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Full Length Research Paper

Physiological and ecological investigation on adoption of some groundcover plants as turfgrass alternatives in arid landscape region of Kish Island during cool season

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Kish Island located in the south of Iran with 90 square kilometers, having limited expansion, sustainable ecology, erotology characteristics including low soil depth and low sweet water, does not allow the variability in plant coverage in the Island's landscape. Investigation should be conducted on groundcover species having some abilities in adapting to such environment, demanding low water and care and being suitable for the landscape. In this study 10 species of groundcover plants were chosen including: *Festuca ovina* L., *Carpobrotus acinaciformis* (L.) L. Bolus., *Sedum spurium* Bieb., *Alternanthera dentata* Moench., *Glaucium flavum* Crantz., *Frankenia thymifolia* Desf., *Sedum acre* L., *Potentilla verna* L., *Achillea milleifolium* L., *Lampranthus spectabilis* Haw. The plants were cultivated for ecological and physiological evaluation under 4 regions of Kish landscape natural situation during 2008 and 2009. Ecological traits were height, total fresh and dry weight of plant, leaf number and area, coverage area and visual quality; and physiological features including chlorophyll and proline contents. According to the results, it is indicated that *C. acinaciformis*, *G. flavum* and *A. milleifolium* have been established and began to develop, and can be recommended for cultivation in Kish Island green spaces and the same conditions elsewhere.

Key words: Xeriscaping methods, drought stress, water efficiency, salt stress.

INTRODUCTION

About 47% of the earth area consists of arid regions. Two billions of people occupy these regions the majority of whom living in developing countries (International Union for Conservation of Nature and Natural Resources, 1999). About 65% of Iran's area consists of arid regions, in which regions extreme temperatures commonly observed daylight along with dust movement caused by storm and extreme winds and also long time drought periods after erratic precipitations are major problems. Extreme lack of water quality and quantity, often lime soils and harsh climates are the environmental conditions that govern these regions (Alshuwaikhat and Nkwenti, 2006). However, there are still ambiguities in landscape design strategies that are inclined to support unlimited sources of good quality water; suitable soil and climate govern some tropical and subtropical regions (Kazemi and Beechham, 2008). Old-designed landscapes in arid zones sometimes depend on continuous consumption of water, energy and nutrition to retain them. Managing and maintaining such areas, as time passes by is money and environmental consuming (Jones and Zwar, 2003). Xeriscaping is a term in landscape designing that represents methods having efficiency in water consumption comprising suitable plant selection, applying drip irrigation, mulch and other techniques that prosper gardening in harsh environments (Environmental Center of Arid Lands, 1992; Walsh, 1993; Bradly, 1994). Xeriscape term was coined by programmers for limited water sources, which can be a steady item for outdoor landscape programming without urban water sources and inappropriate plants utilization (Assadollahi and Tallebi, 2008).

One of the xeriscape techniques is the application of groundcover plants that can tolerate harsh environments,

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drought, and salinity. These plant groups also suppress weed growth and prevent soil erosion (Relph and Appleton, 1999; Eom et al., 2006; Khalil et al., 2006). Groundcover plants term is called for the group of plants that are short and fast growing with uttermost 1 m height which could cover an area in minimum time period (Tehranifar, 2001). Factors such as low precipitation and irrigation with saline waters that annually penetrate thousand tones of salts into soil cause salinity accumulation in different regions (Khayyat, 2008). Salinity may affect ornamental aspects of wild and cultivated species. Nevertheless, some wild plants have totally more degree of saline tolerance in comparison with cultivated ones (Morales et al., 2001). Therefore, the use of salinity and drought tolerant species in landscape projects, parks and public areas needs investigations, and we must select correct items to recline these effects (Morales, 1998). Some groundcover plants are more saline resistant in contrary with other groups of plants and can be an option to solve this problem in saline regions; they also can tolerate low quality water with high EC and continue growth with lowest salinity damages. Signs of salinity stress are the same with those observed in plants exposed to drought.

