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Screening of potential salt tolerant turfgrass species in Peninsular Malaysia

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Abstract

The need for salinity tolerance of turfgrasses is increasing because of the augmented use of effluent or other low quality water (seawater) for turfgrass irrigation. Diverse populations including 34 entries of 16 turfgrass species were screened for salt tolerance from Peninsular of Malaysia under sand culture system. Irrigation seawater of different salinity levels (0, 24, 48, and 72 dS m^{-1}) were applied to turfgrass species grown in a plastic pots filled with a mixture of sand and peat (9:1). The different species of grasses were ranked for salinity tolerance on the basis of shoot and root growth, leaf firing, turf colour and turf quality. The most salt tolerant turf species was *P. vaginatum* (UPM), *P. vaginatum* 'local', *Z. matrella*, *Z. japonica*, *C. dactylon* 'satiri' , *C. dactylon* (Kuala Muda) which were able to tolerate high levels of salinity 48 dS m^{-1}, while, the least tolerant group (24 dS m^{-1}) consisted of *E. ophiuroides*, (UPM), *P. notatum* (UPM), *A. compressus* 'cowgrass' (UPM), *A. affinis* (UPM), and *A. compressus* 'pearl blue' (UPM). The results indicate the importance of turfgrass varietal selection for saline environments.

Keywords: Salt tolerant, turfgrass, sea water.
Abbreviations: UPM_University Putra Malaysia; SDW_shoot dry weight; RDW_root dry weight; dS m^{-1}_deci semen per Meter.

Introduction

Soil salinity is the major abiotic stress drastically affecting the plant growth and crop productivity. Due to continuous buildup of salinity in the soil, millions of hectares of arable lands have now become unfit for cultivation (Ahmad et al., 2007). It is now well accepted that salinity can affect the plant growth by changing their morphological, physiological and biochemical as well as anatomical characteristics (Tester and Davenport, 2003).

Salinity is one of the major problems in agriculture. Raising the sea levels due to global warming increased the land salinity (Barth and Titus, 1984). Many reports exist on the salinity tolerance grass species as grasses are major components of the floras of saline areas. Salinity problem on turf area becoming acute in coastal areas because of the seawater intrusion, where many recreational area, golf courses, polo or even hotel and resort are built near to the beach (Parker, 1975; Murdoch, 1987; McCarty and Dudeck, 1993). Planting the right turfgrass, which is salinity tolerant species, is an alternative solution to this problem. The need for salinity tolerant turfgrasses are also increasing because of the increased use of effluent or other low quality waters for turfgrass irrigation especially in water shortages area (Gill and Rainville, 1994; Harivandi et al., 1992; Marcum, 1999). Usage of recycled water has problems in turfgrass sites such as low quality and high salt composition (Carrow and Duncan 1998; Marcum 1999; Lee et al., 2004a).

Furthermore, previous study has shown that some weeds are intolerant to salinity or even can be killed by salt water when they grow in saline areas (Weicko, 1999; 2000; 2003; Uddin et al., 2011c). Using this strategy, the salt water can be used as a tool to control weed in saline prone turfgrass area. So, the application of salty water will reduce the application of herbicide; therefore, reducing environmental risk, and cost of herbicide and labour (Uddin et al., 2012a; 2011c). The relative salt tolerance among most of the widely used turfgrass species and cultivars has not been adequately studied yet. The proper utilization of highly salt tolerance turfgrass species will give benefit to turfgrass area in Malaysia. The objectives of this study were to screen the most salt tolerant turfgrass species in Peninsular of Malaysia.

Results

Leaf firing (%)

Percentage of leaf firing increased significantly ($p \leq 0.05$) with increasing salinity, in which maximum leaf firing observed in 72 dS m^{-1} salinity level in each entry (Table 1). At 24 dS m^{-1} salinity, all of the tested entries started showing leaf firing symptoms except *P. vaginatum* (UPM). The highest percentage of leaf firing occurred in *A. affinis* (98%), A. *compressus* 'pearl blue' (87%), and *A. compressus* 'cowgrass' (76%). However, *P. vaginatum* entries, *Z. matrella, Z. japonica, S. secundatum*, *C. dactylon* 'satiri' and *Z. tenuifolia* were slightly affected (<10%) compared to other entries. At 48 dS m^{-1}, *P. vaginatum* (UPM), *P. vaginatum* 'local', *Z. matrella* (Pantai Bisikan Bayu), and *Z. matrella*

Table 1. Effect of salinity on leaf firing (%) of different turfgrass species.

Species	Locations	Leaf firing (%) Salinity levels (dS m^{-1})				$LSD_{0.05}$
		0	24	48	72	
A. compressus 'cowgrass'	UPM	0 d	76 c	90 b	100 a	3.77
A. affinis	UPM	0 c	98 b	100 a	100 a	0.62
A. compressus 'pearl blue'	UPM	0 c	87 b	88 b	100 a	8.44
C. dactylon 'bermuda saujana'	UPM	0 d	9 c	67 b	86 a	6.45
C. dactylon 'satiri'	UPM	0 c	5 c	33 b	70 a	5.03
C. dactylon 'tifdwarf'	UPM	0 d	25 c	55 b	83 a	8.87
C. dactylon 'greenless park'	UPM	0 d	28 c	69 b	88 a	6.95
C. dactylon	Kuala Perlis	0 d	15 c	66 b	86 a	9.29
C. dactylon	Kuala Muda	0 d	19 c	49 b	83 a	6.92
C. dactylon	Lumut	0 d	21 c	71 b	87 a	5.66
C. dactylon	Tanjung Bidara	0 d	23 c	58 b	87 a	7.25
C. dactylon 'common'	UPM	0 d	17 c	57 b	86 a	5.70
D. didactyla	UPM	0 d	19 c	73 b	93 a	7.23
E. ophiuroides	UPM	0 d	34 c	74 b	100 a	8.74
P. notatum	UPM	0 d	54 c	91 b	99 a	6.03
P. vaginatum	UPM	0 c	0 c	6 b	29 a	3.21
P. vaginatum ' local '	Marang	0 d	5 c	18 b	53 a	4.75
P. vaginatum ' local '	Pantai Batu Burok	0 d	5 c	17 b	51 a	4.54
P. vaginatum ' local '	Kuala Muda	0 c	3 c	19 b	55 a	5.15
P. vaginatum ' local '	Batu Feringgi	0 c	5 c	17 b	54 a	5.73
P. vaginatum ' local '	Lumut	0 c	3 c	11 b	57 a	6.74
P. vaginatum ' local '	Pantai Kelanang	0 c	4 c	19 b	53 a	5.83
P. vaginatum ' local '	Pantai Morib	0 c	4 c	16 b	55 a	6.63
P. vaginatum ' local '	UPM	0 d	6 c	20 b	60 a	5.83
P. vaginatum ' local '	Tanjung Puteri	0 c	3 c	16 b	54 a	5.80
S. secundatum	UPM	0 d	5 c	61 b	80 a	4.71
Z. japonica	UPM	0 c	5 c	26 b	74 a	5.48
Z. japonica Steud.	UPM	0 d	11 c	48 b	78 a	4.17
Z. matrella	Kuala Perlis	0 d	9 c	28 b	64 a	6.92
Z. matrella	Pantai Bisikan Bayu	0 c	2 c	18 b	53 a	3.02
Z. matrella	Cherating	0 c	10 c	33 b	64 a	12.13
Z. matrella	UPM	0 c	6 c	26 b	70 a	12.39
Z. matrella	Port Dickson	0 d	11 c	17 b	55 a	5.87
Z. tenuifolia	UPM	0 d	9 c	75 b	83 a	4.75

Means within rows followed by same letter are not significantly different at p = 0.05.

