International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 258-263

Received: 20-05-2018
Accepted: 21-06-2018

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Evaluation of warm season turfgrasses on for physiological and biochemical traits under salt affected soil condition

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Abstract
Turfgrass are the essential and basic unite of landscaping salinity is one of the major environmental factor which limits turf growth and quality. Salt accumulation in plant hinder water absorption, inducing physiological drought in turfgrass, scarcity of fresh water along with soil stalinization has resulted in an increasing need for screening and evaluation of salt tolerant turfgrasses. With this background the present research was laid out at Horticultural College and Research Institute for Women, Tiruchirappalli. Tamil Nadu Agricultural University, Coimbatore. To evaluate the growth response of warm season turfgrasses *viz*., *Zoysia japonica* (T_1), *Zoysia tenuifolia* (T_2), *Cynodon dactylon* (T_3), *Paspalum vaginatum* (T_4), *Stenotaphrum secundatum* (T_5), *Stenotaphrum secundatum* cv Variegata (T_6), *Sporobolus tremulus* (T_7), *Poa pratensis* (T_8) and *Axonopus compressus* (T_9) under salinity ecosystem. Among the turfgrass species, *Paspalum vaginatum* (T_4) recorded the best suitable turfgrass in the salinity ecosystem, followed by *Sporobolus tremulus* (T_7) and *Cynodon dactylon* (T_3) respectively.

Keywords: Evaluation of turfgrasses, turf quality, salinity tolerance, warm season turfgrasses

Introduction
A beautiful lawn is always an emotional appeal that can be translated into spiritual comforts. The lawn typically offers peace, serenity and helps to escape from the glare and hard surfaces of sidewalks. Lawn serves decorative function and enhances the beauty of a landscape so is called as heart of the garden. Nowadays, due to faster urbanization process more than half of the world population lives in urban (~3.5 billion) particularly in India and China. There will be an increase by 10 per cent in 2030 (Lal and Augustin, 2012) [22]. And, the contribution of urban landscape strongly influences the biogeochemical cycles of carbon, nitrogen and water, which alters the global climate through the gaseous emissions.
Soil salinity is an escalating problem worldwide (Shahid, 2013) [33]. More than 20 per cent of cultivated land worldwide is affected by salt stress, and the amount is increasing every day (Gupta and Huang, 2014) [14].
The turfgrass industry is a billion dollar industry while establishing and maintaining turf requires quality irrigation water which is the most important challenge worldwide. Salinity is a major abiotic environmental stress that is reported to be responsible for reducing plant growth across the globe. Sea water intrusion, in coastal states, has imposed salinity problems in turfgrass culture Sodium chloride (NaCl) is the major compound contributing salinity in soils, and more salt-tolerant turfgrasses are required to cope this problem. Therefore, development of salt-tolerant turfgrasses is becoming increasingly necessary in many parts of the world. This increased the need of salt tolerant grasses continues because of salt accumulation in soil, increased restrictions on ground water utilization, traffic and salt water intrusion into ground water. In general, turfgrass species and cultivars within a species vary in their salinity tolerance. These variations probably result from genetic variations, especially in genes relating to salinity tolerance mechanisms and their interactions with environments (Duncan and Carrow, 1999) [13].

Materials and Methods
Field experiment was conducted in the Horticultural College and Research Institute for Women, Tiruchirappalli, Tamil Nadu Agricultural University and Coimbatore.

During 2016-2017. The experimental field plot size of 1.00 m X 2.25m, for growing the turfgrass species under open field condition. Sandy clay loam parent material basaltic genesis was used as medium. The experimental plot was ploughed up to the depth of 30 cm. The soil EC 0.78 to 1.68 dSm^{-1} organic carbon 0.83 per cent, pH ranges from 8.31 to 8.98. Temperatures range between 18.00 to 43.5 ºC, RH 41 to 86 per cent. The irrigation water quality with EC1.2 dSm^{-1}, pH 9.0, TSS 688ppm, Ca 30 mg g^{-1}, Mg 30 mg g^{-1}, Na 185 mg g^{-1} Bicarbonate 231 mg g^{-1}, SAR 5.3 meq^{-1}. Average rainfall during the cropping period was 68.7mm in 2016 and 43.85mm in 2017.