However, the plants catching salinity stress are not getting wilt. High consumption of energy during osmotic adjustment in saline caught plants is a negative factor affecting growth (Greenway, 1973; Said et al., 2003). Groundcover plants can also be an appropriate replacement for turfgrasses; turfgrasses are the species used widely in landscapes. Majority of grasses need fertile, somewhat acidic or neutral soils with proper drainage (Morris, 2002). However, the lands with all these properties are scarcely found (Mortezaeinejad, 2007). Turfgrasses need high water, caring and nutrition. Furthermore, they are so much expensive to establish especially in inappropriate condition or climates. Therefore, in arid regions cultivated grass areas must be reclined (Australian West Water Sources Society, 1986; Windust, 1995). Basically, turfgrasses cannot tolerate shade, extreme drought or moisture situation and will not establish or develop in slope areas, in these cases groundcover plants also could be a proper replacement (Nameth and Chatfield, 2001). Variety in color, shape, texture and blooming time along with other interesting characteristics are advantages of groundcover plants in urban landscape designing compared to lawns (Bowker and Edingar, 1994). Dou et al. (2004) investigated the growth habit and ornamental characteristics of 305 groundcover plant species from gene bank of Yunnan Province of China and reported that three species included *Alysicarpus vaginalis, Indigofera spicata* and *Ficus tikoua* are suitable for application in green space of tropical regions of China. Establishment of groundcover plants depends on various factors affecting plant growth, such as physical properties of soil, salinity, drought, existing vegetation and low or high extreme temperatures which could impose some limitations (Uso and Pouch, 2000).

Festuca ovina L. is an ornamental and herbaceous plant whose gray color tends to blue color with 10 to 25 cm height. It belongs to Poaceae family. *F. ovina* needs good and fertile soil with suitable drainage and ordinary irrigation but can tolerate irregular irrigation (Bowker and Edingar, 1994; Tehranifar, 2001). *Carpobrotus acinaciformis* (L.) L. Bolus is a succulent perennial plant native to south Africa. It has succulent leaf with triple edge sections. Its showy flowers are pink or purple (Phillips, 1998). It belongs to Aizoaceae family preferring sandy soils with good drainage. However, it could tolerate saline and poor soils. It has been applied in oceanic regions due to preventing sandy soil erosion. Furthermore, it is resistant to drought and tolerates wind and salt spray from sea (Taylor, 1990). *Sedum spurium* Bieb. is a perennial groundcover plant tolerating all soil condition except poor drainage. It belongs to Crassulaceae family. Leaves are round and thick in red color (Bowker and Edingar, 1994) which has low to moderate growth, preferring partial shade light. *Alternanthera dentat*a Moench is native to Central and South America uniting to tropical regions and is known as a thermophile plant. It belongs to Apocynaceae family. Leaves are red and green; whereas fine flowers are white (U.S Preservation Natural Resources Service, 2009). *Glaucium flavum* Crantz. is a perennial groundcover plant in need of full sunlight having low water requirement. It belongs to Papaveraceae family; its leaves have variant lobes and its showy flowers are yellow (U.S. Preservation Natural Resources Service, 2009). *Frankenia thymifolia* Desf is evergreen, downy and interlace groundcover plant (Ghahreman, 2000). It belongs to Frankeniaceae family which is considerably saline and drought tolerant and suitable for saline soil reclamation (Easton and Kleindorofer, 2009). *Sedum acre* L. is native to Europe and North and West of Asia and is one of the most beautiful and tolerant species among *Sedum* genus (Safari, 1995). It belongs to Crassulaceae family and could grow in poor and low moisture soils, tolerating environmental stresses (Eom et al., 2005). *Potentilla verna* L. is a perennial groundcover plant with similar growth habit to strawberry. It belongs to Rosaceae family and is propagated by its runners. *Achillea milleifolium* L. is a perennial groundcover plant with medicinal properties (Wilhun, 2002; Witchel, 2002). *Achillea* genus has 130 species (Saukel et al., 2004; Guo et al., 2004) and most of them are in Eurasia and North of Africa (Post, 1993; Bremer and Humpheris, 1993; Zheng-Yi and Raven, 1994). It belongs to Asteraceae family, tolerating drought, frost and poor soils (Tehranifar, 2001). *Lampranthus spectabilis* Haw. is a fast growing groundcover plant tolerating drought conditions and would be well in shade sides. It belongs to Aizoaceae family and is easily propagated by stem cutting (Mozafarian, 1999).

Kish Island pertains to growth region of gulf and Omani

(dry forests beside the equatorial zones). Plants of this zone are xerophilous and thermophilous, requiring high temperatures, humidity and moderate winters. Major plant coverage of this zone is sparse trees and shrubs. Typical plants are *Zizyphys spina – christi* (L.) Willd, *Ficus bengalensis* L. and *Acacia nilotica* (L.) Delile (Statistical Annals of Kish, 2005). Four differential regions in Kish have been identified to vary in microclimate (Table 2). Soil and water properties of each four regions have been estimated (Table 3). Kish has a short cool season beginning from November up to April. Climatic data during cool season are presented in Table 1. In this study, we investigated establishment of 10 groundcover plants in four different microclimate regions of Kish Island in south of Iran and we decided to compare them for better coverage in such landscape.