(Lumut) showed less injury, which was below 20%. Meanwhile, *P. notatum*, *A. compressus* 'cowgrass', and *A. compressus* 'pearl blue' showed serious injury, 91%, 90%, and 88%, respectively, whereas, significant highest leaf injury (100%) observed in *A. affinis* at the same salinity level. At the highest salinity treatment (72 dS m^{-1}) severe leaf injury occurred in all tested entries except for *P. vaginatum* (UPM) (29%).

Compare to other *C. dactylon* accession, *C. dactylon* (Kuala Muda) was noticed to have the highest salt tolerance, in terms of percentage leaf firing. Among the *Z. matrella* accession, *Z. matrella* (Pantai Bisikan Bayu), can be considered as highest tolerant to salinity. The *P. vaginatum* 'local' (Pantai Batu Burok), which showed the lower leaf firing in every salinity treatment, was the highest salt tolerant among the *P. vaginatum* 'local' accession.

Turf colour index

Turf color index of all turfgrass species was significantly ($p \leq 0.05$) influenced by salinity levels (Table 2). As salinity increased, turf color index declined. The highest turf colour index under control treatment obtained in *E. ophiuroides*, and the lowest was in *Z. matrella* 'Kuala Perlis'. At 72 dS m^{-1}, *P. vaginatum* (UPM), *P. vaginatum* 'local' (Pantai Batu Burok), *P. vaginatum* 'local' (Kuala Muda), *P. vaginatum* 'local' (Pantai Morib), and *P. vaginatum* 'local' (UPM) demonstrated higher relative turf colour index. From the data obtained, *C. dactylon* 'satiri' and *C. dactylon* 'Tifdwarf' were observed the most salinity tolerant in bermudagrasses regarding to the relative turf colour index, whereas, *P. vaginatum* (UPM) can maintain its nice green colour, and highest relative turf colour index compare to all other entries in every salinity treatment.

Turf quality

Turf quality under salt stress as indicated by visual rating was presented in Table 3. Turf quality deteriorated with increasing salinity level. Quality deterioration was severe in *A. compressus* 'cowgrass', *A. compressus* 'pearl blue', and *A. affinis* at 24 dS m^{-1}. In contrast, turf quality of *P. vaginatum* (UPM), *P. vaginatum* 'local' (Kuala Muda), and Z. *matrella* (Pantai Bisikan Bayu) was unaffected at the same salinity level. At 48 dS m^{-1} salinity, *P. vaginatum* species (7.0 – 8.0), *Z. matrella* (Pantai Bisikan Bayu) (7.0), *Z. matrella* (UPM) (7.0), and *Z. matrella* (Port Dickson) (7.0) showed higher turf quality among others, while, *A. affinis* exhibited the lowest turf quality rating (1.0). However, all entries showed bad turf quality except *P. vaginatum* (UPM), *P. vaginatum* 'local'

Table 2. Effect of salinity on turf colour index of different turfgrass species.

Species	Locations	Turf colour index				$LSD_{0.05}$
		Salinity levels (dS m^{-1})				
		0	24	48	72	
A. compressus 'cowgrass'	UPM	6.91 a	4.51 b	4.38 b	3.12 c	0.49
A. affinis	UPM	6.91 a	4.43 b	4.33 b	3.33 c	0.56
A. compressus 'pearl blue'	UPM	7.49 a	5.41 b	4.93 b	3.40 c	0.63
C. dactylon 'bermuda saujana'	UPM	7.38 a	6.96 a	5.47 b	3.59c	0.67
C. dactylon 'satiri'	UPM	7.30 a	6.85 ab	6.37 b	4.78 c	0.51
C. dactylon 'tifdwarf'	UPM	7.49 a	7.15 a	5.97 b	4.52 c	0.76
C. dactylon 'greenless park'	UPM	7.38 a	7.08 a	5.12 b	4.34 c	0.42
C. dactylon	Kuala Perlis	7.40 a	7.28 a	5.54 b	4.53 c	0.63
C. dactylon	Kuala Muda	7.40 a	7.28 a	5.94 b	3.79 c	0.58
C. dactylon	Lumut	7.40 a	7.25 a	5.44 b	4.06 c	0.92
C. dactylon	Tanjung Bidara	7.37 a	7.29 a	5.07 b	3.98 c	0.86
C. dactylon 'common'	UPM	7.55 a	7.11 a	6.27 b	3.75 c	0.59
D. didactyla	UPM	7.58 a	7.02 b	5.27 c	3.66 d	0.53
E. ophiuroides	UPM	7.64 a	4.51 b	3.43 c	2.25 d	0.92
P. notatum	UPM	7.51 a	7.16 a	4.69 b	3.72 c	0.49
P. vaginatum	UPM	7.39 a	7.22 a	7.17 a	6.42 b	0.28
P. vaginatum ' local '	Marang	7.31 a	7.08 ab	6.97 b	5.75 c	0.26
P. vaginatum ' local '	Pantai Batu Burok	7.23 a	7.05 a	6.92 a	5.77 b	0.37
P. vaginatum ' local '	Kuala Muda	7.23 a	6.86 ab	6.51 b	5.93 c	0.38
P. vaginatum ' local '	Batu Feringgi	7.27 a	6.82 b	6.50 b	5.51c	0.37
P. vaginatum ' local '	Lumut	7.53 a	7.19 ab	6.72 b	5.80 c	0.53
P. vaginatum ' local '	Pantai Kelanang	7.37 a	6.87 a	6.61 ab	5.83 b	0.81
P. vaginatum ' local '	Pantai Morib	7.27 a	6.86 ab	6.59 b	5.86 c	0.56
P. vaginatum ' local '	UPM	7.48 a	7.27 a	6.75 b	6.01 c	0.36
P. vaginatum ' local '	Tanjung Puteri	7.23 a	7.01 a	6.56 b	5.73 c	0.44
S. secundatum	UPM	7.09 a	6.61 ab	6.40 b	4.17 c	0.59
Z. japonica	UPM	7.48 a	7.35 a	6.60 b	5.29 c	0.34
Z. japonica Steud.	UPM	7.54 a	7.11 a	5.80 b	5.05 c	0.74
Z. matrella	Kuala Perlis	6.77 a	6.71 a	5.70 b	4.76 c	0.68
Z. matrella	Pantai Bisikan Bayu	7.39 a	7.17 a	6.60 b	5.73 c	0.43
Z. matrella	Cherating	7.33 a	7.12 a	6.15 b	5.21 c	0.77
Z. matrella	UPM	7.47 a	7.05 b	6.54 c	5.21 d	0.36
Z. matrella	Port Dickson	7.39 a	7.19 a	6.58 a	5.26 b	0.85
Z. tenuifolia	UPM	7.42 a	7.29 a	6.15 b	4.43 c	0.47

Means within rows followed by same letter are not significantly different at p = 0.05.