Planting materials of nine turfgrass species were examined in this study which were salinity tolerance based on earlier findings of Liu *et al*., 2009 [23]. Sods of each grass species were collected from two years old turfgrasses in botanical garden Tamil Nadu Agricultural University, Coimbatore and Horticultural College and Research Institute for Women, Tiruchirappalli. Tamil Nadu Agricultural University. *Zoysia japonica,* Zoysia *tenuifolia, Cynodon dactylon, Paspalum vaginatum, Stenotaphrum secundatum, Stenotaphrum secundatum* cv varigatum, *Sporobolus tremulus*, *Poa pratensis* and *Axonopus compressus,* were used in this study. The experiment was laid out in randomized block desgin and planting by springing method. Grasss were irrigated with borewell water twice a day in the initial period by using a hose pipe, after establishment the irrigation frequencies extended based on their requirements. Foliar application of urea at the rate of 4g N sq $m^{-1}month^{-1}$ and 19:19:19 at the rate of 10g sq $m^{-1}month^{-1}$ were applied alternatively. Micronutrients application was carried out once in every month uniformly to all the treatments $FeSO_4$ at the rate of 4 gm sq $m^{-1}month^{-1}$. Hand weeding was carried out at frequent intervals in all stages of its growth. The physiological parameters *viz*., relative water content (Barrs and Weatherly, 1962) [5], chlorophyll content (Yoshida *et al*., 1971) [42], and electrolyte leakage (Blum and Ebercon (1981) [9].), for biochemical parameters catalase activity (Barber, 1980) [4], total non-structural carbohydrates (Hedge and Hofreiter, 1962) [16], and proline content Bates *et al*. (1973) [6]

Statistical Analysis

The experiment was conducted randomized block design to understand the effect of treatments for the different parameters examined in turf and groundcovers in the field and mean comparisons were made after computing LSD values and ANOVA with P<0.05 level. All the statistical analysis was achieved utilizing the statistical analysis software AGRES.

Result and discussion

Relative Water Content (per cent)

In turfgrass species, the relative water content was estimated and presented in Table 1. The values were highly significant. Among the nine turfgrass species studied *Paspalum vaginatum* (T_4) indicates its superior performance and registered high RWC with 82.26 per cent followed by *Sporobolus tremulus* (T_7) with 79.73 per cent. On the other *Zoysia japonica* 72.75 per cent on par with *Poa pratensis* (72.99 per cent), *Cynodon dactylon* (78.88 per cent) On par with *Sporobolus tremulus* (79.99 per cent) *Stenotaphrum secundatum* (75.48 per cent) and *Stenotaphrum secundatum* cv Variegata (74.73 per cent). The minimum relative water content recorded in *Axonopus compressus* (T_9) of 67.08 per cent

Plants often suffer from water deficit and ion toxicity when exposed to salinity, resulting in growth inhibition. Relative water content in shoot growth of salt-sensitive turfgrass species are reduced more rapidly than those in salt-tolerant turfgrasses under salinity stress (Alshammary *et al.*, 2004[2]; Liu *et al.*, 2009[23]; Suplick-Ploense *et al.*, 2002[37]). Significant variations were found among the turfgrasses exposed to salt affected soil ecosystem, treatments for the trait relative water content (RWC). The highest RWC was shown by *Paspalum vaginatum* (T_4) under the salinity condition depicting that it has greater tolerance to salinity compared to *Sporobolus tremulus* (T_7), *Cynodon dactylon* (3), and other grass species. *Sporobolus tremulus* (T_7), had better RWC in relation to *Cynodon dactylon* and *Zoysia japonica*. Among the twelve native turfgrasses studied under tropical condtion the highest RWC recorded in *Cynodon dactylon X Cynodon transvaalensis* (Ubendra *et at*. 2015) [38]. But White *et al.*(2001) [41], reported that *Zoysia japonica* genotypes with high RWC have better recovery from stress and required less supplemental irrigation. Salinity treatment affected RWC, The response of plant to salinity stress occur mainly through osmotic-changing phase and ion specific phase (Munns and Tester, 2008) [27]. The results suggested that ion imbalance might cause growth reduction.

