN	2.836	4.862	5.812	6.738	7.5	
CD% (0.05)						
Species (S)	0.189					
Treatment (T)	0.189					
Interaction (A*B)	0.423					

**Table 11. Effect of salinity on warm season turf grass of Relative water content**

Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
Manila Grass	34.9	31.4	27.5	26.1	25.1	29
Tif-Dwarf	36.9	35.2	32.8	31.8	30.1	33.36
Bahia Grass	34.3	29.9	26.7	24.4	23.1	27.68
Selection-1	32.8	31.3	30	28.4	25	29.5
Zoysia Grass	40.1	30.3	28.7	27.1	25.5	30.34



Species	T0 (Control)	T1 (0.6 dS m <sup>-1</sup> )	T2 (5.0 dS m <sup>-1</sup> )	T3 (10 dS m <sup>-1</sup> )	T4 (15 dS m <sup>-1</sup> )	MEAN
MEAN	35.8	31.62	29.14	27.56	25.76	
CD% (0.05)						
Species (S)	3.09					
Treatment (T)	3.09					
Interaction (A*B)	8.92					

#### 4. CONCLUSION

On the present experiment, it is concluded that the development of turf grass industry in the salt affected is challenging due to scarcity of fresh water for irrigation. Appropriate realistic physiological criteria are essential to define the salinity tolerance and growth response of turf grass species. Among the salinity effect studies Bahia grasses is shown best result with respect of Day taken establishment, Leaf length, Leaf width, Fresh shoot weight, Dry shoot weight, & Proline content. Highest clipping yield, mowing frequency and chlorophyll content is shown in Zoysia grass. Highest leaf firing and dry root weight is shown in Selection – 1. Relative water content is shown in Tif – Dwarf Species. Earlier establishment of turf grasses is shown in Manila grass. The conclusion is based on response of five turf grass species to salinity tolerance.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

- Dhanalakshmi R, V, Bhasker V, Subhramama. Influence of soil parameter on the establishment of turf grass species under different method of planting. Int J Curr Microbiol Appl Sci. 2018;03:2607-15.
- Flowers TJ, Colmer TD. Salinity tolerance in halophytes. New Phytol. 2008;179(4):945-63.
- Harivandi MA, Mercum KB. Are view of salt tolerance among sport field turf grass. Acta Hort. 2008;783:159-62.
- Lovella S, Potenza G, Viggiani R, Valerio M, Castronuovo D, Fascetti S, et al. Effect of salinity on warm season Turf grass species collected in a mediterranean Environment. J Agron. 2017;16:45-50.
- Malik S, Rehman SU, Younis A, Mohamad Q, Nadeem M, Riaz A. Evaluation of quality growth and physiological potential of various turf grass cultivator for shade garden. J Hortic Biotechnol. 2014;18(3):110-21.
- Roch M, Band loch DS. Morphological and developmental compression of seven green quality hybrid Bermuda grass and (*Cynodon dactylon* (L.), Pers. XC. Transvaalensis Burt-Davy) cultivars, International turf grass society Research. 2005;10:627-34.
- Sairam RK, Tyagi A, Chinnusamy V. Salinity tolerance: Cellular mechanisms and gene regulation. (in) Plant–Environment Interactions. 3rd ed Huang B, editor. Boca Raton, FL: CRC Press; 2006.
- Ubendra, Jawaharlal M, Kumar CSR. Evaluation of turf grass species suitable for tropical conditions based on quantitative and qualitative traits. 2015;10(3):1021-6.
- Abdullah Z, Khan MA, Flowers TJ. Causes of sterility in seed set of rice under salinity stress. Journal of Agronomy and Crop Science. 2001; 187(1):25–32.
- Hixson AC, Crow WT, McSorley R, Trenholm LE. Saline irrigation affects *belonolaimus longicaudatus* and *hoplolaimus galeatus* on seashore *paspalum*. Journal of Nematology 2004;37:37–44.
- Marcum KB. Use of saline and on-potable water in the turf grass industry: Constraints and developments. Agriculture Water Management. 2006;80:132,97–124.46.
- Jacoby B. Mechanism involved in salt tolerance of plants. Handbook of Plant and Crop Stress. Marcel Dekker Inc., New York. 1999;97–124.
- Harivandi A, Bulter JD, Wu L. Salinity and turfgrass culture in Turfgrass. Agronomy Monograph, ASA. CSSA and SSSA, Madison, Wis, USA. 1992;208–30.
- Agnihotri R, Chawla SL, Patil S. Evaluation of warm season turfgrasses for various qualitative and quantitative traits under Gujarat agro-climatic conditions. Indian J Agri Sci. 2017b; 87(7):934-42.
- Rhodes D, Nadolska-Orczyk A. Salinity, osmolytes and compatible solutes. (in)

