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Ecological Response to Habitat Variation for Perennial Species in Saudi Arabia

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Abstract: Background: It is important to investigate the relationship between plant distribution and edaphic factors in coastal plains of Saudi Arabia showing remarkable changes in response to environmental alterations. The present study aims to assess the response of some perennial species to variations in soil characteristics and changes in water status from wet winter to dry summer season. **Material and Methods:** The study has assessed ecological responses in 7 different habitats in the western part of Saudi Arabia at Ras Sharah on the Red Sea coast. The habitats considered in this study included; salt marsh (I), coastal dune (II), sandstone and conglomerates (III), transitional area covered with loose sand (IV), rocky plain covered with loose sand deposits (V), compact transitional area (VI), and loose sand non-saline (VII). **Results:** The most suitable habitat for the growth of perennial species was habitat V for *Panicum turgidum* Forssk, habitat VII for *Cyperus conglomeratus* Rottb, habitat VI for *Taverniera aegyptiaca* Boiss, habitat III for *Indigofera spinosa* Forssk, habitat II for *Zygophyllum album* L. f., and habitat I for *Halopeplis perfoliata* (Forssk.) Bge ex Schweinf. The main reason for stress was identified as the salinity and drought stresses resulting from soil characteristics and changing climatic conditions from wet to dry season. It was shown *that Panicum turgidum* possess the most exceptional tolerance capacity. **Conclusion:** The study has concluded that recorded perennial species tolerated the stress conditions by accumulating osmoregulation metabolites as soluble carbohydrates proline, protein, and amino acids.
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Keywords: Coastal Plains, Ecological Responses, Edaphic Factors, Habitat, Perennial Species, Soil Characteristics.

Introduction

The changing global environment has led to multi-scale alterations as a response to the climatic changes and land use. The ecosystem, human health, and well-being are affected as a result of degradation, loss of habitat, and fragmentation (Oliver & Morecroft, 2014). There is a significant impact of habitat loss, degradation, and fragmentation on the health and well-being of human beings(Willis & Bhagwat, 2009). The major factors leading to biodiversity erosion include loss of habitat and degradation.

Moreover, a broad range of current ecosystem services is affected as a result of warming climate and changed rainfall patterns. This is likely to reduce the biodiversity as the plant species fail to adapt to the climatic changes (Ohlemuller et al., 2008). Wetlands facilitate sustainable development and human welfare among different ecosystems because of social, environmental, and economic value. Previous studies have reported information on the distribution of plant species and communities in the different habitats along the Red Sea coast at the western region of Saudi Arabia(Fakhry & Aljedaani, 2018; Thomas et al., 2016). An earlier study by El-Demerdash, Hegazy, & Zilay (1995) distinguished five habitat types of widely different vegetation that helped in characterizing the coastal Tihama plains at the South Western region of Saudi Arabia.

Water stress is considered as the primary force in plant evaluation process (Brodribb et al., 2017). Moreover, the ability to cope with water deficit is an important determinant of natural plant distribution, crop distribution, and productivity. It is difficult to assess the factors that control the water balance of the plants in a desert environment. It is believed that all the concerned factors act simultaneously in a soil-plant-atmosphere continuum (Hall, & Kaufmann, 1975). The most distinctive feature of plants growing in an arid

environment is the accumulation of increased amounts of low molecular weight soluble solutes in their cells through osmotic adjustment (Choi et al., 2012). A study has shown that increasing salinity is associated with significantly higher fractions of glutamine, glutamate, proline, and increased the osmolality of plant sap (Rolletschek, and Hartzendorf, 2000). In coastal habitats, leaf surface abrasion by sand grains causes holes in the leaf surface, which in combination with salt spray results in local leaf tissue necrosis that is visible as sunken brown marks on the leaf surface (Rozema, 1985).