Table 1: Effect of salinity on relative water content (RWC) and total chlorophyll content (mg g^{-1} fw) of turf species

Treatments	Turfgrass species	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean
T_1	*Zoysia japonica*	67.50	71.63	81.47	74.81	68.32	72.75	2.60	2.52	2.91	1.89	1.68	2.32
T_2	*Zoysia tenuifolia*	66.87	68.58	83.84	69.26	66.33	70.98	2.34	1.87	2.68	1.91	1.59	2.08
T_3	*Cynodon dactylon*	83.80	75.36	86.28	76.31	72.64	78.88	3.16	2.79	3.82	2.92	2.49	3.04
T_4	*Paspalum vaginatum*	86.84	76.43	89.65	82.76	75.64	82.26	2.56	2.37	2.60	2.49	2.16	2.44
T_5	*Stenotaphrum secundatum*	76.41	72.62	83.32	73.24	71.81	75.48	2.54	2.23	2.58	2.34	1.78	2.29
T_6	*Stenotaphrum secundatum cv Variegata*	80.25	69.74	84.69	71.53	67.45	74.73	1.91	1.68	2.28	1.73	1.69	1.86
T_7	*Sporobolus tremulus*	84.25	75.62	87.04	77.20	74.52	79.73	2.96	2.66	3.08	2.86	2.28	2.77
T_8	*Poa pratensis*	79.49	71.36	82.56	66.31	65.24	72.99	2.30	1.89	2.06	2.19	1.52	1.99
T_9	*Axonopus compressus*	66.95	69.12	69.63	65.07	64.65	67.08	1.81	1.43	1.93	1.37	0.97	1.50
Mean		76.93	72.27	83.16	72.94	69.62		2.46	2.16	2.66	2.13	1.79	
SEd		1.86	1.93	1.99	1.86	0.84		0.04	0.05	0.05	0.48	0.03	
CD (0.05 %)		3.94*	4.09*	4.22*	3.95*	1.80*		0.09*	0.11*	0.12*	0.66*	0.08*	

*Significant at 5 per cent level

Total Chlorophyll (mg g^{-1})

Significant influence was recorded in total chlorophyll content of turfgrass species. The observation was recorded in Table 2. The maximum chlorophyll content was recorded in *Cynodon dactylon* (T_3) with 3.04 mg g^{-1}, followed by *Sporobolus tremulus* (T_7) with 2.77 mg g^{-1}. On the other hand

Zoysia japonica (T_1) (2.32mg g^{-1}) on par with *Stenotaphrum secundatum* (T_5) with 2.29 mg g^{-1}. The minimum chlorophyll content was recorded in *Axonopus compressus* (T_9) with1.50 mg g^{-1}.

Our results indicated that low salinity level did not cause reduction in chlorophyll content. In the present study *Cynodon dactylon* (T_3) recorded the highest chlorophyll content and it was followed by *Sporobolus tremulus* (T_7). This is the accordance with the statement that darker the leaf colour, more is the chlorophyll content (Johnson, 1973) [18]. The *Cynodon dactylon* (T_3), grass had greater chlorophyll content compared to other grasses like *Sporobolus tremulus* (T_7), *Zoysia japonica* (T_1), *Paspalum vaginatum* (T_4) and other grass species, this might be due to the genetic character which may be responsible for higher chlorophyll content in the leaves of *Cynodon dactylon* (T_3). This indicates that leaf colour would be a visible index for measuring salt stress.

Table 2: Effect of salinity on electrolyte leakage per cent and catalase activity (µmol of H_2O_2 used min $^{-1}$ g^{-1}) of turfgrasse

