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ECOPHYSIOLOGICAL RESPONSES OF SOME PSAMMOPHYTES AT NORTH SINAI AND SIWA OASIS

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The present investigation aimed at the study of the ecophysiological responses of some psammophytes at two different habitats; South El-Bardwil Lake and Siwa Oasis. Physical and chemical properties of the soil were recorded. The floristic composition of the two selected pilot areas was realized. The chemical composition of some species was discussed in relation to climatic and edaphic factors. The results indicated that:

1- South El- Bardwil Lake was dominated by *Zygophyllum album* community type, while the Khamisa sand dune was dominated by *Cornulaca monacantha* community type.
2- The annual species were highly represented in the El-Bardwil sand dune habitat.
3- The maritime influence has great impact on zonation pattern of vegetation in the coastal sand dunes.
4- Most of the perennials occupied the crest of dune at the two pilot areas.
5- Plant species have two modes of physiological adaptation to the environmental stresses; some species were electrolytic dependants while the other were non- electrolytic dependants in their adaptive responses to the prevailing conditions.

Keywords: ecophysiological responses, psammophytes, sand dunes, north Sinai, Siwa Oasis

The present investigation was carried out in two contrasted pilot areas. The first area is located south of El-Bardwil lake between long 32° 50′ and 33° 10′ E and lat. 31° 00′ and 31° 50′ N. extending for about 70 km in length and ranged from 3 to 10 km in width where a series of maritime sand dune ridges are present. The mobile dunes represent a great portion of this pilot area. Generally, the climate of north Sinai is characterized by arid, long hot,

rainless summers and mild winters with scarce amounts of rainfall (NARSS, 1994). The second pilot area is located southwest of Siwa Oasis (Khamisa). Siwa Oasis is one of the depressions (10-17 m/ below the sea level) located in the northern part of the western desert of Egypt between long. 25° and 26° E and lat. 29° and 30 ° N. about 300 km south of the Mediterranean Coast. According to the values of Emberger (1951) Pluviothermic Quotient (1.43) Siwa climate is characterized by severe aridity. Sand formations are dominant feature of the landscape of Siwa Oasis. They are formed of aeolian materials which settle on wide areas forming sheets of sand or building sand bars and/ or sand dunes. On the south and southeastern sides of the lakes (e.g Siwa lake and El- Maraqi lake) there are extensive areas of sand dunes that vary in height (2-3m), size and shape (Zahran, 1972; Zahran and Willis, 1992).

The aim of the present investigation was the elucidation of the eco-physiological and philological responses of different plant species in relation to edaphic and climatic factors in the two studied areas (El- Bardwil and Khamisa).

MATERIALS AND METHODS

The eco- physiological responses and the phenological aspects of the sand dune vegetation were studied in relation to climatic and micro-edaphic factors at two different pilot areas; south El- Bardwil (north Sinai) and Khamisa (southwest Siwa Oasis).

Soil Sampling and Analysis

In each pilot area, three sites were set up. Three soil samples at two different depths (0-30 and 30-60 cm) were collected from each site and were mixed together to form homogeneous samples. All soil samples were air dried, then the particle size distribution was undertaken by the sieve method after Wild *et al.* (1979). The pH, electrical conductivity (EC), calcium carbonate, moisture content, cations (Na^+, K^+, Ca^{++}, Mg^{++}) and anions (HCO_3^-, Cl^-, SO_4^-) were determined according to Jackson (1967) and Piper (1950). The particle size, moisture content, calcium carbonate content were expressed as a percentage. The cations and anions content were expressed as me / L . The electrical conductivity was expressed as dSm^{-1}.