Over the past few decades, various studies have reported water scarcity across the Arabian Peninsula given the substantial changes in land use (Abdel-Rahman & Almalki, 2018).These changes occur as a response to unparalleled levels of population growth, increased economic growth, and urbanization (UN Population Division 2016). This degrades a natural habitat of Saudi Arabia as a result of these changes the sustainable use of resource becomes challenging (Sheppard et al., 2013). Until now, no research has assessed the overall status of soil and biodiversity in Saudi Arabia. Moreover, previous studies investigating the influence of environmental factors are required to be updated. The previous studies on the vegetation alteration in Aseer, Riyadh, and Taif regions showed that climate and topography are the main factors which impact the speciation degree (Al-Sodany et al., 2011; Abdel-Rahman & Almalki, 2018). Therefore, the present study aims to elucidate the metabolical variations due to edaphic and summer season drought stress in some characteristic perennial species growing in 7 habitats at the Red Sea desert. The study also investigates the influence of different soil characteristics (especially the direct influence of the maritime environment) on these plant species.

Materials and Methods

Study Design

The present study was carried out on transect extends along 10 Km from the seashore to non-saline habitat at Ras Sharah in Western Saudi Arabia (Figure 1). The time duration of this study was from June 2017 to June 2018. The mean annual rainfall in the area is 4.7-38.7 mm, concentrated from November to February, the average maximum temperature is 40.3°C, and the minimum average temperature is 14.5°C.

Study Setting

The main habitats in this area include salt marsh (I), coastal dune (II), sandstone and conglomerates (III), transitional area covered with loose sand (IV), rocky plain covered with loose sand deposits (V), compact transitional area (VI) and loose non-saline sand (VII). These habitats represented a gradient in soil salinity and the influence of distance from the sea. The perennial species (*Halopeplis perfoliata* (Forssk.) Bge ex Schweinf., *Zygophyllum album* L. f., *Cyperus conglomerates* Rottb., *Panicum turgidum* Forssk., *Indigofera spinosa* Forssk., and *Taverniera aegyptiaca* Boiss) were selected as the testing plants because they were dominant and represented the vegetation of the different habitats. The selected sites had a reasonable degree of habitat and plant cover homogeneity.

Study Procedure

The study procedure was conducted on twenty quadrates (2mx1m) that were selected randomly in each habitat during summer and winter seasons of 2017. The recorded plant species in each quadrate were collected. Twenty samples from the recorded species in each habitat were collected during both the seasons. The sampled plant materials were washed under running tap water followed by distilled water, wiped thoroughly by fine tissue, and then the plant leaves (or young branches) were divided into two portions. The first portion was used to determine the content of photosynthetic pigments, after extraction with 85% acetone as shown by Metziner et al (1965). The second portion was extracted with double distilled water for the determination of soluble reducing sugars (Chaplin & Kennedy, 1994), soluble protein (Bradford, 1976), amino acids(Ya, 1966), and proline(Bates, Waldern, and Teare, 1973).

Study Parameters

The parameters considered in this study include; electrical conductivity, soil texture, the content of the vital nutrient elements, chlorophyll content, water content, metabolism of plant species, variation in the soluble protein, the content of soluble carbohydrates, and proline content.

Soil Analysis

Nine composite soil samples (0-30 cm in depth) were collected within each habitat, three of them were placed in weighed aluminum foils. Then, they were dried in an oven at 105°C to determine their soil moisture content. The other samples were air-dried, passed through a 2mm sieve, and packed in paper bags for further analysis. Soil texture was determined by the Boujoucos hydrometer method that was employed by Black et al(Black, Evan, & Ensminger, 1965). An electrical conductivity meter (WTW-LF-91, England) and a glass electrode pH meter (WTW model 512) was used for measuring EC and pH in a 1:5 soil water extract. Total Na+, K+, Ca+2, Mg+2 were determined by using a flame photometer and an atomic absorption spectrophotometer according to Allen et al (1974) Chlorides in the soil extracts were determined by using

chloride meter (EIL selective ion electrode ORION). Values for salinity were calculated from the conductivity measurements. Oxidizable organic matter in the soil samples was determined through the methods proposed by Walkley and Black (1934).

Statistical Analysis

The data was entered, coded, and analyzed using the Statistical Package of Social Sciences (SPSS) version 20.0. Descriptive statistics were applied to study the effect of the concerned parameters on the ecological responses of different habitats. Results obtained were treated statistically by applying the analysis of variance.