Treatments	Turfgrass species	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean
T_1	*Zoysia japonica*	23.81	24.56	24.43	26.82	27.82	25.49	32.51	17.62	16.23	15.34	15.21	19.38
T_2	*Zoysia tenuifolia*	21.96	22.68	22.53	23.34	26.37	23.38	30.29	16.28	15.13	14.43	14.04	18.03
T_3	*Cynodon dactylon*	19.84	23.36	23.12	24.43	25.74	23.30	33.42	24.34	20.67	13.16	12.97	20.91
T_4	*Paspalum vaginatum*	17.26	18.26	18.19	19.29	19.63	18.53	36.61	26.75	26.42	24.47	22.12	27.27
T_5	*Stenotaphrum secundatum*	19.07	21.03	20.54	22.67	26.56	21.97	31.26	22.73	23.26	21.43	20.86	23.91
T_6	*Stenotaphrum secundatum* cv Variegata	22.92	24.81	24.12	26.41	28.62	25.38	29.94	20.39	22.19	20.46	20.09	22.61
T_7	*Sporobolus tremulus*	17.68	18.31	18.45	21.72	23.48	19.93	34.49	25.51	25.26	23.86	21.71	26.17
T_8	*Poa pratensis*	24.72	25.38	24.82	25.19	27.34	25.49	28.73	13.17	15.58	13.38	12.59	16.69
T_9	*Axonopus compressus*	36.59	39.14	38.78	39.42	40.18	38.82	24.35	18.82	14.62	12.22	10.08	16.02
Mean		22.65	24.17	23.89	25.48	27.30		31.29	20.62	19.93	17.64	16.63	
SEd		0.33	0.50	0.39	0.66	0.49		0.56	0.49	0.43	0.33	0.32	
CD (0.05 %)		1.20*	1.07*	0.83*	1.39*	1.05*		1.20*	1.04*	0.92*	0.70*	0.68*	

*Significant at 5 per cent level

Electrolyte Leakage (per cent)

The electrolyte leakage is an indication of membrane injury caused by external salt environment. The values are presented in Table 2. Among the turfgrass studied the minimum electrolyte leakage was recorded in *Paspalum vaginatum* (T_4) with 18.53 per cent, followed by *Sporobolus tremulus* (T_7) with 19.93 per cent. On the other hand *Zoysia japonica* (T_1) on par with *Poa pratensis* (T_8) with 25.49 per cent. The highest electrolyte leakage was noticed in *Axonopus compressus* (T_9) with 38.82 per cent.

Leaf electrolyte leakage (EL) showed a sharper increase in *Axonopus compressus* (T_9) than that of other grasses under the salinity treatments this confirms that susceptible nature of *Axonopus compressus* (T_9). *Paspalum vaginatum* (T_4) has shown more salinity tolerance compared to *Sporobolus tremulus* (T_7), *Stenotaphrum secundatum* (T_5) and others. This result is similar to the findings of Liu *et al*., (2011) [24]. Salinity levels affected photosynthesis through stomatal closure, damage in cell wall and the photochemical reactions and carbon assimilation for the other remaining grasses like *Cynodon dactylon* (T_3) and *Zoysia japonica* (T_1) *etc*. (Megdichi *et al*, 2008[26]; Stoeva and Kaymakanova, 2008) [35]. Alarcon *et al*. (1993) [1]. Apparently *Paspalum vaginatum* (T_4) has strong membrane integrity to maintain osmolytes against leaking out, which required less organic osmolytes for osmotic adjustment, which was evident from the least leaf firing showed by *Paspalum vaginatum* (T_4) in the study. The similar results also indicated by Uddin *et al*., (2012) [39].

Biochemical parameters (µmol of H_2O_2 used min^{-1} g^{-1})

Catalase activity

Catalase is an important scavenging enzyme responsible to offshoot the pre radical damage. The amount of catalase was estimated and presented in Table 2. The highest catalase activity was recorded in *Paspalum vaginatum* (T_4) with 27.27 (µmol of H_2O_2 used min^{-1} g^{-1}), followed by *Sporobolus tremulus* (T_7) with 26.17 (µmol of H_2O_2 used min^{-1} g^{-1}), However *Axonopus compressus* (T_9) recorded least catalase activity during the experimental period with 16.02 (µmol of H_2O_2 used min^{-1} g^{-1}) and which is on par with *Poa pratensis* (16.69 µmol of H_2O_2 used min^{-1} g^{-1}).

In the present study, the changes in catalase (CAT) activity suggest that oxidative stress is an important component of *Paspalum vaginatum* (T_4) and *Sporobolus tremulus* (T_7), the least CAT in *Axonopus compressus* (T_9). The decrease CAT content in turfgrasses indicated less lipid per-oxidation and more oxidative damage to the grasses. The low CAT content in *Axonopus compressus* (T_9) grass compared to *Paspalum vaginatum* (T_4), *Sporobolus tremulus* (T_7) and others grasses implied that the oxidative damage was more severe in *Axonopus compressus* (T_9), grass and that the antioxidant defense mechanism of *Axonopus compressus* (T_9) grass is less effective than those of *Paspalum vaginatum* (T_4), *Sporobolus tremulus* (T_7) and others. Similar evidence of lipid per-oxidation and antioxidant activity has been reported by other researches (Shalata and Tal, 1998[34], Ben Amor *et al*, 2006[7]; P'erez *et al*., 2009 [28]; *et al*., 2010) [32].