MATERIALS AND METHODS

Plant materials

Plants were gathered from three cities, Esfahan, Mashhad and Tehran commercial nurseries. Ten groundcover plants used included *F. ovina*, *C. acinaciformis*., *S. spurium*, *A. dentata*., *G. flavum*, *F. thymifolia*, *S. acre*, *P. verna*, *A. milleifolium*, *L. spectabilis*, which are known as xerophytic groundcover plants.

Site condition

Kish Island is located in the Persian Gulf of the mainland Iran (latitude range: 53°53′E to 54°32′E and 26°34′N). Regarding the report of National Cartographic Center of Iran, the area of Kish Island is 90 km^2. Altitude from sea level is on average 32 m. According to different climate's classification method, Kish's climate is considered as a very dry and semi equatorial. Annual temperature average is 26.67°C (Table 1). The highest absolute temperature is 45°C and the lowest is 8°C. Amount of annual rainfall is 171 mm and 82% of this is in winter, about 10% in fall and others in spring and summer (Mokhtarpoor, 1998). The relative humidity mean is 65% that reaches to uttermost 70% in summer.

Measurements of growth characteristics

Morphological parameters

Visual scoring was given to plants by eye estimation, based on the range 1 to 9 (1= worst and 9= best Ghani et al., 2010). Height and coverage area of plants were measured and expressed in cm and cm^2. Leaf number was counted. Leaf area was measured by leaf area meter in eight replicates of each species (model AM200, ADC BioScientific, UK) and expressed in cm^2 $plant^{-1}$. Plants were uprooted and separated into shoots and roots and fresh weight (FW) was recorded. The samples were dried in an oven at 70°C until constant dry weight (DW) was obtained (after 4 days). The FW and DW were expressed in g $plant^{-1}$.

Chlorophyll and proline contents

Chlorophyll content was estimated by the method of Saini et al. (2001). Near to 0.5 g of plant material was taken in a pestle and mortar, and homogenized with 10 mL of 80% acetone. The extract was centrifuged at 8000×g for 10 min and the supernatant was made up to 25 mL with 80% acetone and was used for the estimation of chlorophyll content. Absorbance was read at 645 and 663 nm in a spectrophotometer (model UV-120-02, Shimadzu, Japan) and the quantity of read chlorophyll was calculated by standard formula and expressed as mg g^{-1} FW:

Total chlorophyll (mg g^{-1} FW) = 20.2 (A_{645}) +8.02 (A_{663}) × v/w×1000,

A= absorbance rate in wavelength exposed, V=final volume of acetone and extract, and W is fresh weight of samples.

The proline content was estimated by the method of Bates et al. (1973). The plant material was homogenized in 3% aqueous sulfosalicylic acid and the homogenate was centrifuged at 10,000 rpm. Supernatant was used for the estimation of proline content. The reaction mixture consisted of 2 mL acid Ninhydrin and 2 mL of glacial acetic acid, which was boiled at 100°C for 1 h. After termination of reaction in ice bath, the reaction mixture was extracted with 4 ml of toluene and absorbance was read at 520 nm and expressed in mg g^{-1} DW.

Statistical analysis

Experiment was conducted as a randomized block design with factorial arrangements. Factors included plant species and landscape regions with eight replicates. Data were analyzed by MSTAT-C software. Treatment means were separated using Turkey's test (P=0.05).

RESULTS

Height of plants

Plants of Pavioon region were uppermost in height compared to other region's plants and had a significant difference with Sadaf and Saffain regions' plants during cool season. *A. milleifolium* was the tallest plant compared to other species and had significant difference among them. *A. milleifolium* in Sanaei and Pavioon regions was the tallest plant when compared with all species in all regions (Table 4).

Visual quality of plants

Visual quality of Pavioon's plants was the best compared to other region's plants and had a significant difference with plants of Sadaf and Saffain regions in cool seasons. *C. acinaciformis* was the best when compared with other species and had a significant difference with them. *C. acinaciformis* in Sanaei, Sadaf and Saffain regions, *P. verna* in Sanaei and Pavioon regions, *L. spectabilis* in Sanaei and Pavioon regions, and *F. thymifolia* in Saffain region were the best species when compared with other species in four regions during cool season (Table 5).