(Marang), and Z. *matrella* (Pantai Bisikan Bayu) at the highest level of salinity treatment 72 dS m^{-1}. Based on this result, *P. vaginatum* (UPM) exhibited the best turf quality within all of the entries. On the other hand, Z. *matrella* (Pantai Bisikan Bayu) was seen as a very tolerant to salinity among the zoysiagrasses.

Dry weight of shoot

The shoot dry weight (SDW) of turfgrass species was decreased under salt stress in all turf species but showed different magnitudes of decline (Table 4). The turf species *Z. matrella* (UPM) produced maximum shoot dry weight (9.23 g per pot) followed by *C. dactylon* (Tanjung Bidara) (8.52 g pot^{-1}) under control condition. Results showed that *P. vaginatum* (UPM) was the most salt tolerant species as it did not show significant decrease up to 48 dS m^{-1} salinity level, followed by *P. vaginatum* 'local', *C. dactylon* 'satiri' (UPM), *Z. japonica* (UPM), *Z. matrella* (UPM), *Z. matrella* (Pantai Bisikan Bayu), and *Z. matrella* (Port Dickson), which were tolerant to salinity of only up to 24 dS m^{-1}. The SDW was reduced gradually with increasing salinity level. The SDW reduction in *P. vaginatum* (UPM) at 72 dS m^{-1} was only 21% compared to the control treatment. Higher SDW reductions were observed in *A. affinis* (UPM) (71%), *A. compressus* 'pearl blue' (UPM) (70%), and *A. compressus* 'cowgrass' (UPM) (69%) at the same level of salinity.

Dry weight of root

The results showed that root dry weight (RDW) significantly ($p \leq 0.05$) decreased with increasing salinity levels (Table 5). The *Z. matrella* (UPM) species had higher root dry weight (20.97 g per pot) in control, while *S. secundatum* had lower RDW as compared to other entries. There were no significant differences at salinity level of 48 dS m^{-1} compared to control in *P. vaginatum* 'local' (Kuala Muda), *P. vaginatum* 'local' (Batu Feringgi), *P. vaginatum* 'local' (Pantai Kelanang), *P. vaginatum* 'local' (UPM), and *P. vaginatum* 'local' (Tanjung Puteri). But later, at higher salinity levels, RDW reduced gradually with increasing salinity level. At highest salinity (72 dS m^{-1}), RDW reduction was less in *P. vaginatum* (30%) followed by *P. vaginatum* 'local' (Tanjung Puteri) (36%), while highest RDW reduction was found in *A. compressus* 'cowgrass' (UPM) (67%) followed by *A. affinis* (UPM) (62%), *A. compressus* 'pearl blue' (UPM) (60%).

Table 3. Effect of salinity on turf quality of different turfgrass species.

Species	Locations	Turf quality				$LSD_{0.05}$
		Salinity levels (dS m^{-1})				
		0	24	48	72	
A. compressus 'cowgrass'	UPM	9 a	3 b	3 c	1 d	0.04
A. affinis	UPM	9 a	2 b	1 c	1 c	0.03
A. compressus 'pearl blue'	UPM	9 a	3 b	3 b	1 c	0.67
C. dactylon 'bermuda saujana'	UPM	9 a	8 b	4 c	3 d	0.06
C. dactylon 'satiri'	UPM	9 a	8 b	5 c	4 d	0.07
C. dactylon 'tifdwarf'	UPM	9 a	6 b	4 c	3d	0.07
C. dactylon 'greenless park'	UPM	9a	6 b	4 c	3d	0.08
C. dactylon	Kuala Perlis	9 a	7 b	4 c	3 d	0.08
C. dactylon	Kuala Muda	9 a	7 b	5 c	3 d	0.10
C. dactylon	Lumut	9 a	7 b	4 c	3 d	0.06
C. dactylon	Tanjung Bidara	9 a	7 b	4 c	3 d	0.08
C. dactylon 'common'	UPM	9 a	7 b	4 c	3 d	0.06
D. didactyla	UPM	9 a	7 b	3 c	2 d	0.10
E. ophiuroides	UPM	9 a	6 b	3 c	1 d	0.07
P. notatum	UPM	9 a	5 b	3 c	1 d	0.06
P. vaginatum	UPM	9 a	9 a	8 b	6 c	0.33
P. vaginatum ' local '	Marang	9 a	8 b	7 c	4 d	0.06
P. vaginatum ' local '	Pantai Batu Burok	9 a	8 b	7 c	5 d	0.07
P. vaginatum ' local '	Kuala Muda	9 a	9 a	7 b	4 c	0.07
P. vaginatum ' local '	Batu Feringgi	9 a	8 b	7 c	4 d	0.07
P. vaginatum ' local '	Lumut	9 a	8 a	8 b	4 c	0.07
P. vaginatum ' local '	Pantai Kelanang	9 a	8 a	7 b	4 c	0.08
P. vaginatum ' local '	Pantai Morib	9 a	8 b	7 c	4 d	0.08
P. vaginatum ' local '	UPM	9 a	8 b	7 c	4 d	0.05
P. vaginatum ' local '	Tanjung Puteri	9 a	8 b	7 c	4 d	0.07
S. secundatum	UPM	9 a	8 b	4 c	3 d	0.03
Z. japonica	UPM	9 a	8 b	6 c	3 d	0.07
Z. japonica Steud.	UPM	9 a	8 b	5 c	3 d	0.50
Z. matrella	Kuala Perlis	9 a	8 b	6 c	4 d	0.07
Z. matrella	Pantai Bisikan Bayu	9 a	9 a	7 b	5 c	0.05
Z. matrella	Cherating	9 a	8 b	6 c	4 d	0.11
Z. matrella	UPM	9 a	8 a	7 b	4 c	0.11
Z. matrella	Port Dickson	9 a	8 b	7 b	4 c	0.08
Z. tenuifolia	UPM	9 a	8 b	3 c	3 c	0.05

Means within rows followed by same letter are not significantly different at p = 0.05.