Results

Soil Analysis

Soil moisture content, electrical conductivity, macro-elements (Na+, K+, Ca+2, and Mg+2) chlorides, and organic matter in the study area showed significant variations based on the type of habitat and season (Table 1). The percentages of soil moisture (Habitat I, 17.77±1.96) and organic matter (Habitat I, 1.90±0.32) were higher in summer as compared to the winter season (soil moisture HI, 15.72±1.92 and organic matter HI, 0.53±0.19) in all habitats. Electrical conductivity and chlorides content fluctuated during the two different seasons. Habitat I attained the highest electrical conductivity (10.0±2.63) and content of chlorides (8.0±0.18); while, habitat VII attained the lowest electrical conductivity (0.012±0.006) and content of chlorides (7.35±0.05) in both seasons (Table 1).

Analysis of soil texture revealed remarkable differences in the sand percentage at different habitats. Table 2 shows that the maximum sand percentage (95.0, 96.0%) is recorded in habitat VII during summer and winter seasons due to the decrease in the percentage of silt in the different habitats. All soil samples showed an alkaline reaction in the summer season, ranging from 7.2 to 8.0 in the different habitats. The soil reaction decreased in the winter season, ranging between 6.6 and 7.3 in the different habitats.

The content of the vital nutrient elements is (Na+, K+, Ca+2, and Mg+2) showed in table 3 indicated that Ca+2 content (82.9±0.2) is higher than those of other elements in the habitats I, II and III. While Mg+2 content was higher in the other habitats. The soil Na+ content decreased from habitat I (3.92±0.11) to habitat VII (0.75±0.04). Variations in soil calcium content were sharp from one habitat to another in the study area. The maximum value in the habitat I was about 207 times the minimum value in habitat VII.

The variations in the contents of the monovalent cations Na+ and K+ and the divalent cations Ca+2 and Mg+2 affected their ratios together in the soil of the different habitats as shown in table 3. The ratio of Na+/K+ varied in the soil from habitat I to habitat VII due to decrease in Na+ and increase in K+ content in the soil. The decrease was remarkable so that the maximum in the habitat I became about 20 times the minimum in habitat VII. The Na+/K+ ratio was higher in winter than in summer season at habitats I and II as compared to other habitats. The ratio of Ca+2/Mg+2 decrease also from a maximum in the habitat I to a minimum value in habitat VII. This decrease was remarkable that the maximum value was 100 times the minimum one. Winter ratios of Ca+2/Mg+2 were higher than summer season ratios in the soil of most habitats. The ratio of Na+/K+ and Ca+2/Mg+2 indicated that Na+ and Ca+2 were higher than K+ and Mg+2 in the soil of the first three habitats I, II, and III (more significant than unity). In the other habitats, soil exhibited a different ratio of the two elements, where K+ and Mg+2 contents were higher (lower ratios than the unit).

Plant Analysis

The few numbers of the recorded perennial species increased from salt marsh (habitat I) south words to habitat VII, except habitat V, which was inhabited by one species. The recorded perennial species were *H. perfoliata* in habitat I, *P. turgidum*, *C. conglomeratus* and *Z. album* in habitat II, *P. turgidum*, *T. aegyptiaca* and *I. spinosa* in habitat III, *P. turgidum*, *C. coglomeratus* and *Z. album* in habitat IV, *P. turgidum* in habitat V, P. turgidum, *T. aegyptiaca* and *I. spinosa* in habitat VI and *P. turgidum*, and *C. conglomeratus* in habitat VII.

The chlorophyll a, b, and carotenoids content of the recorded species varied significantly in the summer season with a range of about 0.35, 0.12, and 0.1, mg/g fresh weight, respectively in *T. aegyptiaca* and 0.02, 0.01 and 0.003 mg/g fresh weight, respectively in *P. turgidum* (Habitat III). The content varied significantly in the winter season with a range of about 0.53, 0.19, and 0.13mg/g fresh weight in *T. aegyptiaca* (in Habitat III) to about 0.06, 0.03 and 0.03 mg/g fresh weight in *P. turgidum* (in habitat VI), respectively. Chlorophyll a was the highest in the recorded species at all habitats in the two different seasons; while, carotenoids were the lowest.