Vegetation Analysis and Plant Sampling

The sand dune vegetation of El- Bardwil (north Sinai) and Khamisa (Siwa Oasis) was studied in a total of 6 sites; three sites (the crest, the flank and the foot of the dune) in each pilot area. In each site, a list of species was recorded and 15 random quadrats (10 × 10 m) were studied. Species density, frequency and cover were determined according to Muller- Dombois and Ellenberg (1974). The relative values of density, frequency and cover were summed to give the importance values for each species (Ludwig and

Reynolds, 1988). The abundance– dominance scale followed by Tadros and Atta (1958) was applied. The plant samples representing the two pilot areas were collected to be analyzed for cations (Na^+, K^+, Ca^{++}, Mg^{++}) according to Richards (1954) and some metabolic constituents; total available carbohydrates (TAC) according to Said *et al.* (1964), total nitrogen (TN) by the micro-Kjeldahl method, total chlorophyll (T.ch) and carotenoids (cartn) according to Vernon and Selly (1966). All results were expressed as mg / gm dry matter. All data presented in the tables are means of the readings.

Climate of the Study Areas

The climatic characteristics (average of 6 years from 1995 to 2000) of El- Arish province, north Sinai and Siwa Oasis, western desert are given in table (1). The data reveal that there are substantial differences between the two areas. According to the UNESCO/FAO bioclimatic map of the Mediterranean zone (1963) and Ayyad and Ghabbour (1986), north Sinai region climatologically falls within the arid Mediterranean zone and the climate of this region is attenuated sub- desertic with a short dry period. On the other hand, Siwa Oasis falls within the extreme desert of south west Egypt which is a part of the driest region of the world; the climate of this region is accentuated desertic with a long period of drought (Bornkamm, 1991).

Data in table (1) shows that the average annual rainfall in north Sinai is 9.3 mm, while in Siwa Oasis it is 0.8 mm. The average annual maximum temperature in north Sinai (25.6° C) is low as compared with that of Siwa Oasis (29.7° C). The highest mean monthly maximum temperature (31.7° C) shows that the plant cover of north Sinai is not subjected to very high injurious temperatures during summer. The average mean minimum temperature (15.9° C) is not so low as to inhibit growth or prevent germination. The reverse is true in Siwa Oasis where this region is characterized by very strong solar radiation for a long period and similarly strong reradiation from the soil upward during the night causing extreme differences between day and night of air and soil temperatures. The average annual soil temperature is 20.4° C in north Sinai province, while in Siwa Oasis it reached 31.3° C.

The annual average of relative humidity in north Sinai is 71.7%. The driest months are May and October, while the most humid months are February, July, November and December (R.H. ranged from 74–78 %). In Siwa Oasis the annual average of relative humidity is 41%. The driest months are April, May, June, July (R.H. ranged from 30-34%), while the most humid months are January, November, December (R.H. ranged from 52-56 %).

As evident from table (1) the wind speed fluctuates within a range between 3.0 m/sec and 4.6 m/sec within the two areas of the study. Wind direction varies in the different seasons; the blowing of southern and south

eastern winds in winter make the air warmer, while the blowing of northern and north-western winds in summer make it cooler in north Egypt. This phenomenon, together with the maritime impact, make the air temperature mild and diminishes the ranges of diurnal and seasonal oscillation in the northern part of Egypt at all. The annual mean evaporation is 4.5 mm / day in north Sinai, while in Siwa Osais it is 7.1 mm/ day. The high humidity during summer months results in decreasing the evaporation rate in these months.

TABLE (1). The climatic characteristics of El- Arish province and Siwa Oasis (average of 6 years 1972-1992, Ministry of Civil Aviation, Meteorological Authority).