Relative shoot growth

Relative shoot growth was decreased significantly with increasing salinity for all entries (Table 6). Among the species, *P. vaginatum*, *P. vaginatum* 'local', *Z. matrella*, *Z. japonica*, *Z. japonica* Steud., *Z. tenuifolia*, *S. secundatum*, and *C. dactylon* 'satiri' were less affected at 24 dS m^{-1} salinity level, and showed reduction less than 20%. At 48 dS m^{-1} salinity treatment, no significant difference was found in *P. vaginatum* (UPM), *P. vaginatum* 'local' (Marang), *P. vaginatum* 'local' (Pantai Batu Burok), *P. vaginatum* 'local' (Kuala Muda), *P. vaginatum* 'local' (Batu Feringgi), *P. vaginatum* 'local' (Lumut), and *P. vaginatum* 'local' (Pantai Kelanang) with control treatment. On the other hand, other entries produced significantly less relative shoot growth compared to control at the same salinity level. At 72 dS m^{-1}, *P. vaginatum* (UPM) exhibited the highest relative shoot growth 79% among the entries.

On the contrary, *A. affinis*, *A. compressus* 'pearl blue', *A. compressus* 'cowgrass', *E. ophiuroides*, *D. didactyla*, and *P. notatum* produced the lowest relative shoot growth, which were 29%, 30%, 31%, 35%, 36%, and 37%, respectively. The highest relative shoot growth gained at *C. dactylon* 'satiri' and *Z. matrella* (Pantai Bisikan Bayu) in every salinity level, indicating the capability of high salt tolerance among the tested bermuda and zoysia grasses. The highest salinity tolerance of *P. vaginatum* (UPM) induced less shoot growth reduction in every salinity treatment compare to others entries.

Relative root growth

Significant variability in relative root growth parameter was found in this experiment (Table 7). Root growth of *P. vaginatum* (UPM), and *P. vaginatum* 'local' (Pantai Morib) were increased significantly to 110% and 107%, respectively, as salinity increased up to 24 dS m^{-1}, while there was no significant effect in *P. vaginatum* 'local' (Kuala Muda), *P. vaginatum* 'local' (Pantai Kelanang), *P. vaginatum* 'local' (Tanjung Puteri), *C. dactylon* 'satiri', and *C. dactylon* 'greenless park' in this level. However, a slightly (<15%) decreased trend of root growth observed in all *P. vaginatum* 'local' accessions, and *Z. matrella* (Pantai Bisikan Bayu) at 48 dS m^{-1} salinity. Among the tested entries, *P. vaginatum* (UPM) maintained the highest root growth (100%) within this salinity level. On the other hand, *C. dactylon* 'bermuda saujana', *C. dactylon* 'satiri', *C. dactylon* (Kuala Muda),

Table 4. Effect of salinity dry weight of shoot of different turfgrass species.

Species	*Locations*	Dry weight of shoot (g) Salinity levels (dS m^{-1}) 0	24	48	72	$LSD_{0.05}$
A. compressus 'cowgrass'	UPM	3.91 a	1.95 b	1.40 bc	1.22 c	0.64
A. affinis	UPM	5.04 a	2.81 b	1.90 c	1.39 c	0.82
A. compressus 'pearl blue'	UPM	4.93 a	2.54 b	1.47 b	1.44 b	1.23
C. dactylon 'bermuda saujana'	UPM	3.86 a	2.93 b	2.46 bc	1.97 c	0.53
C. dactylon 'satiri'	UPM	3.82 a	3.11 ab	2.70 bc	2.10 c	0.86
C. dactylon 'tifdwarf'	UPM	5.84 a	4.03 b	3.91 b	2.91 c	0.83
C. dactylon 'greenless park'	UPM	6.75 a	5.19 b	3.69 c	3.14 c	1.13
C. dactylon	Kuala Perlis	5.25 a	3.29 b	3.11 b	2.47 c	0.50
C. dactylon	Kuala Muda	6.78 a	5.07 b	3.95 c	2.94 d	0.82
C. dactylon	Lumut	7.57 a	5.16 b	4.46 bc	3.68 c	1.18
C. dactylon	Tanjung Bidara	8.52 a	6.17 b	4.67 bc	3.59 c	1.70
C. dactylon 'common'	UPM	3.43 a	2.04 b	1.50 b	1.32 b	0.86
D. didactyla	UPM	5.51 a	4.10 b	2.30 c	1.95 c	0.89
E. ophiuroides	UPM	5.20 a	3.51 b	1.97 c	1.80 c	1.10
P. notatum	UPM	4.18 a	2.84 b	1.73 c	1.57 c	0.71
P. vaginatum	UPM	3.51 a	3.45 a	3.25 a	2.78 b	0.44
P. vaginatum ' local '	Marang	4.83 a	4.21 a	3.88 ab	2.72 b	1.25
P. vaginatum ' local '	Pantai Batu Burok	2.57 a	2.41 a	2.23 a	1.57 b	0.60
P. vaginatum ' local '	Kuala Muda	4.04 a	3.78 a	3.57 a	2.72 b	0.71
P. vaginatum ' local '	Batu Feringgi	4.66 a	4.38 a	4.01 ab	2.80 b	1.46
P. vaginatum ' local '	Lumut	3.22 a	2.96 a	2.70 a	1.98 b	0.69
P. vaginatum ' local '	Pantai Kelanang	4.24 a	3.83 a	3.55 a	2.43 b	1.00
P. vaginatum ' local '	Pantai Morib	4.58 a	4.39 a	4.09 a	2.77 b	0.83
P. vaginatum ' local '	UPM	5.91 a	5.23 ab	4.75 b	3.17 c	0.87
P. vaginatum ' local '	Tanjung Puteri	5.01 a	4.77 a	4.54 a	3.21 b	1.07
S. secundatum	UPM	4.02 a	3.30 a	2.19 b	1.87 b	1.05
Z. japonica	UPM	3.50 a	3.01 b	2.57 c	1.90 d	0.37
Z. japonica Steud.	UPM	2.75 a	2.32 a	1.64 b	1.37 b	0.45
Z. matrella	Kuala Perlis	3.91 a	2.51 b	1.68 c	1.55 c	0.63
Z. matrella	Pantai Bisikan Bayu	4.09 a	3.63 ab	3.45 b	2.62 c	0.47
Z. matrella	Cherating	3.52 a	2.83 b	2.60 b	1.84 c	0.54
Z. matrella	UPM	9.23 a	8.03 a	6.62 b	5.10 c	1.28
Z. matrella	Port Dickson	7.22 a	6.34 ab	5.75 b	4.18 c	0.95
Z. tenuifolia	UPM	7.75 a	6.31 b	5.18 b	3.61 c	1.35

Means within rows followed by same letter are not significantly different at p = 0.05.