Water content varied significantly in leaves of studied species in different habitats during different seasons (Table 3 and 4). In summer, the highest percentage of water content (86.0%) was in *H. perfoliata* and *Z. album* at habitat I and II, respectively; while, the lowest percentage (51.0%) was recorded in I. spinosa at habitat VI. The corresponding values in winter were 95% in *Z. album* at habitat IV and 60.0% in *I. spinosa* at habitat VI. Table 3 has shown that there

was a significant decrease in the water content decreased in the dry season (summer) relative to the wet season (winter) in most plant species collected from different habitats.

The metabolism of plant species was also affected significantly by habitat and season, where the content of proline increased in summer dry season with the highest increase (642.9%) in leaves of *P. turgidum* at habitat V (Table 3 and 4). Soluble amino acids in the leaves of *T. aegyptiaca* showed the highest content in both summer and winter seasons (1.12, 0.78 mg/g) at habitat VI and III, respectively (Table 3). Table 3 has also shown that there was significant variation in the soluble protein ($P<0.01$) in all studied species in the different habitats during both summer and winter seasons. *P. turgidum* at habitat V attained the highest protein content at the two seasons. On the contrary, protein content in the previous species decreased with dryness in the habitats II, IV, and VII. The results exhibited significant variation in the content of soluble carbohydrates in all studied species sampled from the different habitats during the two seasons (Table 3).

Carbohydrates accumulated with different levels of *P. turgidum* in the dry season at all habitats except at habitat III, where it decreased. The highest accumulation (3466.7%) was recorded at habitat IV. Considering the proline content, the highest proline accumulation was found in leaves of *C. conglomeratus* was at habitat II; while, proline accumulation in leaves of *T. aegyptiaca* was at habitat VI. Leaves of *Z. album* accumulated proline in the dry season at habitat II. On the contrary, proline content in *I. spinosa* and *H. perfoliata* decreased during the summer season, and the maximum decrease for the former species was only at habitat VI (Table 5, 6, and 7).

Tables

Table 1: The physical characters of soil collected from the different habitats of the study area during winter (W) and summer (S) seasons (means ± standard error)

Habitat	Season	Soil moisture %	EC mmhos/cm	pH	Organic Matter %
I	S	17.77±1.96	10.0±2.63	8.0±0.18	1.90±0.32
	W	15.72±1.92	3.19±0.50	7.28±0.03	0.53±0.19
II	S	0.67±0.16	1.11±0.33	7.63±0.07	0.29±0.03
	W	2.06±0.80	1.35±0.07	7.27±0.04	0.78±0.16
III	S	0.77±0.14	0.22±0.21	8.0±0.03	0.32±0.04
	W	1.38±0.32	0.11±0.005	6.83±0.07	1.13±0.19
IV	S	0.40±0.05	0.55±0.06	7.35±0.01	0.45±0.07
	W	2.11±0.04	0.36±0.07	7.11±0.07	0.86±0.15
V	S	0.83±0.13	0.14±0.01	7.45±0.06	0.44±0.20
	W	2.16±0.42	0.43±0.03	7.03±0.07	1.17±0.19
VI	S	0.66±0.04	0.13±0.01	7.18±0.11	0.55±0.06
	W	1.30±0.14	0.08±0.01	6.65±0.11	1.39±0.31
VII	S	0.64±0.16	0.012±0.006	7.35±0.05	0.04±0.00
	W	1.34±0.31	0.08±0.009	6.63±0.08	1.48±0.18

Table 2: The physical characters of soil collected from the different habitats of the study area during winter (W) and summer (S) seasons (means ± standard error)

Habitat	Season	Sand %	Silt %	Clay %
I	S	81.20±0.9	12.17±1.03	6.20±0.33
	W	93.00±1.13	1.92±0.30	5.08±0.91
II	S	94.50±0.84	3.17±0.40	2.34±0.51
	W	95.50±0.00	2.42±0.54	2.67±0.54
III	S	92.00±0.44	3.67±0.34	2.0±1.32
	W	93.50±0.55	1.25±0.23	1.60±0.38
IV	S	94.30±0.69	2.33±0.47	3.34±0.73
	W	94.50±0.27	2.33±0.49	5.25±0.47
V	S	93.80±0.93	2.83±0.51	3.84±0.47
	W	94.70±1.16	1.34±0.37	4.34±1.17
VI	S	92.30±1.25	1.75±0.19	5.92±1.30
	W	94.17±0.62	1.25±0.30	4.60±0.62
VII	S	95.17±1.12	2.50±0.48	2.34±0.78
	W	96.00±0.40	0.75±0.00	3.25±0.81