Items / Months	El - Arish , North Sinai								Siwa Oasis							
	Air temperature C		Soil temp. C	Rain mm	RH %	Evaporation mm/day	Avarage wind speed km/h	wind direction	Air temperature C		Soil temp. C	Rain mm	RH %	Evaporation mm/day	Average wind speed km/h	Wind direction
	Max.	Min.	20 cm depth						Max.	Min.	20 cm depth					
January	18.4	9.4	10.9	33.8	71.0	3.6	20.9	WSW	19.6	4.6	20.6	1.0	53	4.1	10.5	W
February	19.4	10.0	12.3	15.5	74.0	4.0	17.6	W	21.8	5.9	21.1	2.1	45	4.8	11.8	W
March	21.7	11.7	15.9	13.2	70.0	4.5	13.0	WNW	25.1	8.6	24.8	0.3	38	6.0	13.9	W
April	23.3	13.9	20.2	10.2	71.0	4.7	13.7	NNW	29.8	12.6	32.8	1.1	33	7.2	14.4	W
May	26.7	16.7	23.8	1.8	63.0	4.9	15.5	NNW	34.1	16.7	37.2	1.2	30	9.7	12.6	N.N.W
June	29.4	20.0	26.7	0.0	73.0	4.9	14.1	NNW	37.8	19.6	38.8	0.0	30	10.3	11.7	N.N.W
July	31.1	21.7	26.9	0.0	74.0	4.8	10.7	NNW	37.7	20.8	39.6	0.0	34	11.2	11.1	N.N.E
August	31.7	22.3	28.8	0.0	73.0	4.9	10.0	NNW	37.5	20.8	39.7	0.0	37	8.9	9.8	N.N.E
September	30.6	21.1	25.7	0.0	70.0	5.2	15.4	NNW	34.9	18.6	37.3	0.1	41	8.2	8.9	N.N.E
October	28.9	18.3	23.0	6.4	69.0	4.8	18.7	NNW	31.3	15.0	33.7	0.4	45	6.8	8.1	N.N.E
November	25.0	15.0	17.7	9.9	74.0	4.0	17.9	WNW	25.9	10.1	27.9	1.1	52	5.1	7.6	W
December	20.6	11.1	12.9	20.8	78.0	3.6	21.8	WSW	21.1	6.2	22.2	2.1	56	3.3	9.4	W
Annual mean	**25.6**	**15.9**	**20.4**	**9.3**	**71.7**	**4.5**	**15.8**		**29.7**	**13.3**	**31.3**	**0.8**	**41**	**7.13**	**10.8**	

The plant communities of the Mediterranean coastal zone in Egypt are clearly subjected to climatic factors which are more favorable than those of the Siwa Oasis habitat.

RESULTS

Three topographically different representative profiles were chosen to cover the widest possible ranges of soil variation within each pilot area; the first at the crest, second at the flank and the third at the foot of the dune. Two depths (0-30 and 30-60 cm) were dug in each profile where a large volume of root materials extends. The physical characteristics (Table 2) of the soil exhibit a wide range of variation along the topographic gradient and depths at the two pilot areas. In the first area (El- Bardwil), soil texture is dominated by fine ingredients (fine sand is 8- fold the coarse sand). Silt and clay ranges were 4.5-4.1, 7.1-5.2 and 13.1-7.8% at the crest, flank and the foot of the

dune, respectively. On the other hand, soil of Khamisa was coarse– textured (the coarse sand: fine sand is approximately 2 : 1) where the coarse sand ranged from 53.9 to 58.51%. Silt and clay ranges were 2.7 – 2.5, 2.6-2.4 and 9.3 – 10.1 at the crest, the flank and the foot of the dune, respectively. However, the percentages of silt and clay differed between and within the pilot areas of the study, being higher in El- Bardwil soil than in Khamisa soil. Also, they varied with topographic, being smaller from the summit to the foot of the dune.

Soil moisture content varied between and within the two areas, being higher in El- Bardwil soil than in Khamisa. It tended to increase from the crest to the base of the dune. Moisture content in El- Bardwil soil is 2-fold that of Khamisa soil at the different sites and depths. This means that soil moisture content coincides with soil texture class.

TABLE (2). Physical properties of the soil from the study areas .