C. dactylon (Tanjung Bidara), *Z. japonica*, *Z. matrella* (Kuala Perlis), *Z. matrella* (Cherating), and *Z. tenuifolia* produced moderate (60 to 80%) of root growth compared to control. At 72 dS m^{-1}, *P. vaginatum* (UPM) produced the highest root growth (70%) among the entries followed by *P. vaginatum* 'local' entries, *Z. matrella* (Pantai Bisikan Bayu) (60 to 69%). From the results of relative root growth, *P. vaginatum* (UPM) produced the lowest relative root growth reduction (30%), indicating the highest salinity tolerance among the entries.

Discussion

Percentage of leaf firing has been considered as an important criterion for salt tolerant turfgrass assessment under salt stress because leaf firing is easily noticed on turfs, and also easily measured (Uddin et al., 2009a; Uddin and Juraimi, 2012). According to Marcum and Murdoch (1994), relative percent leaf firing has been shown to be closely related to relative percent leaf dry weight for zoysiagrasses, bermudagrass and other warm season turfgrasses.

In the present study, leaf firing ranged from 100% to 29%, at 72 dS m^{-1}. The results revealed that increasing the level of salinity accelerates leaf firing (%), which might be related to hyper accumulation of toxic ions in the leaf tissues (Marcum, 1999; Lee et al., 2004a; Adavi et al., 2006). In this study, broad range of leaf firing and salinity tolerance were found among the eight zoysiagrass entries (7% to 75%) in response to 48 dS m^{-1}. Among them, *Z. matrella* (Pantai Bisikan Bayu) and *Z. matrella* (Port Dickson) were equivalent in salinity tolerance as highly salt tolerant paspalum species, while *Z. tenuifolia* was similar in tolerance to salt sensitive *E. ophiuroides*. Marcum et al. (1998) also found a broad range of salinity tolerance among the five zoysiagrasses species, from 19 to 80%, on relative leaf firing, in response to 36 dS m^{-1} NaCl. The wide range of salinity tolerance within the zoysiagrasses contrasts with the relatively narrow range of tolerance of some turfgrass genera (Dudeck et al., 1993; Reid et al., 1993; Torello and Spokas, 1983).

The accumulated toxic ions (Na^+ and Cl^-) may lead to photo-oxidative damage of colour; and therefore, reduced colour index. Several researchers reported that salinity decreased chlorophyll content in plant, which could be responsible for reduction in turf colour (Lee et al., 2004b; Marcum and Pessarakli 2006; Uddin et al., 2011c). Colour content of *P. vaginatum* species entries seems to be insensitive to salinities up to 48 dS m^{-1}. This result agreed with Lee et al. (2004b) that found chlorophyll concentration of nine seashore paspalum ecotypes were decreased with the minimum as salinity increased up to 50 dS m^{-1}.

Table 5. Effect of salinity on dry weight of root of different turfgrass species.

Species	Locations	Dry weight of root (g)				$LSD_{0.05}$
		Salinity levels (dS m^{-1})				
		0	24	48	72	
A. compressus ‘cowgrass’	UPM	6.33 a	3.20 b	2.09 b	1.85 b	1.58
A. affinis	UPM	10.93 a	6.46 b	5.60 b	4.13 c	0.95
A. compressus ‘pearl blue’	UPM	4.98 a	2.99 b	2.46 bc	1.98 c	0.80
C. dactylon 'bermuda saujana'	UPM	4.93 a	4.84 a	3.27 b	2.38 c	0.76
C. dactylon 'satiri'	UPM	10.79 a	11.13 a	8.37 b	5.98 c	0.88
C. dactylon 'tifdwarf'	UPM	8.42 a	6.96 b	4.48 c	3.99 c	1.45
C. dactylon 'greenless park'	UPM	12.76 a	12.63 a	7.50 b	5.99 c	1.10
C. dactylon	Kuala Perlis	9.24 a	7.42 a	4.60 b	4.61 b	1.90
C. dactylon	Kuala Muda	14.83 a	14.41 a	9.88 b	6.37 c	0.92
C. dactylon	Lumut	13.33 a	11.23 a	7.25 b	6.04 b	2.28
C. dactylon	Tanjung Bidara	14.44 a	12.33 b	8.75 c	6.00 d	2.03
C. dactylon 'common'	UPM	9.62 a	6.78 b	5.04 c	4.19 c	1.62
D. didactyla	UPM	4.29 a	3.50 a	2.35 b	1.81 b	0.83
E. ophiuroides	UPM	4.59 a	2.23 b	1.76 b	1.30 b	1.96
P. notatum	UPM	3.27 a	1.96 b	1.39 c	1.33 c	0.51
P. vaginatum	UPM	7.90 b	8.62 a	7.89 b	5.49 c	0.72
P. vaginatum ' local '	Marang	8.69 a	8.42 a	7.64 b	5.17 c	0.73
P. vaginatum ' local '	Pantai Batu Burok	4.37 a	4.09 ab	3.84 b	2.66 c	0.51
P. vaginatum ' local '	Kuala Muda	4.10 a	4.29 a	4.06 a	2.52 b	0.39
P. vaginatum ' local '	Batu Feringgi	8.95 a	8.67 a	8.28 a	5.54 b	0.84
P. vaginatum ' local '	Lumut	7.44 a	7.12 ab	6.16 b	4.21 c	1.01
P. vaginatum ' local '	Pantai Kelanang	8.09 a	8.53 a	7.79 a	5.04 b	0.89
P. vaginatum ' local '	Pantai Morib	10.00 ab	10.64 a	9.82 b	6.02 c	0.67
P. vaginatum ' local '	UPM	7.20 a	6.62 a	6.46 a	4.28 b	0.78
P. vaginatum ' local '	Tanjung Puteri	11.37 a	11.57 a	10.76 a	7.24 b	0.99
S. secundatum	UPM	3.42 a	2.84 ab	1.57 b	1.41 b	1.51
Z. japonica	UPM	4.05 a	3.32a b	3.08 b	1.99 c	0.77
Z. japonica Steud.	UPM	6.03 a	4.00 b	2.96 b	2.74 b	1.64
Z. matrella	Kuala Perlis	4.43 a	3.67 b	2.86 c	2.47 c	0.61
Z. matrella	Pantai Bisikan Bayu	6.03 a	5.47 ab	5.07 b	3.64 c	0.71
Z. matrella	Cherating	3.19 a	2.64 ab	2.28b c	1.81 c	0.61
Z. matrella	UPM	20.97 a	17.80 b	17.14 b	11.26 c	2.24
Z. matrella	Port Dickson	8.24 a	7.45 ab	6.81 b	4.75 c	1.23
Z. tenuifolia	UPM	16.19 a	14.65 a	11.85 b	7.66 c	2.37

Means within rows followed by same letter are not significantly different at p = 0.05.