Table 3: The chemical characters of soil collected from the different habitats of the study area during winter (W) and summer (S) seasons (means ± standard error)

Habitat	Season	Na mg/g. d wt	K mg/g. d wt	Na/K	Ca mg/g. d wt	Mg mg/g. d wt	Ca/Mg
I	S	3.92±0.11	0.78±0.05	5.03	70.0±0.6	14.0±0.29	5.01
	W	3.87±0.12	0.38±0.03	10.18	82.9±0.2	13.2±0.30	6.29
II	S	0.7±0.02	0.26±0.02	2.69	52.0±0.2	11.0±0.13	4.78
	W	0.89±0.07	0.29±0.03	3.07	47.2±0.05	12.8±0.15	3.69
III	S	0.55±0.03	0.54±0.13	1.02	47.2±0.05	9.8±0.20	4.82
	W	0.26±0.02	1.46±0.03	0.18	12.1±0.06	10.9±0.28	1.11
IV	S	0.75±0.04	1.14±0.06	0.66	3.9±0.17	7.87±0.10	0.50
	W	0.27±0.005	1.26±0.02	0.21	3.4±0.09	8.34±0.25	0.41
V	S	0.43±0.04	1.42±0.06	0.30	1.8±0.03	7.98±0.07	0.22
	W	0.22±0.015	1.19±0.18	0.19	3.0±0.0	8.88±0.36	0.34
VI	S	0.43±0.04	1.43±0.08	0.30	0.2±0.0	7.11±0.48	0.03
	W	0.13±0.02	1.28±0.03	0.10	1.7±0.01	7.65±0.13	0.20
VII	S	0.33±0.04	1.31±0.07	0.25	0.4±0.04	7.63±0.09	0.05
	W	0.1±0.01	1.00±0.07	0.10	0.4±0.04	6.1±0.11	0.06

Table 4: Analysis of variance (F values) for the physical characters of soil collected from the different habitats of the study area during winter (W) and summer (S)

Analysis of variance (F values)													
Habitat	-	200.6**	10.8**	ns	13.7**	3.8*	20.6**	ns	7150.1**	235.6**	-	7481**	832.1**	-
Season	-	56.4**	85.8**	20.5**	13.4**	ns	55.1**	ns	266.7**	48.3**	-	2412**	48.7**	-
Interaction	-	59.5**	5.0**.	8.19**	8.8**	ns	17.29**	ns	45.17**	12.5**	-	9123.5**	42.0**	-

* = P<0.05 is significant, ** = P<0.01 is highly significant and ns= non-significant

Table 5: Photosynthetic pigments (mg/g.fr. wt.) for the recorded species at the different habitats in the study area during the winter (W) and summer (S) seasons (mean ± standard error)