Location		El – Bardwil (north Sinai)					Khamisa (Siwa Oasis)				
Site	Depth	Coarse sand %	Fine sand %	Silt & clay %	Moisture content %	Texture class	Coarse sand %	Fine sand %	Silt &clay %	Moisture conten%	Texture class
Crest	0 – 30	10.2	85.3	4.5	1.86	Sand	58.36	38.92	2.72	0.89	Sand
	30 – 60	10.15	85.75	4.13	2.23	Sand	58.42	38.97	2.57	1.3	Sand
Flank	0 – 30	3.1	89.8	7.1	1.82	Sand	58.42	38.95	2.63	0.96	Sand
	30 – 60	11.8	82.95	5.25	2.10	Sand	58.51	39.01	2.48	1.28	Sand
Foot	0 – 30	10.4	76.5	13.1	1.95	Sand	54.41	36.27	9.32	1.41	Sand
	30 – 60	8.25	83.7	7.85	2.54	Sand	53.89	35.95	10.16	1.56	Sand

The chemical composition of the soil samples from the studied areas is given in table (3). As evident from table (3) soil reaction (pH) ranged from 8.1-8.4 and from 7.8-8.9 in El- Bardwil and Khamisa soils, respectively, being mildly alkaline in some layers to distinctly alkaline in others. The electrical conductivity (EC) tended to increase from the summit to the foot of the dune in both areas. It ranged from 0.8 dSm^{-1} in the surface layer (0-30 cm) to 2.4 dSm^{-1} in the deeper ones (30-60 cm) in El- Bardwil soil, while in Khamisa the electrical conductivity ranged from 0.15 dSm^{-1} to 1.06 dSm^{-1} in the surface layer (0-30 cm) and from 0-18 to 0.71 in the deeper one (30-60 cm). The increasing salinity of the surface layer at the foot of the dune (1.06 dSm^{-1} in Khamisa may be due to the increased evaporating power, forming a mild salted crust soil. Generally, the soils are non-saline on the summits and the flanks to slightly saline on the base of the dune in the two pilot areas.

TABLE (3). Chemical composition of the soils from the study areas.

Location		El-Bardwil (north Sinai)										Khamisa (Siwa Oasis)									
Site	Depth	EC dSm^{-1}	pH	$CaCO_3$ %	Cations me / L				Anions me / L			EC dSm^{-1}	pH	$CaCO_3$ %	Cations me / L				Anions me / L		
					Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	SO_4^-				Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	SO_4^-
Crest	0-30	0.9	8.4	0.22	5.5	0.3	1.4	0.7	0.92	5.1	2.2	0.15	8.9	9.79	1.15	0.20	0.67	0.33	0.38	1.50	0.47
	30-60	1.4	8.3	0.20	6.9	0.4	3.9	1.8	1.6	6.9	3.1	0.18	8.81	11.84	1.3	0.12	0.84	0.06	0.55	0.83	0.75
Flank	0-30	0.8	8.2	0.23	5.8	0.4	1.6	0.60	0.85	5.2	2.1	0.35	7.9	12.38	1.89	0.31	0.33	0.67	0.38	2.20	1.62
	30-60	1.6	8.4	0.22	8.5	0.4	4.6	2.2	1.8	10.5	4.1	0.23	7.83	9.79	1.01	0.20	0.83	0.54	0.39	1.24	0.95
Foot	0-30	0.9	8.2	0.20	7.6	0.2	1.3	0.2	1.1	5.2	2.3	1.06	8.21	31.64	8.57	0.63	2.05	1.45	2.95	7	2.75
	30-60	2.4	8.1	0.23	18	0.6	3.5	2.4	2.6	17	4.6	0.71	8.66	48.66	5.69	0.42	1.78	1.39	1.91	4.46	2.91

Calcium carbonate ($CaCO_3$) content indicates that soils of El- Bardwil sand dunes are very slightly calcareous, while the soils of Khamisa sand dunes are of highly calcareous nature. Depthwise, slightly distribution of $CaCO_3$ showed two distinct patterns where $CaCO_3$ tends to increase downwards within the soil profiles of Khamisa area, while in El- Bardwil area $CaCO_3$ content was approximately the same within and between the different profiles. Soluble cations are mostly in the order $Na^+ > Ca^{++} > Mg^{++} > K^+$, while soluble anions follow the order $Cl^- > SO_4^- > HCO_3^-$ except in few cases where K^+ exceeds Mg^{++}.