Area coverage

The maximum coverage area was found from Pavioon's

Table 1. Monthly average of cool season temperature, precipitation and relative humidity at Kish, Hormozgan, Iran.

Month	2006			2007			2008			2009		
	M.T. (°C)	P (mm)	H (%)	M.T. (ºC)	P (mm)	H (%)	M.T. (°C)	P (mm)	H (%)	M.T. (°C)	P (mm)	H (%)
November	27.40	2.07	66.54	26.90	0.00	59.87	27.75	0.60	56.91	27.51	1.50	65.83
December	20.32	53.19	59.45	20.74	47.15	60.13	21.98	51.30	57.26	22.01	65.52	60.78
January	18.00	25.45	60.00	19.00	22.89	62.33	18.85	27.0	64.40	19.88	29.40	60.66
February	19.03	19.25	66.98	18.25	11.15	65.98	18.70	9.30	61.11	19.70	2.80	67.38
March	21.45	4.46	61.24	21.20	10.17	63.20	22.00	0.00	64.24	23.48	0.20	62.25
April	25.90	2.00	64.37	27.75	13.00	68.14	26.25	0.00	61.53	24.45	40.62	66.17
Average	22.01	17.7	63.09	22.30	17.39	63.27	22.58	14.70	60.90	22.83	23.34	63.84

M.T: Mean temperature (C°), P: precipitation (mm), H: humidity (%).

Table 2. Geographical coordinates of topography and distance from sea in four different regions of Kish Island.

Region	Latitude	Longitude	Altitude (m)	Distance from sea (m)
Sanaei	54˚01'06 83"	26˚33'28 17"	5.48	426
Sadaf	54˚00'01 61"	26˚32'36 89"	30.17	2800
Pavioon	54˚02'05 00"	26˚31'58 99"	0.61	65
Saffain	53˚56'56 02"	26˚34'24 81"	2.43	35

Table 3. pH and EC of soil and water from four different regions of Kish Island.

Regions	Water		Soil	
	EC	pH	EC	pH
Sanaei	1.7	6.3	2.16	8.06
Sadaf	1.2	7.3	1.3	8.02
Pavioon	0.9	7.7	2.4	7.91
Saffain	1.8	6.7	5.06	7.82

plants which had a significant difference with others during cool season. *A. milleifolium* and *C. acinaciformis* were the best species in area coverage and had significant difference with other species. *A. milleifolium* and *L. spectabilis* in Pavioon region were the fastest species when compared with others during cool season (Table 5).

Total fresh and dry weight of plants

Plants of Sanaei region were the heaviest in terms of FW, when compared with other region's plants during cool season and had significant difference with them, except for Saffain. Furthermore, *C. acinaciformis* in Sadaf and Saffain were the heaviest plants when compared with other species in four regions. Plants of Sanaei regions had the heaviest DW when compared with others during cool season (Table 5). Maximum DW can be attributed to *A. milleifolium* having significant difference with other species. Furthermore, *A. milleifolium* in Sanaei and Pavioon regions had maximum DW which had significant difference with other plants in four regions during cool season (Table 5).

Leaf number

Maximum leaf number was found from Sanaei and Pavioon region's plants during cool season and had significant difference with other regions. *L. spectabilis* was the best plant based on the number of leaves produced, having significant difference with other plants. Also, this species had the best performance in Pavioon region and had significant difference with other species in all regions except itself in Sanaei, Sadaf and Saffain regions, *A. dentata* in Sanaei, Pavioon and Saffain regions, *C. acinaciformis* in Saffain and Sadaf region in

Table 4. Ecological indices (leaf area and number) under evaluating in used plants in four regions of Kish Island.