Habitat	Species	Chlorophyll a		Chlorophyll b		Chlorophyll a/b		Carotenoids	
		S	W	S	W	*S*	W	S	W
I	*H. perfoliata*	0.08±0.01	0.09±0.003	0.03±0.002	0.04 ±0.01	3.44±0.36	2.29±0.22	0.05±0.004	0.05±0.002
II	*P. turgidum*	0.03±0.004	0.11±0.01	0.01±0.002	0.04±0.004	2.65±0.82	2.92±0.08	0.01±0.003	0.03±0.004
	C. conglomeratus	0.05±0.01	0.16±0.02	0.03±0.01	0.05±0.004	2.15±0.68	3.09±0.09	0.02±0.003	0.06±0.004
	Z. album	0.08±0.02	0.09±0.01	0.02±0.003	0.03±0.002	3.89±0.75	3.03 ±0.15	0.02±0.004	0.03±0.002
III	*P. turgidum*	0.02±0.003	0.17±0.01	0.01±0.003	0.05±0.01	1.33±0.21	3.97±0.54	0.003±0.00	0.05±0.004
	I. spinosa	0.23±0.06	0.37±0.04	0.08±0.01	0.13±0.02	3.03±0.29	2.92±0.18	0.08±0.01	0.13±0.01
	T. aegyptiaca	0.35±0.02	0.53±0.02	0.12±0.01	0.19±0.01	3.04±0.06	2.79±0.39	0.10 ±0.01	0.13±0.01
IV	*P. turgidum*	0.05±0.01	0.24±0.03	0.01±0.003	0.07±0.01	3.61±0.77	3.56±0.13	0.02±0.010	0.06±0.01
	C. conglomeratus	0.05±0.01	0.08±0.01	0.02±0.002	0.03±0.002	2.58±0.23	2.92±0.31	0.03±0.002	0.03±0.004
	Z. album	-	0.12±0.01	-	0.03±0.001	-	4.31±0.65	-	0.05±0.003
V	*P. turgidum*	0.17±0.01	0.19±0.03	0.05±0.003	0.06±0.01	3.53±0.28	3.39±0.13	0.05±0.003	0.06±0.01
VI	*P. turgidum*	0.05±0.01	0.06±0.01	0.02±0.002	0.03±0.003	3.08±0.24	2.40±0.13	0.02±0.002	0.03±0.01
	I. spinosa	0.26±0.02	0.35±0.06	0.1±0.002	0.12±0.02	2.6±0.15	2.99±0.16	0.10±0.003	0.12±0.01
	T. aegyptiaca	0.24±0.01	0.50±0.05	0.09±0.01	0.18±0.03	3.01±0.65	2.96±0.19	0.10±0.003	0.13±0.01
VII	*P. turgidum*	0.08±0.01	0.20±0.04	0.02±0.003	0.06±0.01	4.97±0.96	3.13±0.14	0.02±0.003	0.05±0.01
	C. conglomeratus	0.08±0.01	0.09±0.02	0.03±0.002	0.03±0.004	3.02±0.29	2.83±0.31	0.03±0.01	0.05±0.01

Table 6: Water content, proline, soluble proteins, carbohydrates, and free amino acids contents in the recorded plant species at the different habitats in the study area during winter (W) and summer (S) seasons (mean ± standard error)

Habitat	Species	Water content %		Proline (mg/g. fr. Wt.)		Protein (mg/g. fr. wt.)		Carbohydrate (mg/g. fr. wt.)		Amino acids (mg/g. fr. wt.)	
		S	W	S	W	S	W	S	W	S	W
I	*H. perfoliata*	86.50±0.56	87.59±0.57	0.08±0.004	0.09±0.02	2.40±0.13	1.25±0.13	0.02±0.002	0.16±0.01	0.14±0.01	0.33±0.02
II	*P. turgidum*	60.50±2.11	68.00±1.67	0.09±0.01	0.05±0.01	1.93±0.51	2.31±0.03	1.03±0.12	0.17±0.03	0.05±0.01	0.23±0.02
	C. conglomeratus	66.17±1.51	80.67±0.56	0.04±0.003	0.03±0.03	2.48±0.13	1.44±0.11	2.98±0.25	0.20±0.04	0.05±0.01	0.23±0.03
	Z. album	86.33±0.67	93.33±0.49	0.50±0.05	0.32±0.03	0.59±0.13	1.59±0.07	0.06±0.01	0.02±0.003	0.09±0.01	0.36±0.01
III	*P. turgidum*	66.83±2.14	75.17±1.01	0.1±0.002	0.08±0.03	2.68±0.11	2.32±0.14	0.05±0.02	0.29±0.05	0.07±0.01	0.17±0.03
	I. spinosa	59.83±2.06	69.67±1.73	0.01±0.001	0.14±0.01	1.11±0.13	1.31±0.12	0.04±0.003	0.25±0.03	0.05±0.003	0.37±0.03
	T. aegyptiaca	68.83±2.37	77.50±1.12	0.05±0.01	0.16±0.01	1.27±0.09	1.64±0.18	0.05±0.01	0.88±0.14	0.06±0.01	0.78±0.07
IV	*P. turgidum*	69.33±0.76	71.33±0.76	0.20±0.003	0.08±0.02	1.48±0.11	3.14±0.13	1.07±0.15	0.03±0.004	0.91±0.04	0.41±0.07
	C. conglomeratus	63.33±0.92	78.33±0.76	0.04±0.004	0.05±0.001	2.09±0.07	1.63±0.14	2.65±0.30	0.08±0.01	0.28±0.05	0.24±0.03
	Z. album	--	95.17±0.70	--	0.22±0.08	--	2.60±0.33	--	0.08±0.02	--	0.11±0.003
V	*P. turgidum*	61.33±1.58	69.50±1.45	0.52±0.05	0.07±0.004	4.31±0.29	3.63±0.26	0.06±0.01	0.04±0.01	0.26±0.03	0.44±0.04
VI	*P. turgidum*	63.17±0.95	65.00±0.73	0.02±0.004	0.06±0.01	2.45±0.14	1.67±0.07	0.51±0.14	0.17±0.06	0.48±0.09	0.07±0.01
	I. spinosa	51.83±2.41	60.17±1.78	0.02±0.003	0.43±0.06	0.78±0.16	1.76±0.06	0.02±0.003	0.02±0.003	0.46±0.09	0.35±0.03
	T. aegyptiaca	53.67±3.13	69.17±2.19	0.22±0.02	0.13±0.01	1.35±0.13	2.21±0.09	0.58±0.08	0.05±0.01	1.12±0.07	0.28±0.03
VII	*P. turgidum*	61.83±1.19	71.00±0.97	0.04±0.01	0.07±0.02	0.89±0.07	2.54±0.16	0.11±0.01	0.09±0.03	0.27±0.02	0.16±0.04
	C. conglomeratus	61.33±1.78	80.00±0.296	0.02±0.002	0.03±0.01	4.93±0.28	0.69±0.09	0.99±0.07	1.63±0.49	0.24±0.03	0.10±0.003