The phytosociological features and the phenological aspects of the vegetation in the two studied areas are given in table (4). Results of the present work showed that the flora recorded in the two habitats consists of 14 flowering plant families of 27 genera and species. Family Poaceae was the first contributor (5 sp.), followed by Legumi nosae (4 sp.), while Asteroceae and Caryophyllaceae occupied the third rank (each of 3 sp.). Family Chenopodiaceae ranked fourth (2 sp.); the other families have one species. There are many species specified of sand dune habitats for example, *Cornulaca monacantha, Zygophyllum album, Stipagrostis scoparia and Ammophilla arenaria.* The latter species is restricted in its distribution to maritime sand dunes from Rafah in the north to El- Sullum in the west. El-Bardwil sand dune habitat was dominated by *Zygophllum album* community type (IV = 46.1 %). The associated species were 19 perennials; *Cornulaca monacantha, Artemisia monosperma, Astragalus fruiticosum, Lygos reatam,*

Convolvulus lanatus, Panicum turgidum, Calligonum comosum, Thymelaea hirsuta, Stipagrostis scoparia, Lotus criticus, Erodium hertum, Haplophyllum tuberculatum, Pancrchatium maritimum, Ammophila arenaria, Paronychia Sinaica, Heliotropum digynum, one binnial species Centauria pallescens, and 7 annual species; *Polycarpon succulentum, Silene succulenta Schismus barbatus, Bassia muricata, Cutandia memphytica, Ifloga spicata and Echium longifolium.* Most of the perennial species occupied the crest of the dune, while annual species were distributed on the flank and the foot of the dune. On the other hand, Khamisa sand dune habitat was dominated by *Cornulaca monacantha* community type (IV= 220.1%). Only four perennials associates were recorded: *Zygophyllum album* (IV= 66.2 %), *Alhagi maurorum* (IV= 12.4 %), *Stipagrostis scoparia* (IV= 0.9 %) and *Cistanche tubulosa* (IV= 0.4 %). The most interesting point here was the complete absence of annual species.

Most species, either perennials or annuals, were in vegetative or flowering phases in the El- Bardwil habitat, while species of Khamisa (all perennials) were in vegetative, fruiting and even dormant stages during the period of study.

The chemical composition of some representative perennial species from the two habitats is given in table (5). Results indicated that some species were either electrolytic dependent or non- electrolytic dependent in their adaptive responses to the environmental stresses (edaphic or climatic stresses), while some others responded to such stresses through accumulation of electrolytic and non- electrolytic constituents in their tissues. For example, *Cornulaca monacantha, Stipagrostis scoparia, Convolvulus lanatus, Artemisia monosperma and Ammophila arenaria* were non- electrolytes dependent; while *Zygophyllum album* was the only species depended upon the inorganic constituents in the El- Bardwil habitat. On the other hand, the later species responded to the environmental stress through accumulation of some metabolic constituents more higher than the cationic contents in Khamisa habitat. *Cornulaca monacantha,* and *Stipagrostis scoparia* took the same trend as in the first habitat.

Generally, desert plants have a specific mechanism; physiological, morphological and even structural, which accommodate, the environmental stresses.

TABLE (4). Vegetation analysis of the study areas; I. El- Bardwil (north Sinai), II: Khamisa (Siwa Oasis) Early April, 2005.