Index	Region	*G. flavum*	*P. verna*	*A. milleifolium*	*L. spectabilis*	*C. acinaciformis*	*A. dentata*	Mean
Leaf number	Sanaei	23.33c[z]	340.00^{bc}	192.33^{bc}	1044.00^{ab}	371.00^{bc}	843.33^{abc}	469.00^{A}
	Sadaf	33.00^{c}	179.67^{bc}	45.33^{c}	219.33^{bc}	541.67^{abc}	356.67^{bc}	229.28^{B}
	Pavioon	24.67^{c}	390.00^{bc}	206.00^{bc}	1307.60^{a}	172.83^{bc}	637.33^{abc}	456.42^{A}
	Saffain	48.67^{c}	233.33^{bc}	98.00^{c}	653.30^{abc}	638.33^{a-c}	582.00^{abc}	375.61^{B}
	Mean	32.42^{E}	285.75^{D}	135.42^{E}	806.08^{A}	430.96^{C}	604.83^{B}	
Leaf area (cm^{-2})	Sanaei	89.48^{a}	9.20^{b}	117.20^{a}	4.31^{b}	12.60^{b}	7.81^{b}	34.93^{A}
	Sadaf	103.87^{a}	7.08^{b}	99.02^{a}	5.06^{b}	11.00^{b}	7.42^{b}	33.94^{A}
	Pavioon	101.41^{a}	9.73^{b}	133.00^{a}	5.18^{b}	11.41^{b}	8.45^{b}	39.08^{A}
	Saffain	99.40^{a}	8.28^{b}	100.92^{a}	4.87^{b}	10.46^{b}	7.16^{b}	33.62^{A}
	Mean	98.54^{A}	8.57^{B}	112.54^{A}	4.86^{B}	11.36^{B}	7.71^{B}	

[z]Means with similar letters (small letters for interactions and capital letters for means) are not significantly different by Tukey's test at 5% level.

four regions during cool season (Table 4).

Leaf area

Leaf area index had no significant difference among plants of four regions. However, plants of Sadaf region had the lowest leaf area among other regions. *G. flavum* and *A. milleifolium* in all regions produced maximum leaf area during cool season (Table 4).

Chlorophyll content

Plants of Pavioon region had maximum chlorophyll content; significant difference was observed in comparison to others during the cool season. *P.* verna, *F. thymifolia* and *G. flavum* had maximum content of chlorophyll compared to other species. As interaction point, *P. verna* had maximum chlorophyll content when compared with other plants in four regions and it showed significant differences with both *A. dentata* and *C. acinaciformis* in all regions, both *S. spurium* and *F. ovina* in Sanaei and Saffain regions, *S. acre* in Pavioon, Sadaf and Sanaei regions, and *L. spectabilis* in Sanaei, Sadaf and Saffain regions. During the cool season it was *F. ovina* which had maximum amount of chlorophyll in Sanaei region, but having no significant difference with itself in Pavioon region (Figure 1).

Proline content

Plants of Sadaf had maximum proline amount with no significant difference with other regions. *F. thymifolia* had maximum proline content when compared with other species and had significant difference with them. Interaction results showed that *F. thymifolia* in Pavioon had the highest proline content when compared with other plants and had significant difference with them except *F. thymifolia* in three other regions (Figure 2).

DISCUSSION

Visual quality of plants in Pavioon region was the greatest in comparison with plants of other regions. We found that it was a result of vicinity to sea and great quality of soil and water (Table 1) caused the best view of plants, whereas the plants of Sadaf region had the lowest visual quality. Area coverage of Sadaf's plants was in minimum state which was caused by a greater drought stress. Total fresh and dry weights of plants in Sadaf region were minimum. These results are similar to Mahieu et al. (2009) report in pea (*Pisum sativum* L.). Leaf number of Sadaf and Saffain plants was in minimum, which could be attributed to longer distance from sea and more water stress in Sadaf region and high EC of soil in Saffain region. Fornes et al. (2007) stated that the number of leaves in *Petunia* was reduced in saline treatments. Plants of Pavioon region had the highest chlorophyll content which can be explained by vicinity to sea and good quality of water and soil. Plants of Sadaf region also had the least chlorophyll content which is similar to reports of Mohamadkhani and Heidary (2007) in two cultivars of *Zea mays* L. and Abaszadeh et al. (2007) in lemon balm (*Melissa officinalis* L.). Proline content showed no significant difference in all regions' plants. It can be explained that proline in cool season was not affected by water stress and temperature was not too high to induce difference in proline content.

Although Kish Island has properties of dry regions, the relative humidity of air is relatively high and is reported about 65% which can reach up to 70% in summer; this high relative humidity causes dew formation almost in all days of the year in the Island which could delay temperature increment and water stress the next day, and could directly be used by plants (Shahandeh, 2002; Basiri et al., 2005). Therefore, high RH could provide

Table 5. Ecological indices (coverage area, fresh weight, height, dry weight and visual quality) under evaluating in used plants in four regions of Kish Island.