Table 7: Analysis of variance (F values) for the content of the photosynthetic pigment (chlorophyll a, b and carotenoids and contents of proline, proteins, carbohydrate (Carbo) and amino acids (AA) of the studied plants by the different habitats, seasons and their interactions

Parameter	Test	Chl. a	Chl. b	Carotenoids	Chl. a/b	Proline	Protein	Carbo	AA
H. perfoliata	Ha	-	-	-	-	-	-	-	-
	Se	ns	7.354*	ns	7.191*	ns	173.9**	459.3**	83.82**
	Ha.Se	-	-	-	-	-	-	-	-
P. turgidum	Ha	54.86**	15.22**	12.98**	ns	384.9**	92.11**	106.3**	191.3**
	Se	337.6**	135.4**	76.42**	ns	373.9**	19.17**	313.8**	63.18**
	Ha.Se	32.25**	9.934**	5.464**	4.053**	351.4**	46.70**	151.8**	105.2**
C. conglomeratus	Ha	6.287**	7.968**	ns	ns	31.69**	85.54**	10.31**	21.06**
	Se	27.52**	14.23**	57.66**	ns	0.692	868.7**	1016**	0.000
	Ha.Se	10.09**	3.681*	17.45**	ns	6.462**	327.2**	499.7**	36.24**
Z. album	Ha	ns	ns	9.188*	ns	108.5**	251.4**	5.511*	18.47**
	Se	ns	ns	ns	ns	53.87**	64.29**	17.25**	189.5**
	Ha.Se	-	-	-	-	-	-	-	-
I. spinosa	Ha	ns	ns	ns	ns	164.9**	0.990	775.0**	114.4**
	Se	13.07**	12.08**	12.56**	ns	555.9**	90.58**	553.6**	33.89**
	Ha.Se	ns	ns	ns	ns	146.7**	40.26**	536.8**	134.5**
T. aegyptiaca	Ha	8.372*	ns	ns	ns	59.90**	30.21**	25.14**	182.7**
	Se	78.94**	ns	47.06**	ns	ns	107.1**	23.55**	8.861*
	Ha.Se	ns	ns	ns	ns	115.0**	16.99**	486.3**	139.3*

Ha: Habitat, Se: Season * = P < 0.05 is significant, ** = P < 0.01 is highly significant and ns = non-significant

Discussion

The present study indicated sharp variations in soil moisture in the seven studied habitats due to the fluctuations in the climate from winter wet to summer dry seasons. This was found to restrict the number of plant species and affect the water. The variation in soil moisture revealed that the plant species suffer from increasing drought stress by heading east (apart from the sea coast) in the study area, with a maximum at habitat VII. This drought stress increased during the dry season. Other edaphic factors especially soil texture, soluble chlorides, contents of significant nutrient elements (Na+, K+, Ca+2, and Mg+2), and organic matter and the soil solution electrical conductivity (EC) exhibited a wide range of significant variation between the different habitats of the study area.