Items / Species	Family name	Life form	Growth form		Average IVs	
			I	II	I	II
Zygophyllum album	*Zygophyllaceae*	Per	4g	3Do, fr	46.10	66.2
Cornulaca monacantha	*Chenopodiaceae*	Per	2 g	5 Do, fr	35.69	220.1
Artemisia monosperma	*Asteraceae*	Per	3 g	-	32.4	-
Astragalus frusticosum	*Leguminosae*	Per	3 g	-	23.32	-
Lygos raetam	*Leguminosae*	Per	2 g, fl	-	22.10	-
Convolvulus lanatus	*Convolvulaceae*	Per	1 fl	-	15.46	-
Panicum turgidum	*Poaceae*	Per	1 g	-	14.76	-
Calligonum comosum	*Polygonaceae*	Per	1 g	-	12.87	-
Thymelaea hirsuta	*Thymeliaceae*	Per	1 g, fl	-	12.60	-
Stipagrostis scoparia	*Poaceae*	Per	1 fl	2 fr	11.1	0.9
Lotus creticus	*Leguminoseae*	Per	2 g	-	7.7	-
Erodium hirtum	Geraniaceae	Per	2 fl	-	7.11	-
Haplophyllum tuberculatum	*Rutaceae*	Per	+ g	-	3.85	-
Panchratium maritimum	*Liliaceae*	Per	4 g	-	3.79	-
Ammophila arenaria	*Poaceae*	per	2g	-	2.28	-
Heliotropium digynum	*Boriinaceae*	per	+ g	-	1.91	-
Paronychia sinaica	*Caryophyllaceae*	per	3fp	-	1.49	-
Alhagi maurorum	*Leguminoseae*	Per	-	4 Do,g fr	-	12.4
Cistanche tubulosa	*Orobanchaceae*	Per	-	+ f	-	0.4
Centaurea pallescens	*Asteraceae*	Bi	2 fl	-	8.17	-
Polycarpon succulentum	*Caryophyllaceae*	Bi	3g, fl	-	14.54	-
Silene succulenta	*Caryophyllaceae*	Bi	2 g	-	12.59	-
Schismus barbatus	*Poaceae*	Bi	3 fl	-	9.13	-
Bassia muricata	*Chenopodiaceae*	Bi	1 g	-	3.04	-
Cutandia memphytica	*Poaceae*	Bi	2 g, fl	-	2.96	-
Ifloga spicata	*Asteraceae*	Bi	+ g	-	2.61	-
Echium longifolium	*Boraginaceae*	Bi	1 fl	-	2.41	-

Per = Perennials
Ann = Annuals
g = Green
fl = Flowering
fr = Fruiting
Do = Dormant
IVs= Important values

5 = Very abundant
4 = Abundant
3 = Fairly abundant
2 = Rare
1 = Very rare
+ = Just present

TABLE (5). Mineral ions and some metabolic contents (mg/g dry wt.) of some representative plants from the study areas (El- Bardwil and Khamisa).

Species	El – Bardwil (north Sinai)										Khamisa (Siwa Oasis)									
	Na^+	K^+	Ca^{++}	Mg^{++}	Total	TAC	TN	T. Ch	Car.	Total	Na^+	K^+	Ca^{++}	Mg^{++}	Total	TAC	TN	T.Ch	Car.	Total
Cornulaca monacantha	6.55	7.2	8.45	4.28	**26.48**	29.1	11.9	4.7	2.4	**48.1**	8.32	7.95	9.91	4.45	**30.63**	22.2	10.7	3.9	2.85	**39.65**
Zygophyllum album	14.0	6.4	22	2.3	**44.7**	27.1	13	2.48	1.35	**43.93**	23.8	8.8	2.8	8.3	**43.7**	15.6	8.2	1.8	1.64	**27.24**
Stipagrostis scoparia	0.45	3.45	7.95	3.1	**14.95**	13.9	5.5	4.7	2.3	**26.4**	0.76	4.71	8.21	3.82	**17.50**	11.75	5.65	2.41	2.77	**22.58**
Convolvulus lanatus	10.3	6.32	8.98	5.36	**30.96**	32.2	9.5	6.9	3.5	52.1	-	-	-	-		-	-	-	-	
Artemisia monosperma	6.18	8.59	5.4	6.33	**26.5**	29.1	7.6	5.1	2.6	44.4	-	-	-	-		-	-	-	-	
Anunophila arenavia	0.65	4.7	6.9	6.65	**18.85**	17.2	9.6	4.9	2.7	34.4	-	-	-	-		-	-	-	-	

TAC = Total available carbohydrates.
TN = Total nitrogen.
T.Ch = Total Chlorophyll.
Car = Carotenoids.