In this study, the turf quality rating was reduced when the salinity level increased in agreement with Alshammary (2008), Uddin et al. (2009a), Uddin et al. (2012b) and Uddin and Juraimi, (2012). The greater reduction at 24 dS m^{-1} salinity level in the turf quality of *A. compressus* ‘cowgrass’, *A. affinis*, and *A. compressus* ‘pearl blue’ demonstrated the poorer salinity tolerance compared to other entries. Uddin et al., (2009a) also reported that turf quality of *A. compressus* ‘cowgrass’, and *P. notatum* drastically reduced at 24 dS m^{-1} salinity level.

Growth parameters such as shoot and root growth are also considered to be excellent criteria for determining salinity tolerance of turf grasses (Marcum and Murdoch, 1990a; Marcum and Kopec, 1997; Dean et al., 1996; Marcum, 1999; Uddin et al., 2012b, 2011a, Uddin and Juraimi, 2012). Rather than comparing absolute growth under stress, salinity tolerance is better expressed as relative (to control) growth reduction, an indication of plant vigor under stress (Uddin et al., 2012b, Uddin and Juraimi 2012). Shoot dry weight reduction in *P. vaginatum* (UPM) at 48 dS m^{-1} salinity level was only 7%, compared to the control treatment. However, dramatic yield reductions were observed in *A. affinis* (UPM) (62%), *A. compressus* ‘pearl blue’ (UPM) (68%), and *A. compressus* ‘cowgrass’ (UPM) (64%) at the same salinity level. Similar results were also reported by Marcum and Murdoch, (1994) who observed 50% shoot dry weight reduction in *P. vaginatum* at 36.4 dS m^{-1}, and in *Z. matrella* at 35.9 dS m^{-1}. Lee et al. (2005) also reported that *P. vaginatum* was able to maintain 50% of shoot dry weight relative to the control up to 37 dS m^{-1}. In the current study, minimum shoot dry weight reduction was recorded in *P. vaginatum* species entries at 24 and 48 dS m^{-1}, respectively.

Results on relative root growth show some differences in shoot growth. In the current study, root production was stimulated relative to control in *P. vaginatum* (UPM) and *P. vaginatum* (Pantai Morib). According to Alshammary et al. (2008), root growth stimulated in saltgrass and tifgreen, in response to salinity increase from 2.5 to 18.8 dS m^{-1}. This phenomenon may be an adaptive mechanism enabling these plants to maintain their water balance. Root growth stimulation under saline conditions has also previously been reported in bermudagrass (Dudeck et al., 1983), seashore paspalum (Peacock and Dudeck, 1985), St. Augustinegrass (Meyer et al., 1989), *S. virginicus* (L.) Kunth. (Marcum and Murdoch, 1992), *D. spicata*, *S. airoides*, and *Z. japonica* (Marcum, 1999). Increased rooting with subsequent higher root adsorbing area may be an adaptive mechanism to the osmotic, and nutrient deficiency stresses under saline conditions (Rozema and Visser, 1981).

According to numerous studies, seashore paspalum exhibits superior salt tolerance (Carrow and Duncan 1998; Dudeck and Peacock 1985; Duncan 1998; Duncan and Carrow, 2000). Another turf species, zoysiagrass (Harivandi et al., 1992; Marcum et al., 1998) and bermudagrass are listed as tolerant

Table 6. Effect of salinity on relative shoot growth of different turfgrass species.

Species	Locations	Relative shoot growth (%) Salinity levels (dS m^{-1})				$LSD_{0.05}$
		0	24	48	72	
A. compressus 'cowgrass'	UPM	100 a	51 b	36 bc	31 c	15.59
A. affinis	UPM	100 a	59 b	38 c	29 c	15.40
A. compressus 'pearl blue'	UPM	100 a	54 b	32 c	30 c	21.73
C. dactylon 'bermuda saujana'	UPM	100 a	77 b	63 c	51 c	12.99
C. dactylon 'satiri'	UPM	100 a	86 ab	74 bc	56 c	18.84
C. dactylon 'tifdwarf'	UPM	100 a	71 b	68 b	51 c	9.72
C. dactylon 'greenless park'	UPM	100 a	78 b	55 c	46 c	18.11
C. dactylon	Kuala Perlis	100 a	63 b	60 b	47 c	7.57
C. dactylon	Kuala Muda	100 a	75 b	58 c	44 d	11.36
C. dactylon	Lumut	100 a	69 b	61 b	50 c	11.81
C. dactylon	Tanjung Bidara	100 a	75 b	56 c	43 c	17.87
C. dactylon 'common'	UPM	100 a	66 b	46 c	43 c	19.66
D. didactyla	UPM	100 a	75 b	42 c	36 c	6.05
E. ophiuroides	UPM	100 a	68 b	40 c	35 c	19.02
P. notatum	UPM	100 a	68 b	42 c	37 c	15.68
P. vaginatum	UPM	100 a	99 a	93 a	79 b	12.78
P. vaginatum ' local '	Marang	100 a	94 a	89 a	61 b	21.86
P. vaginatum ' local '	Pantai Batu Burok	100 a	95 a	91 a	64 b	21.97
P. vaginatum ' local '	Kuala Muda	100 a	95 a	91 a	69 b	16.94
P. vaginatum ' local '	Batu Feringgi	100 a	93 ab	89 ab	61 b	31.86
P. vaginatum ' local '	Lumut	100 a	94 a	87 ab	66 b	21.49
P. vaginatum ' local '	Pantai Kelanang	100 a	95 a	90 a	62 b	22.96
P. vaginatum ' local '	Pantai Morib	100 a	95 a	89 a	61 b	17.75
P. vaginatum ' local '	UPM	100 a	90 ab	82 b	55 c	11.63
P. vaginatum ' local '	Tanjung Puteri	100 a	96 a	90 b	64 b	21.51
S. secundatum	UPM	100 a	82 a	58 b	51 b	18.80
Z. japonica	UPM	100 a	86 b	74 c	55 d	8.53
Z. japonica Steud.	UPM	100 a	85 a	60 b	50 b	15.97
Z. matrella	Kuala Perlis	100 a	65 b	44 c	41 c	12.07
Z. matrella	Pantai Bisikan Bayu	100 a	89 b	84 b	64 c	10.01
Z. matrella	Cherating	100 a	80 b	72 b	51 c	17.73
Z. matrella	UPM	100 a	89 a	72 b	56 c	12.45
Z. matrella	Port Dickson	100 a	89 b	80 b	59 c	10.91
Z. tenuifolia	UPM	100 a	83 b	69 c	49 d	12.53

Means within rows followed by same letter are not significantly different at p = 0.05.

(Carrow and Duncan, 1998; Marcum and Murdoch, 1994). In general, our findings were in agreement with the results of these studies. Grouping the entries by species revealed *P. vaginatum* (UPM) to be most salt tolerant, followed by *P. vaginatum* 'local', *Z. matrella*, *Z. japonica*, *C. dactylon* 'satiri', and *C. dactylon* (Kuala Muda).