A similar study recorded the ecological relations between the plant distribution and edaphic factors present within the coastal plains in Saudi Arabia(Salman, 2015). The study examines the pattern of vegetation along with the involvement of vegetative composition and environmental factors. The results showed the main edaphic factors that affected the vegetation in Jazan area including the pH, moisture, electrical conductivity, organic carbon, calcium

carbonate, bicarbonate, the sodium adsorption ratio, and the soil cations (sodium, potassium, calcium). These results clarified that the Jazan area is a sub-tropical desert region and therophytes are the most common life form found here (Salman, 2015). Strong challenges are faced by the long-term permanence of Saudi Arabia's wetland as a result of human activities such as habitat degradation, coastal development, and sustained population growth, despite the societal services and ecological values. Another studyhelped in highlighting the biodiversity, threats, and evolution of the ecosystems in Arid Arabian Peninsula(Al-Obaid et al., 2017). The study mainly focused on the key freshwater taxa and showed that the well-managed ecosystems are resilient in response to the uncertain events.

The comparison was conducted for the range of diversity measures under different degrees including the mycorrhizal potential and soil properties(Uddin & Robinson, 2017). The results showed that the majority of the significant ecological alterations were dependent on the Phragmites density. The results of the present study showed that the high drought tolerance capacity of *P. turgidum* affected the distribution in the majority of the habitats. On the contrary, the distance to village parameter was revealed as the most influential factor on the species diversity index that relates to degrade rangelands and reduce species diversity (Eghdamiet al., 2019).

Salinity and drought stresses were identified as a major reason resulting from the soil and climatic changes from wet to dry season. This understanding as extended by another study that showed the impact of salinity on the physiological characteristics of plant (Acosta-Motos et al., 2017). It was shown that the process of photosynthesis is severely affected as salinity induces oxidative stress at the subcellular level(Acosta-Motos et al., 2017). A study similar to the present one provided significant insights about the implications for land and agricultural water management in a particular area. Under different types of land cover, there was a significant impact of soil water in surface, root zone and deep soil layer(Niu, Musa, & Liu, 2015). Similarly, the knowledge about floristic composition and vegetative analysis of wild legumes was presented in a study conducted in Taif district, Saudi Arabia. It was shown that different climate builds up as a result of the elevation of gradients among the studied areas that promote diversification of plants (Fadl, Farrag, & Al-Sherif, 2015)

The present study has shown that native species suffer from these stressful conditions, especially during the dry summer season. Plants respond to the imposed stress by the accumulation of some compatible solutes such as sugars, amino acids, and proline in their most suitable habitats; however, they failed partially or totally in the others. Moreover, high drought tolerance capacity of *P. turgidum* was confirmed and that it could be the reason of its distribution in the majority of the habitats making it an attractive forage plant for grazing animals in the arid areas. The results of the present study have clarified that there are different amplitudes of distribution for native plant species of this area.

Conclusions

The present study has assessed the response of some perennial species to variations in soil characteristics along with the changes in water status from wet winter to dry summer season in 7 different habitats in the western part of Saudi Arabia at Ras Sharah on the Red Sea coast. The results showed that the most suitable habitat for the growth of each studied species was habitat V for *P. turgidum*, habitat VII for *C. conglomeratus*, habitat VI for *T.aegyptiaca* and *I. spinosa*, habitat II for *Z. album*, and habitat I for *H. perfoliata*. The salinity and drought stresses resulted from soil characteristics and changing climatic conditions from wet to dry season represent the main stress in the area.

The study results are limited as it has only assessed the impact of one environmental factor that is soil. However, other edaphic factors also play an important role in the distribution of different plant community types. Therefore, future studies need to consider the impact of other factors including human and plant impacts that modify the distribution and abundance of plant species and other spectrums.

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Conflicts of Interest

The authors declare no conflict of interest.

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