DISCUSSION

According to the Emberger's classification system (1951), El- Bardwil area belongs to the Mediterranean arid bio-climatic zone. The prevailing climate is a Mediterranean type, characterized by fairly mild rainy winter and a hot summer. In other words, the climate of this area is attenuated sub-desertic with a short dry period. Generally, north Sinai lies under the Mediterranean phytogeographical region (Good, 1947). On the other hand, the Khamisa area locate in Siwa Oasis is apart of the most extreme desert of the world (Zahran and Willis, 1992). According to Wickens (1976) most of the flora of siwa Oasis belongs to the Saharo– Sindian region.

It has been found from the results of the present study that there is a vertical zonation in the soil chemical characteristics along the dune from the crest to the foot. Consequently a vertical zonation of natural vegetation has been developed along the microtopographic gradients of the dunes. This was obviously clear in sand dunes of the El- Bardwil habitat. The zonation pattern was not clear in the Khamisa area due to the gently sloping of the sand dunes. These results agreed well with the findings of El- Ghonemy (1973), Migahid *et al.* (1971), Abdel– Razik *et al.* (1994), Huisman and Tooren (1993) and El- Khouly (2001) which concluded that zonation of

vegetation along the dune was parallel to variations in soil characteristics. The differences in salinity, flooding or maritime impacts and moisture content were important determinants of the differences in species composition along the topographic gradients of the sand dune. It is clear from the results that the physical and chemical properties of soils of the two pilot areas exhibited a wide range of variation. Beside the severe aridity in Siwa Oasis, the coarse textured, loose and permeable characters of the soil were responsible for rapid drying of the surface layers of the soil and rapid increase in the water content of the more deeper ones. Consequently the vegetation of Siwa Oasis, in general, was very limited in diversity, number of individuals and distribution. These results are in agreement with Ayyad and Fakhry (1994 and 1996) where they found that diversity is greater in the plant communities on stabilized sand dunes than those found on the active and partially stabilized sand dunes.

Results indicated that the high representation of annual species in the sand dune habitat of El- Bardwil area may be due to several factors such as high percentage of fine ingredients, moisture content of the soil and the mild prevailing climate of this area.

Also, the increase of maritime influence has great impact on the vegetation composition and nature of the characteristic species in north Sinai. The reverse is true for the sand dune habitat of Khamisa where annuals were completely absent. Results of the present work agreed with those of Abd El- Rahman and Batanouny (1959), Rozema *et al.* (1983 and 1985), El- Ghareeb (1991), El– Khouly (2001) and Abd El- Fattah and Dahmash (2002).

Results indicated also that most perennials were recorded on the crest of the dune either in El- Bardwil or in Khamisa sand dune habitats where the perforation is high and the water accumulated in the deeper layers, so these perennial species have long vertical well developed root systems. For example, *Cornulaca monacantha, Zygophyllum album, Stipagrostis scoparia, Convolvulus lanatus and Artemisia monosperma* were abundant in the upper part of the dune where the soil is not saline. These observations are in agreement with those of Zahran (1972), Ahmed and Girgis (1979), Abd El- Ghani (1998) and El- Khouly (2001).

It is notable from the results that the phenological aspects differed within and between species of the two pilot areas. This may be due to the great variations in the climate and the edaphic factors of the two different habitats. The species being vegetative and flowering in the El- Bardwil habitat, while they were in vegetative, fruiting and even in dormant phases in the Khamisa habitat.

Results of the present investigation indicated that there are two modes of physiological adaptation to the environmental stresses. Some species depend to a large extent on accumulation of organic intermediates in

building up their osmotic potential, whereas the osmotic adjustment of some other species depends mainly on the accumulation of electrolytes and to a less extent on organic constituents. The results are in agreement with those of Wallace and Harrison (1978), Bannister (1981), El- Shourbagy *et al.* (1984), El- Monayeri *et al.* (1986), Ahmed *et al.* (1999) and Moussa (1994 and 2001). The greater carotenoid compounds in species of the Khamisa sand dune habitat than those of EL-Bardwil habitat may reflect the injury to more intensive solar radiation. Generally, under harsh environment, where the resources especially water and nutrients become limited in time or in space, desert plants optimize their metabolism to cope with such environmental stresses.