Index	Region	*G. flavum*	*S. acre*	*P. verna*	*A. millifolium*	*L. spectabilis*	*F. thymifolia*	*S. spurium*	*C. acinaciformis*	*A. dentata*	*F. ovina*	Mean
Covering area (cm^2)	Sanaei	9208.57b-f[z]	1406.56^{fgh}	3968.17^{d-h}	10934.25^{bcd}	12172.73^{bc}	5315.58^{c-h}	1604.50^{fgh}	11759.30^{bcd}	5948.68^{b-h}	1783.74^{fgh}	6410.21^{B}
	Sadaf	5309.13^{c-h}	1014.23^{gh}	1409.23^{fgh}	4788.23^{c-h}	1305.97^{gh}	4844.62^{c-h}	1260.71^{gh}	11467.75^{bcd}	1425.04^{fgh}	730.37^{h}	3355.53^{C}
	Pavioon	9936.68^{b-e}	1203.92^{gh}	5674.30^{c-h}	22480.94^{a}	13785.62^{a}	4027.33^{d-h}	1215.21^{gh}	6737.70^{b-h}	2528.66^{e-h}	2077.06^{e-h}	6966.74^{A}
	Saffain	8858.88^{b-g}	1295.33^{gh}	3921.86^{d-h}	8151.70^{b-h}	6469.15^{b-h}	8363.17^{b-h}	2849.24^{e-h}	11564.60^{bcd}	3936.51^{d-h}	1258.25^{gh}	5666.87^{B}
Mean		8328.31^{B}	1230.01^{F}	3743.39^{D}	11588.78^{A}	8433.36^{B}	5637.67^{C}	1732.41^{F}	10382.34^{A}	3459.72^{E}	1462.35^{F}	
Total fresh weight	Sanaei	494.50^{cde}	54.23^{h}	188.13^{fgh}	649.90^{c}	627.53^{c}	241.33^{e-h}	148.10^{fgh}	1773.60^{b}	353.50^{d-g}	155.00^{fgh}	468.58^{A}
	Sadaf	493.30^{cde}	46.23^{h}	87.93^{h}	54.20^{h}	40.09^{h}	225.42^{fgh}	139.40^{fgh}	2212.66^{a}	193.16^{fgh}	36.32^{h}	352.87^{B}
	Pavioon	492.46^{cde}	90.57^{h}	205.70^{fgh}	678.93^{c}	654.60^{c}	100.56^{gh}	156.70^{fgh}	656.13^{c}	266.07^{e-h}	174.13^{fgh}	347.58^{B}
	Saffain	563.10^{cd}	33.72^{h}	134.63^{fgh}	366.20^{def}	235.37^{fgh}	345.10^{dfg}	144.82^{fgh}	2222.80^{a}	249.00^{e-h}	88.70^{hij}	438.39^{A}
Mean		510.85^{B}	56.18^{F}	154.08^{E}	437.30^{C}	389.40^{C}	228.12^{D}	147.26^{E}	1716.48^{A}	265.44^{D}	113.52^{F}	
Height (cm)	Sanaei	18.00^{c-g}	4.66^{n-q}	12.83^{e-l}	37.83^{a}	9.16^{i-q}	6.20^{k-q}	3.83^{q}	18.67^{c-f}	17.63^{c-g}	11.89^{g-o}	14.07^{A}