Materials and Methods

Site description and duration of the experiment

The experiment was carried out in the glasshouse and Weed Science Laboratory of Agriculture Faculty at University Putra Malaysia. The experiment was conducted during the period of September to December, 2008.

Selection of turfgrass samples

Turfgrass samples that had potential salt tolerant were collected from the coastal areas throughout the Peninsular of Malaysia. A total of 34 entries with 16 turfgrass species were screened in this experiment including turfgrass collection from Turf Unit, Universiti Putra Malaysia (Table 8).

Growing medium preparation and turfgrass establishment

The growing medium used in this experiment was the mixture of washed river sand (<2 mm diameter), and peat grow (KOSAS®) with ratio of 9:1 (v/v). Basal fertilizer, Christmas Island Rock Phosphate (CIRP) at the rate 0.5 kg P/100 m², and liming at the rate of 0.6 kg/100 m² were mixed into the soil mixtures before planting. The prepared medium was pulverized and inert materials, visible insect pest and plant propagules were removed. The samples plugs 5 cm x 5 cm were transplanted into 14 cm diameter and 12 cm depth plastic pot containing the prepared growing medium. The volume of pot soil was 1848 cm^3. The native soils under the grasses were washed off. The grasses were grown with non-saline irrigation water for 8 weeks in order to ensure proper establishment.

Cultural practices

All pots were fertilized with NPK Green (15:15:15) @ 50 kg N / ha. The amount of fertilizer per pot was 513 mg and, applied fortnightly. The pot area was 0.0154 m^2 (14 cm diameter). Grasses were clipped by scissors weekly

Table 7. Effect of salinity on relative root growth of different turfgrass species.

Species	Locations	Relative root growth (%) Salinity levels (dS m^{-1})				$LSD_{0.05}$
		0	24	48	72	
A. compressus ‘cowgrass’	UPM	100 a	54 b	37 c	33 c	12.89
A. affinis	UPM	100 a	59 b	51 c	38 d	7.93
A. compressus ‘pearl blue’	UPM	100 a	62 b	50 bc	40 c	12.90
C. dactylon 'bermuda saujana'	UPM	100 a	99 a	66 b	49 c	16.15
C. dactylon 'satiri'	UPM	100 a	104 a	78 b	56 c	7.74
C. dactylon 'tifdwarf'	UPM	100 a	84 b	55 c	49 c	13.21
C. dactylon 'greenless park'	UPM	100 a	100 a	59 b	47 c	7.58
C. dactylon	Kuala Perlis	100 a	84 a	53 b	49 b	18.78
C. dactylon	Kuala Muda	100 a	97 a	67 b	43 c	6.04
C. dactylon	Lumut	100 a	87 b	57 c	48 c	11.90
C. dactylon	Tanjung Bidara	100 a	87 a	62 c	43 d	7.90
C. dactylon 'common'	UPM	100 a	73 b	52 c	45 c	14.56
D. didactyla	UPM	100 a	82 b	56 c	43 c	16.35
E. ophiuroides	UPM	100 a	58 b	48 bc	36 c	18.67
P. notatum	UPM	100 a	61 b	43 c	42 c	14.25
P. vaginatum	UPM	100 a	110 b	100 b	70 c	9.01
P. vaginatum ' local '	Marang	100 a	97 a	88 b	60 c	8.07
P. vaginatum ' local '	Pantai Batu Burok	100 a	93 ab	88 b	61 c	10.63
P. vaginatum ' local '	Kuala Muda	100 a	105a	99 a	61 b	9.71
P. vaginatum ' local '	Batu Feringgi	100 a	98 a	94 a	62 b	9.44
P. vaginatum ' local '	Lumut	100 a	97 a	85 b	58 c	11.71
P. vaginatum ' local '	Pantai Kelanang	100 a	105 a	97 a	63 b	10.65
P. vaginatum ' local '	Pantai Morib	100 a	107 b	98 b	60 c	6.32
P. vaginatum ' local '	UPM	100 a	93 a	90 a	60 b	9.98
P. vaginatum ' local '	Tanjung Puteri	100 a	102 a	95 a	64 b	8.17
S. secundatum	UPM	100 a	96 a	57 b	49 b	27.65
Z. japonica	UPM	100 a	83 b	76 b	51 c	16.65
Z. japonica Steud.	UPM	100 a	74 b	54 c	50 c	19.71
Z. matrella	Kuala Perlis	100 a	84 b	66 c	56 c	12.74
Z. matrella	Pantai Bisikan Bayu	100 a	92 ab	85 b	61 c	10.78
Z. matrella	Cherating	100 a	83 ab	72 bc	58 c	17.55
Z. matrella	UPM	100 a	85 b	83 b	54 c	9.13
Z. matrella	Port Dickson	100 a	91 ab	84 b	58 c	15.19
Z. tenuifolia	UPM	100 a	92 a	76 b	49 c	11.06

Means within rows followed by same letter are not significantly different at p = 0.05.

throughout the experiment at a cutting height of 15 mm for course leaf and, 5 mm for narrow leaf species.

The collection of sea water

The required quantity of sea water for the entire experiment was collected from Port Dickson Beach, Negeri Sembilan. The seawater salinity level was 48 dS m^{-1} calibrated using the refractometer (Model RHS- 10ATC).

Salinity treatment preparation and layout of the experiment

Four salt water concentrations namely 0, 24, 48 and, 72 dS m^{-1} were applied in this study. Untreated checks were irrigated with distilled water. Sea water was diluted 50% by adding distilled water to obtain the 24 dS m^{-1} solution. NaCl salt was added to seawater to obtain solutions with salinity level of 72 dS m^{-1}. To avoid osmotic shock, salinity levels were gradually increased by daily increments of 8 dS m^{-1} in all treatments starting from 9 weeks after planting until the final salinity levels achieved. After the targeted salinity levels were achieved, the treatment water was applied on a daily basis for a period of four weeks. The amount of water applied daily were 250 ml per pot. The study was accomplished in a pot experiment. Each plastic pot was considered as an individual unit. The pots were arranged in a randomized complete block design with five replications.

Leaf firing and turf quality

Leaf firing was estimated as the total percentage of chlorotic leaf area, with 0% corresponding to no leaf firing and, 100% as totally brown leaves. Turf quality was estimated based on a scale of 1-9, with 9 as green, dense and uniform turf, and 1 as thin and completely brown turf (Alshammary et al., 2004). The rating scale of 1 to 9 was illustrated in the following table (Table 9).

Turf colour index

The FieldScout TCM500 NDVI Turf Color Meter was used to measure Turf Colour Index. Based on measuring reflected light from turf grass in the red (660 nm) and near infrared (850 nm -NIR) spectral bands, data is presented in Grass Index from 1.00 (no or less green colour) to 9.00 (darker green colour). As the different species have different turf colour index, relative (%) turf colour index is calculated as followed:

Table 8. List of turfgrass species screened for salt tolerance.