In plants, CAT is considered to be the most important enzymes regulating intercellular levels of H_2O_2. CAT is primarily localized in peroxisomes and glyoxysomes where it breaks down H_2O_2 into H_2O and O (singlet oxygen). Ben Amor *et al.* (2007) [8] reported that H_2O_2 accumulation under salinity stress was related to a decrease in CAT activity. The data from the study showed that CAT activity decreased in both shoots of *Cynodon dactylon* and *Zoysia japonica, Sporobolus tremulus* (T_7) and other grass species under salinity stress. However, the change in CAT activity was least in *Seashore paspalum* which might be due to effective scavenging of H_2O_2 by Seashore paspalum than the Bermuda grass and other grass species.

Total Nonstructural Carbohydrates (mg g^{-1} dw)

Total nonstructural carbohydrate (TNC) in shoot, varied significantly among the turfgrasses the values are presented in Table 3. Among the turfgrass species *Paspalum vaginatum* (T_4) showed the highest total non-structural carbohydrates with 143.27 mg g^{-1} dw, followed by *Zoysia japonica* (T_1) of 136.68 mg g^{-1}dw. On the other hand *Stenotaphrum* *secundatum* with 126.93 mg g^{-1} dw, on par with *Stenotaphrum secundatum* cv Variegata, (128.64 mg g^{-1} dw), *Zoysia tenuifolia*, *Cynodon dactylon* and *Sporobolus tremulus* were on par with each other. The lowest total non-structural carbohydrates *Axonopus compressus* (T_9) with 116.28 mg g^{-1} dw.

The data from the study showed that CAT activity decreased in both shoots of *Cynodon dactylon* and *Zoysia japonica* under salinity stress. However, the change in CAT activity was least in *Seashore paspalum* which might be due to effective scavenging of H_2O_2 by *Paspalum vaginatum* than the *Cynodon dactylon*.

Table 3: Effect of salinity on total nonstructural carbohydrate and Proline content (mg g^{-1}) of turfgrass species

Treatments	Turfgrass species	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	Mean
T_1	*Zoysia japonica*	144.54	135.12	136.32	134.18	133.26	136.68	0.92	0.98	0.95	3.68	4.76	2.26
T_2	*Zoysia tenuifolia*	137.28	132.25	133.16	129.72	126.74	131.83	0.82	0.91	0.88	2.23	3.94	1.76
T_3	*Cynodon dactylon*	134.56	129.71	130.28	125.22	123.43	128.64	0.95	1.05	1.02	3.78	4.96	2.35
T_4	*Paspalum vaginatum*	148.63	145.42	146.50	139.61	136.19	143.27	0.56	0.66	0.65	1.47	2.04	1.08
T_5	*Stenotaphrum secundatum*	132.86	128.06	129.18	123.37	121.16	126.93	0.68	0.76	0.75	1.99	2.97	1.43
T_6	*Stenotaphrum secundatum* cv Variegata	130.49	127.92	128.50	120.64	117.37	124.98	0.65	0.82	0.79	2.08	3.28	1.52
T_7	*Sporobolus tremulus*	136.37	130.37	131.24	127.28	125.48	130.15	0.63	0.74	0.72	2.96	3.32	1.67
T_8	*Poa pratensis*	128.43	119.12	120.15	118.08	116.65	120.49	0.61	0.87	0.86	2.16	3.51	1.60
T_9	*Axonopus compressus*	122.71	115.29	115.81	114.08	113.51	116.28	0.86	0.93	0.90	2.63	3.87	1.84
Mean		135.09	129.25	130.13	125.80	123.75		0.74	0.86	0.83	2.55	3.63	
SEd		2.33	2.41	2.12	2.46	2.12		0.01	0.02	0.01	0.05	0.08	
CD (0.05 %)		4.95*	5.11*	4.69*	5.21*	4.50*		0.03*	0.04*	0.03*	0.11*	0.17*	