	Sadaf	12.84^{e-l}	3.33^{q}	7.84^{k-q}	24.00^{bc}	6.50^{k-q}	3.93^{pq}	4.00^{pq}	20.67^{bcd}	12.33^{e-m}	8.50^{j-q}	10.39^{B}
	Pavioon	15.83^{d-i}	5.16^{m-q}	11.83^{f-n}	38.00^{a}	10.17^{h-q}	5.66^{l-q}	4.40^{opq}	13.10^{e-k}	19.17^{c-e}	17.43^{c-h}	14.08^{A}
	Saffain	13.17^{e-k}	4.10^{opq}	7.16^{k-q}	27.00^{b}	7.93^{j-q}	4.30^{opq}	4.50^{opq}	15.37^{d-j}	11.17^{g-p}	12.00^{e-m}	11.07^{B}
Mean		14.95^{C}	4.32^{F}	9.91^{E}	31.71^{A}	8.48^{E}	5.01^{F}	4.18^{F}	16.95^{B}	15.08^{C}	11.51^{D}	
Total dry weight (g)	Sanaei	82.95^{bcd}	7.29^{no}	53.28^{hij}	149.65^{a}	80.38^{c-f}	67.84^{d-h}	25.70^{k-o}	81.63^{c-f}	107.01^{b}	49.69^{h-k}	70.54^{A}
	Sadaf	79.47^{c-g}	6.25^{no}	24.92^{l-o}	13.15^{mno}	5.56^{o}	63.31^{d-h}	24.20^{l-o}	101.86^{bc}	57.62^{f-i}	11.53^{mno}	38.80^{D}
	Pavioon	84.60^{bcd}	12.20^{mno}	58.27^{e-i}	57.47^{a}	78.48^{c-f}	28.10^{k-o}	27.62^{k-o}	30.64^{j-n}	79.48^{c-g}	55.16^{g-j}	61.20^{B}
	Saffain	94.50^{bc}	4.58^{o}	38.18^{i-l}	83.33^{bcd}	32.64^{j-m}	97.09^{bc}	24.95^{l-o}	102.52^{bc}	65.88^{d-h}	27.49^{k-o}	57.11^{C}
Mean		85.71^{B}	7.58^{H}	43.66^{E}	100.90^{A}	49.77^{E}	64.08^{D}	25.62^{G}	79.16^{C}	77.50^{C}	35.96^{F}	
Visual guality	Sanaei	7.00^{c}	6.33^{c-f}	9.00^{a}	8.00^{abc}	9.00^{a}	7.00^{a-e}	7.00^{a-e}	9.00^{a}	8.66^{ab}	6.66^{b-f}	7.86^{A}
	Sadaf	5.00^{ef}	4.50^{fg}	7.00^{a-e}	4.66^{fg}	3.66^{g}	8.66^{ab}	6.66^{b-f}	9.00^{a}	3.66^{g}	4.66^{fg}	5.98^{C}
	Pavioon	6.00^{d}	6.66^{b-f}	9.00^{a}	8.66^{ab}	9.00^{a}	6.33^{c-f}	6.66^{b-f}	7.66^{a-d}	8.00^{a-c}	8.66^{ab}	7.93^{A}
	Saffain	8.00^{b}	5.00^{efg}	8.00^{abc}	7.66^{a-d}	8.00^{abc}	9.00^{a}	7.66^{a-d}	9.00^{a}	5.66^{d-g}	5.00^{efg}	7.36^{B}
Mean		6.66^{E}	5.62^{G}	8.25^{B}	7.24^{B}	7.41^{D}	7.75^{C}	7.00^{E}	8.58^{A}	6.50^{F}	6.25^{F}	