	Scientific name	Common name	Locations	GPS
1.	*Axonopus compressus* Beauv.	Tropical carpet grass	UPM	N 2^{0}21.513, E 101^{0}72.091
2.	*Axonopus affinis*	Narrowleaf carpet grass	UPM	N 2^{0}21.513, E 101^{0}72.091
3.	*Axonopus compressus* 'pearl blue'	Pearl blue grass	UPM	N 2^{0}21.513, E 101^{0}72.091
4.	*Cynodon dactylon* (L) Pers.	Bermuda Saujana	UPM	N 2^{0}21.513, E 101^{0}72.091
5.	*Cynodon dactylon* (L) Pers.	Bermuda Satiri	UPM	N 2^{0}21.513, E 101^{0}72.091
6.	*Cynodon dactylon* (L) Pers.	Bermuda Tifdwarf	UPM	N 2^{0}21.513, E 101^{0}72.091
7.	*Cynodon dactylon* (L) Pers.	Bermuda Greenless park	UPM	N 2^{0}21.513, E 101^{0}72.091
8.	*Cynodon dactylon* (L) Pers.	Tifdwarf	Kuala Perlis, Perlis	N 6^{0}23.610, E 100^{0}07.764
9.	*Cynodon dactylon* (L) Pers.	Tifdwarf	Kuala Muda, Kedah	N 5^{0}48.812, E 100^{0}37.669
10.	*Cynodon dactylon* (L) Pers.	Tifdwarf	Lumut, Perak	N 4^{0}21.365, E 100°61.099
11.	*Cynodon dactylon* (L) Pers.	Tifdwarf	Tanjung Bidara, Melaka	N 2^{0}17.776, E 102^{0}4.662
12.	*Cynodon dactylon* (L) Pers.	Common Bermuda grass	UPM	N 2^{0}21.513, E 101^{0}72.091
13.	*Digitaria didactyla* Willd.	Seranggoon	UPM	N 2^{0}21.513, E 101^{0}72.091
14.	*Eremochloa ophiuroides* (Munro.) Hack.	Centipede	UPM	N 2^{0}21.513, E 101^{0}72.091
15.	*Paspalum notatum* Flugge. B	Bahia	UPM	N 2^{0}21.513, E 101^{0}72.091
16.	*Paspalum vaginatum* Swartz.	Seashore paspalum	UPM	N 2^{0}21.513, E 101^{0}72.091
17.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Marang, Terengganu	N 5^{0}09.900,E 103^{0}14.006
18.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Pantai Batu Burok, Terengganu	N 5^{0}19.205,E 103^{0}09.413
19.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Kuala Muda, Kedah	N 5^{0}48.763,E 100^{0}37.701
20.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Batu Feringgi, Pulau Pinang	N 5^{0}28.398,E 100^{0}14.765
21.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Lumut, Perak	N 4^{0}21.365, E 100^{0}61.099
22.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Pantai Kelanang, Selangor	N 3^{0}00.235, E 101^{0}42.306
23.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Pantai Morib, Selangor	N 2^{0}45.321, E 101^{0}26.422
24.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	UPM	N 2^{0}21.513, E 101^{0}72.091
25.	*Paspalum vaginatum* Swartz.	Seashore paspalum local	Tanjung Puteri, Johor	N 1^{0}46.158, E 103^{0}77.079
26.	*Stenotaphrum secundatum* (Walt.) Kuntze	St. Augustine	UPM	N 2^{0}21.513, E 101^{0}72.091
27.	*Zoysia japonica*	Japanese lawngrass (Japan)	UPM	N 2^{0}21.513, E 101^{0}72.091
28.	*Zoysia japonica* Steud.	Japanese lawngrass (USA)	UPM	N 2^{0}21.513, E 101^{0}72.091
29.	*Zoysia matrella* (L.) Merr.	Manila grass	Kuala Perlis, Perlis	N 6^{0}23.61, E 100^{0}07.781
30.	*Zoysia matrella* (L.) Merr.	Manila grass	Pantai Bisikan Bayu, Kelantan	N 5^{0}51.832, E 102^{0}30.909
31.	*Zoysia matrella* (L.) Merr.	Manila grass	Cherating, Pahang	N 4^{0}06.04, E 103^{0}23.068
32.	*Zoysia matrella* (L.) Merr.	Manila grass	UPM	N 2^{0}21.513, E 101^{0}72.091
33.	*Zoysia matrella* (L.) Merr.	Manila grass	Port Dickson, Negeri Sembilan	2^{0}28.037 N, 101^{0}50.957 E
34.	*Zoysia tenuifolia*	Korean velvetgrass	UPM	N 2^{0}21.513, E 101^{0}72.091

Table 9. Quality rating scale of turfgrass

Leaf firing (%)	Turf quality
0	9
1-10	8
11-20	7
21-30	6
31-50	5
51-70	4
71-90	3
91-99	2
100	1

Source: Alshammary, 2004

$$\text{Relative turf colour (\%)} = \frac{\text{Turf colour index of salinized treatmentof a species}}{\text{Turf colour index of control treatmentof that species}} \times 100$$

Dry weight of shoot and root, and relative shoot and root growth (%)

At the end of the experiment, shoots and roots were harvested, and washed with tap water and finally with distilled water. Samples were then dried in an oven at 70 ^{0}C for 3 days until constant weight was achieved, and dry weight (g/pot) was recorded. Shoot and root dry weights were expressed as percentages, relative to control for each species by the following formula proposed by Ashraf and Waheed (1990):

$$\text{Relative dry weight(\%)} = \frac{\text{Dry weightof salinized treatmentvalue of a species}}{\text{Dry wightof control treatmentvalue of that species}} \times 100$$

Statistical analysis

Data were subjected to Analysis of Variance (ANOVA) based on the Randomized Complete Block Design (RCBD) (SAS, 2004). The treatment means were separated by the protected Least Significance Differences (LSD) at the 5% significant level.

Conclusion

A numbers of 34 entries of 16 turfgrass species were screened for salt tolerance from Peninsular of Malaysia. The different species of grasses were grouped for salinity tolerance on the basis of shoot and root growth reduction, leaf firing, turf colour and turf quality. The most salt tolerant species group comprised of *P. vaginatum* (UPM), *P. vaginatum* 'local', *Z. matrella*, *Z. japonica*, *C. dactylon* 'satiri' , *C. dactylon* (Kuala Muda) which were able to tolerate high levels of salinity (24 to 48 dS m^{-1}), while, the least tolerant group (24 dS m^{-1}) consisted of *E. ophiuroides*, (UPM), *P. notatum* (UPM), *A. compressus* 'cowgrass' (UPM), *A. affinis* (UPM), and *A. compressus* 'pearl blue' (UPM).

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