*Significant at 5 per cent level

Carbohydrates are the primary source of reserve energy stored in the vegetative organs of plants and provides energy and metabolites for the biosynthetic processes and growth (Ashraf and Harris 2004 [3]; Klotke *et al.,* 2004) [21]. Higher carbohydrate concentration in Seashore paspalum before and during the stress period indicates better tolerance (Kafi *et al.*, 2003[19]; Kerepesi and Galiba, 2000) [20]. In the study, salt stress caused a decrease in carbohydrates. The lowest in *Axonopus compressus* (T_9) with the highest decrease in TNC storage suggested that grasses exposed to salt stress were not primed for growth maintaining and carbon gain at moderate stress levels. Stoop and Pharr (1994) [36] suggested that the utilization and production of carbohydrates could be a limited factor of growth under stress. Therefore, the accumulation of sugars with a concomitant decrease in growth rate under salt stress in turfgrasses might be probably due to the reduced utilization in the actively growing tissue. In all stages of salinity in the treatments, total nonstructural carbohydrates in shoot declined in all the nine grasses under study. This is in line with the findings of Van den Ende and Valluru (2009) [40]; Sathishkumar *et al*., (2014) [31]

Proline Content (mg g^{-1} fw)

Proline is a pre amino acid and external stimulus in any form of stress resulting in the accumulation. It has been estimated and presented in Table 3. Among the turfgrass species, the highest proline content was recorded in *Cynodon dactylon* (T_3) with 2.35 mg g^{-1} fw, followed by *Zoysia japonica* (T_1) with 2.26 mg g^{-1} fw. The lowest proline content was observed in *Paspalum vaginatum* (T_4) with 1.08 mg g^{-1} fw.

Proline have many functions in stress tolerance, including osmotic adjustment, protein and membrane stabilization, gene induction, reactive oxygen scavenging, N and C source, and a reduction equivalent source during stress recovery (Rudolph *et al*., 1986[30]; Delauney and Vermav, 1993[12]; Hare and Cress, 1997[15]; Iyer and Caplan, 1998[17]; Brugiere *et al*., 1999) [11]. Proline accumulation is a protective mechanism observed in plants subjected to stress factors (Phang *et al.,* 2008) [29]. Under unfavorable conditions, such as salinity, drought their amount in plants increases (Mattioli *et al.,* 2009) [25], which was also observed in the study. The salt additive resulted in an increased proline accumulation in the leaves of *Cynodon dactylon* (T_3), *Paspalum vaginatum* (T_4), *Sporobolus tremulus* (T_7), *Zoysia japonica* (T_1) and least accumulation in *Axonopus compressus* (T_9) grass and the results are matching with the findings of (Borowski, 2008) [10]. Under high salinity *Paspalum vaginatum* (T_4) probably did not have any stress, which meant that the proline accumulation under these conditions was significantly lower. This was evident from the study, since *Paspalum vaginatum* (T_4) showed least amount of proline accumulation suggesting that the plant is able to tolerate high level of salinity.

Conclusion

On the basis of our research confirmed that among the turfgrasses cultivated *Paspalum vaginatum* performed very well in the salinity ecosystem which exhibited highest relative water content then other grasses species, *Cynodon dactylon* recorded the highest total chlorophyll content then other species may be its genetic factor, *Paspalum vaginatum* shown the minimum catalase activity which indicates less lipid peroxidation and more oxidation damage of turgrass to antioxidant defense mechanism in *Axonopus compressus* recorded the less effective defense mechanism. Total non structural carbohydrate content is rich in *Paspalum vaginatum* the primary source of reserve energy in the vegetative organ of plants which provide energy and metabolites for bio synthetic process and growth in this *Paspalum vaginatum* shown the highest values then other grasses. Poline is one of the most frequently reported organic solute that accumulated in cytoplasam in salt stressed plants to counter balance the osmotic potential attributed to inorganic ions compartmentalized in cell vacuoles.

Our results indicates that the proline content of all grasses significantly increased with increasing salinity in our study proline content highest values in *Cynodon dactylon* compare to other grasses, *Paspalum vaginatum* showed the minimum proline content, this indicates Seashore paspalum may be feel less stress in the salinity condition

Overwall, among the nine turf species, *Paspalum vaginatum* was the most salt tolerant turf species with least adversely affected by salinity condition followed by *Sporobolus tremulus* and *Cynodon dactylon.*

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