[z]Means with similar letters (small letters for interactions and capital letters for means) are not significantly different by Turkey's test at 5% level.

water as a replacement of essential water in soil for plants, absorbable from air. Hence, distance from sea as a source of high RH is a factor affecting plant growth and development. Furthermore, saline condition is one of plant growth limitations in Kish Island. Saline stress can affect growth and development and cause great reduction in biomass. In this study, we found that drought stress is more important in growth and development of plants. Within regions, Sadaf region has the longest distance from the Persian Gulf and has the highest altitude in comparison

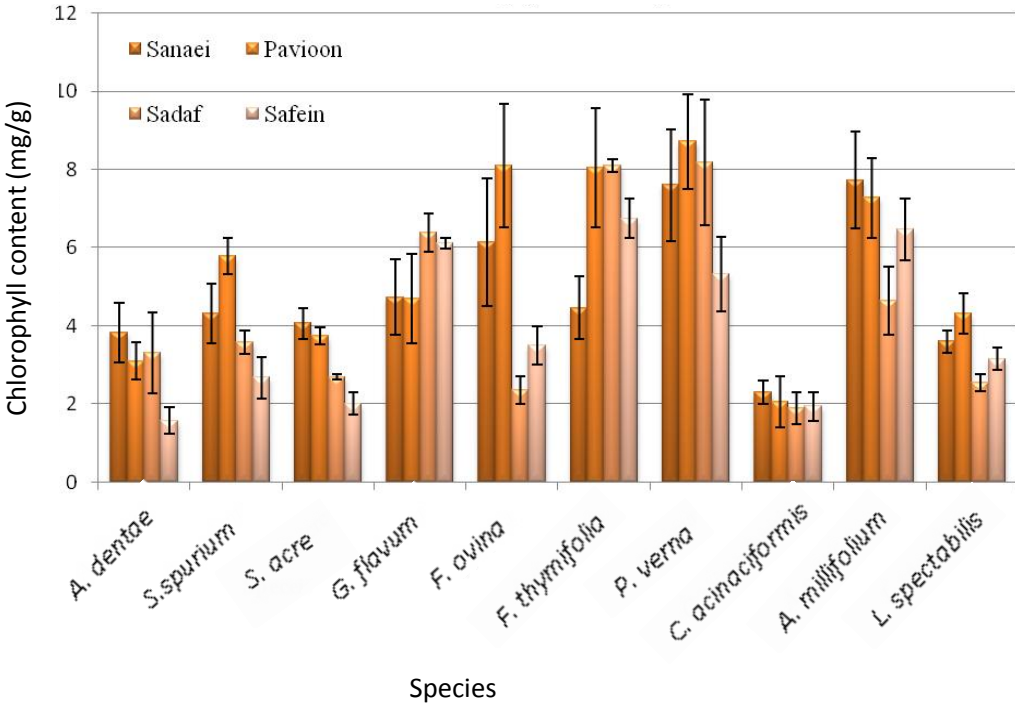

Figure 1. Total chlorophyll content (mg/g leaf fresh weight) of ten groundcover plants as affected by species and region.

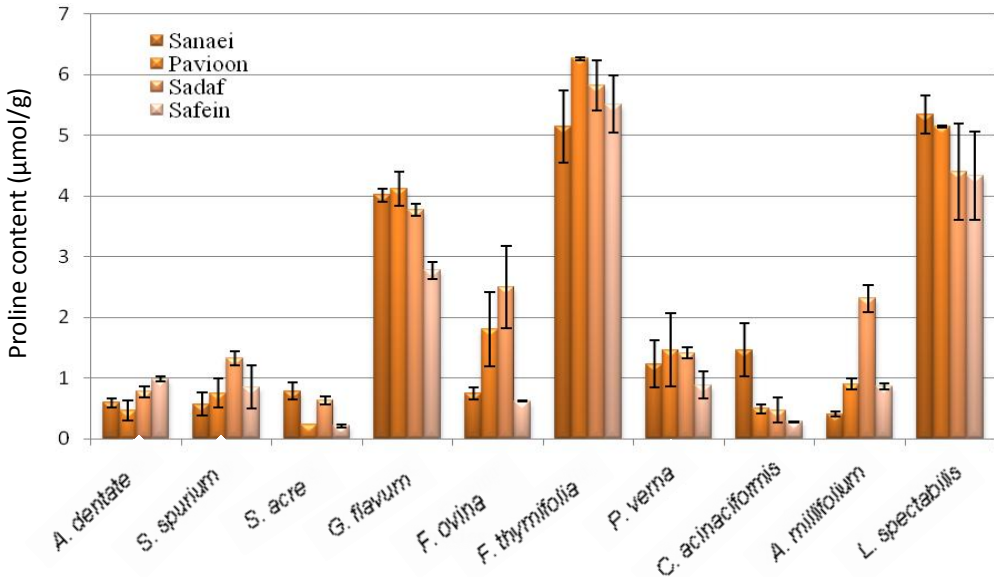

Figure 2. Total proline content (µmol/g leaf fresh weight) of ten groundcover plants as affected by species and region.

with other regions (Table 3). Water stress in plants of this region was more than others. This stress could affect plant's height; the plants of Sadaf region experienced the greatest water stress and were shorter than others, the results are similar to report of Chylinski et al. (2007) in impatiens (*Impatiens balsamina* L.). It seems that more distance from sea and higher altitude affect the plant characteristics. Regarding the growth indices, we could recommend *C. acinaciformis*, *G. flavum*, and *A. milleifolium* to Kish Island and similar regions elsewhere

during cool seasons. *C. acinaciformis* had the best quality in every region and the maximum area was covered by this plant.

Furthermore, it produced the largest fresh weight compared to other species. *C. acinaciformis* is ideal for seaside landscapes and can tolerate salt spray coming from sea, drought soils and prefers sandy soils. *A. milleifolium* a drought tolerant species, producing many leaves and showy flowers, is valuable for landscape designing (Danihelka and Rotreldovfi, 2001; Tehranifar, 2002). Based on the results, *A. milleifolium* had the maximum turnover in covering area, height, leaf area and total fresh weight. *G. flavum* is a good choice for planting in dry regions due to its widespread canopy which can tolerate warm winds usually puffed in such regions. Results showed that *G. flavum* had suitable yield regarding covering area, total fresh and dry weight and leaf area. These results can be usable in selecting the best groundcover plants for the same conditions around the world.

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