Apart from the physical properties of the environment in the two habitats which influence the plant distribution and the eco-physiological responses, their genetic features also need to be deeply studied to verify clearly the biotic and /or abiotic limiting factors having a significant and decisive role in the restriction or expansion of the natural vegetation in such habitats.

CONCLUSION

Climatically, the two pilot areas of the study differed from each other, south El-Bardwil Lake belongs to the arid Mediterranean zone, while Siwa Oasis falls within the hyper arid of the extreme desert of south west Egypt.

Topographically, sand dunes of south El- Bardwil Lake are characterized by sharp steepness having a crest, a flank and a foot. On the other hand, sand dunes of Siwa Oasis, in general, are slightly undulated, gently sloping and the micro- topographic features (summit, slope and base) were not easily detectable.

As regards soil properties, texture class of the sand dunes habitat of El-Bardwil area is dominated by the fine ingredients; this is positively correlated with high moisture content and high soil ions content. On the other hand, soil of Khamisa area was dominated by coarse-textured class ingredients.

Due to the variable topographic features and micro variation in edaphic factors, there is a distinct vertical zonation of natural vegetation along the dune ridge side of south El- Bardwil Lake habitat. This zonation pattern of vegetation was not observed in the Khamisa sand dune habitat.

From the eco-physiological point of view, there are wide variations in the floristic composition between and within the two pilot areas of the study. Sand dunes of El- Bardwil area are dominated by *Zygophyllum album* community type with many associates of perennials and annuals, while *Cornulaca monacantha* community type dominated the sand dunes of the Khamisa area with a very limited number of associate of perennials. The annual species were not represented at all. Also the phenology of different

plants differed between the two habitats. Physiologically, different representative species of the two pilot areas showed two modes of accommodation to the environmental stresses; some species depend on the accumulation of electrolytes while the others depend on the accumulation of organic intermediates in their adaptive responses to prevailing conditions.

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الاستجابات البيئية والفسيولوجية لبعض نباتات التكوينات الرملية بشمال سيناء وواحة سيوة

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يهدف البحث الحالى الى دراسة الاستجابات الأيكوفسيولوجية لبعض نباتات الكثبان الرملية جنوب بحيرة البردويل بشمال سيناء ومنطقة خميسة بواحة سيوة . تم تحليل التربة فيزيائيا وكيميائيا ، تم مسح الغطاء النباتي بمناطق الدراسة وكذلك تمت مناقشة التركيب الكيميائي لبعض الأنواع النباتية وعلاقته بالعوامل المناخية والأرضية بمناطق الدراسة ، أظهرت الدراسة الاتي :

١- تسيدت عشيرة الرطريط *Zygophyllum album* الكثبان الرملية جنوب بحيرة البردويل بينما تسيدت عشيرة الحاد *Corntlaca monacantha* منطقة خميسة بواحة سيوة .
٢- ظهر العديد من الأنواع الحولية بمنطقة البردويل بينما لم تظهر هذه الأنواع بمنطقة خميسة .
٣- كان للتأثير البحري أثراً كبيراً في التوزيع النطاقي للغطاء النباتي الطبيعي للكثبان الساحلية بجنوب بحيرة البردويل .
٤- احتلت الأنواع المعمرة قمة الكثيب الرملي في كل من منطقة البردويل بشمال سيناء وخميسة بواحة سيوة .
٥- تعتمد الأنواع النباتية علي نظامين في التأقلم للظروف البيئية المعاكسة ، بعض النباتات تعتمد علي مراكمة أيونات العناصر المختلفة والبعض الأخر يعتمد علي تكوين بعض المركبات العضوية في سلوكها التأقلمي تجاه الظروف السائدة .