- Salinity: Environment-PlantsMolecules. Lauchli A and Luttge U, (Eds). Kluwer Academic, Boston, Mass, USA; 2002.
16. Borsani O, Valpuesta V, Botella MA. Developing salt tolerant plants in a new century: a molecular biology approach. *Plant Cell, Tissue and Organ Culture*. 2003;73(2):101–15
  17. Zhang XX, Li, Chun- jie. Nan, Zhi-bia. Effect of salt and drought stress on alkaloid production in endophyte infected drunken horse grass *Biochemical systemanal ecology*. 2011;39(4-6): 471-6.
  18. Agnihotri R, Chawla SL. Performance of turf grass genotypes for growth and quality parameters for use on lawn and sports turf. *J Pharmacogn Phytochem*. 2017a;6(6):625-30.
  19. Munns R, Tester M. Mechanisms of salinity tolerance. *Annu Rev Plant Biol*. 2008;59:651-81.
  20. Munnus R. Genes and salt tolerance, Bringing them together. *New Phytol*. 2005;179:945-65.
  21. Pompeiano A, Giannini V, Gaetani M, Vita F, Guglielminetti L, Bonari E, et al. Response of worm season grasses to N fertilization and salinity. *Sci Hortic*. 2014;177:92-8.
  22. Roch M. Band loch DS. Morphological and developmental compression of seven green quality hybrid Bermuda grass and (*Cynodon dactylon* (L.), Pers. XC. Transvaalensis Burtt-Davy) cultivars, International turf grass society Research. 2005;10:627-34.
  23. Sairam RK, Tyagi A, Chinnusamy V. Salinity tolerance: Cellular mechanisms and gene regulation. (in) *Plant–Environment Interactions*. 3rd ed Huang B, editor. Boca Raton, FL: CRC Press; 2006.
  24. Alshammary SF, Qian YL, Wallner SJ. Growth response of four turfgrass species to salinity. *Agricultural Water Management*. 2004;66(2):97–111.
  25. Uddin MK, Juraimi AS, Ismail MR, Othman R, Rahim AA. Effect of salinity stress on nutrient uptake and chlorophyll content of tropical turfgrass species. *Aust J Crop Sci*. 2013;5(6):620-9.
  26. Uddin MK, Juraimi AS. Salinity tolerance turf grass: history and prospects. *Sci World J*. 2013;1-6.
  27. Wadekar VDP, PV, Kadamb GB, Gawade NV, Bosale PB. Evaluation of lawn grass based on qualitative and morphological traits. *Int J Chem Stud*. 2018;6(4):1175-9.
  28. Barr ME. The Venturiaceae in North America. *Canadian Journal of Botany*. 1968;46(6):799–864.
  29. Bates LS, Waldren RP, Teare ID. Rapid determination of free proline for water-stress studies. *Plant and Soil*. 1973; 39(1): 205–7.
  30. Neumann PM, Volkenburgh EV, Cleland RE. Salinity stress inhibits bean leaf expansion by reducing turgor, not wall extensibility. *Plant Physiology*. 1988;88: 233–37.
  31. Maas EV, Hoffman GJ. Crop salt tolerance-current assessment. *ASCE Journal of the Irrigation and Drainage Division*. 1977;103:115–34.
  32. Uddin KM, Juraimi AS, Ismail MR, Othman R, Rahim AA. Relatively salinity tolerance of warm season turf grass species. *J Environ Biol*. 2011;32(3):309-12.
  33. Marcum KB. Salinity tolerance mechanisms of six C4 turf grasses. *Journal of American Society of Horticultural Sciences*. 1994;119(4):779–84
  34. Shabala L, Cuin TA, Newman IA, Shabala S. Salinityinduced ion flux patterns from the excised roots of *Arabidopsis* sos mutants. *Planta*. 2005;222(6):1041–50.
  35. Moradi F, Ismail AM. Responses of photosynthesis, chlorophyll fluorescence and ROS-scavenging systems to salt stress during seedling and reproductive stages in rice. *Annals of Botany*. 2007;99(6):1161–73.
  36. Storey RG, Jones RW. Response of *Atriplex spongiosa* and *Suaeda monoica* to salinity. *Plant Physiology*. 1979; 63(1):156–62.
  37. Paleg LG, Stewart GR, Bradbeer JW. Proline and glycine betaine influence protein salvation. *Plant Physiology*. 1984;75(4):974–8.
  38. Smirnoff N, Cumbes QJ. Hydroxyl radical scavenging activity of compatible solutes. *Photochemistry*. 1989;28(4): 1057–60.
  39. Cavalieri AJ, Huang AHC. Evaluation of proline accumulation in the adaptation of diverse species of marsh halophytes to the saline environment. *American Journal of Botany*. 1979;66(3):307–12.

40. Lee G, Carrow RN, Duncan RR. Photosynthetic responses to salinity stress of halophytic seashore paspalum ecotypes. Plant Science. 2004;166(6): 1417–25.
41. Babita S, Sindhu SS, Ajay A, Harendra Y. Evaluation of physiological and growing behavior of warm season turfgrass species against salinity stress. Indian J Agric Sci. 2019;89(3):482-8.

© 2023Nandu et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License(<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle5.com/review-history/104871>