Stabilization of Sand Dunes in North Sinai Using Some Economical Plants

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Abstract: Three plant species; *Acasia saligna, Prosopis jullflora* and *Morus alba* were cultivated in sand deposited at El-Maghara station, North Sinai. Every kind of plants was planted in three perpendiculars to wind dominant directions to control the sand encroachment wards to the economic cultivation. Sand collectors (traps) were set up at the four wind directions to study the transportation of sand and its accumulation. The transportation of sand in an open area and in front of three kinds of plants was collected during two annuals. The analysis of sand trapped by the sand collectors reveals Acasia plants were superiors in minimizing of sand encroachment than the two kinds of plants, i.e. Prosopis jullflora and Morus alba. The growth behaviours of *Acasia saligna* and *Prosopis jullflora* were superior to *Morus* species. Physical and chemical analysis showed differentiation in edaphic factors in both areas, i.e., unstabilized and stabilized as well as immerge the three kinds of plants.
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Key Words: Meteorological – Edaphic – Sand dunes – Stabilization - movement - growth behavior - *Acasia saligna* - *Prosopis jullflora* - *Morus alba* – Migration – accumulation – traps.

Introduction:

Sand dune fixation is designed to prevent the movement of sand long enough to enable either natural or planted vegetation to become established. In the arid and semi arid regions various species of trees, shrubs and grasses can be used for dune fixation (Kaul, 1985). *Atriplex spp.* and *Acacia spp.,* are among the effective plant species used for the control of shifting sand dunes (Draz *et al*., 1992). In El-Shaikh Zuweid Gad (2004) used biological fixation of coastal sand dunes (Moghat, Liquorice, Sisal and *Opuntia*). Ndiaya *et al.* (1993), showed the growth and yield of *Casuarina eqisetifolia* plants cultivated for the control of the coastal sand dunes of Senegal. Moreover, the monitoring of four plant species grown for sand drift control in India showed that, the growth and the survival of such plants were best on the dune crest and lee ward slopes (Kumar and Shankaranarayan, 1988).

Furthermore, the most popular cultivated plants tolerated the stress conditions under sand dunes in Egypt are: *Acasia saligna, Prosopis pallide* and *Atriplex nummularia* (Draz and El-Maghrabi, 1997 and Gad 1999).

This study is dealing with the prevailing environmental factors and mean activities under El-Maghara sand dunes conditions in North Sinai to clarify the ecological factors affected fixation of mobile of sand dunes in such area.

Materials and Methods:

El-Maghara Research Station is located at 70 Km Southwest El-Arish city, North Sinai peninsula, the elevation is 895 foots above the sea level. The prevailing wind directions are NNW (North- North-West) and WNW (West-North-West), where the resultant sand drift direction was SSE (South-South-East).

This study was carried out to get some clue information about the growth behavior and the effect of the plant fences of three suggested plant species cultivated under El-Maghara on sand dune stress conditions. The center is located at 30º 52' 07" N and 32º 55' 09" Et

The economical plants of *Acasia saligna, Prosopis jullflora* and *Morus alba* were cultivated in three plots (20 x 80m =1600m²) each, and arranged in grid system 4 x 4m (alternated row). The cultivations were carried out at the North to West direction perpendicular with the dominant wind directions.

These plots were located at the windward side of the mobile sand dunes and perpendicular to the effective wind directions. The plants were irrigated by drip irrigation technique.

Acasia saligna and *Prosopis jullflora*, seeds were obtained from private form at El-Arish and sown after H_2SO_4 treatments in polyethylene bag 20 × 30cm, left to germinate and grown under polyethylene greenhouse conditions for one year then retrains planting under permanent conditions at 30/11/2007

Morus alba, Stem cutting were collected from the experimental farm of the faculty of Agricultural (Moshtohor), sown after indol buteric acid (I. B. A. 1 ppm concentrate) treatments in polyethylene bag 20 × 30 cm and left to germinate and grown under polyethylene greenhouse conditions for one year then retrains planting under permanent conditions at 30/11/2007

Ecological studies

1-Meteorological data: were collected from El-Maghara meteorological station, experimental station, Desert Research Center (D.R.C.) as representative of North Sinai governorate.

Table (1) Average seasonal changes in recorded metrological data at El-Maghara research stations during the period extended from 2005/2008.

Seasons	Wind speed (Km/h)	Air temperature (ºC)	Air relative humidity (%)	Total rainfall (mm)	Sun shine (Kw/m²)	Evapo-transpiration (mm/day)
Winter	7.503	20.430	74.163	6.27	3.557	1.890
Spring	8.460	24.933	76.400	0.00	5.083	3.903
Summer	8.130	31.000	76.613	0.00	6.493	5.790
Autumn	7.947	25.273	76.470	8.31	4.250	2.523
Total	-	-	-	14.58	-	-
Mean	8.010	25.409	75.912	-	4.846	3.527

Source: El-Maghara station (Desert Research Center).

2- The irrigation water of El-Maghara research station. The chemical analysis of irrigation water was carried out according to (Richards, 1954) and indicates that water is highly saline with medium sodium content, (Table, 2)

Table (2) - Chemical analysis of the irrigation water of El-Maghara research station

Seasons	Soil pH	E.C		Soluble cations (ppm)				Soluble anions (ppm)			
		ppm	Mmhos/ cm	Ca++	Mg++	Na+	K+	CO3⁻ ⁻	HCO3⁻ ⁻	SO4⁻ ⁻	Cl⁻
Winter	7.7	2961.44	4.63	142.7	232.8	541.2	9.38	12.9	203.2	682.5	113.7
Summer	7.5	3195.65	4.99	366.3	155.7	469.4	85.6	10.5	78.4	629.7	795.5

Soures: - Seidhom;S.H. and Evon,K. Rizk (2006)

3- Edaphic data:-

These edaphic factors were evaluated for soil samples collected from the El-Maghara sand dunes.

Analysis of soil samples

The collected soil samples were subjected to the following analysis:-

a) - Soil moisture content was determined for the soil samples of 0-10, 10-20 and 20-30 cm depth at 105 °C constant weight.

$$\text{Soil moisture content \%} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Dry weight}} \times 100$$

b) - The collected soil samples were air dried, grind and passed through a 2mm sieve. The fine soil samples were subjected to physical and chemical analysis as described by Page *et al.* (1982).

c) - Particle size distribution was carried out for all soil samples using the standard sieving technique (Folk and Ward 1973).

d) - Soil reaction (pH) was measured in soil water suspension (1:2.5) using Beckman bench type pH meter, KM 7001digital pH meter

e) – Soil salinity (EC) of soil extracts measured by electric conductivity in soil water suspension (1:2.5) after Jackson method (1973) using EC meter (digi meter L21).

f) - Organic Matter (OM) content was determined by use of ferrous sulphate (Jackson, 1958).

g) - Soluble cations and anions were determined in the soil saturation extract according to Jackson (1973) as follows:-

- Sodium and potassium were determined by flame photometer (Perken – Elmer, model 149).
- Calcium and magnesium were determined titrimetrically by versenate (EDTA) method.
- Soluble carbonates and bicarbonates were determined by titration with standard hydrochloric acid.
- Chloride was determined by titration with silver nitrate using potassium chromate indicator.
- Sulphate was determined by the turbidity method using spectrophotometer.

Migration and soil accumulation

The amount of migrated soil collected by soil traps (kg) measures soil accumulation, while measuring stands were used to calculate soil erosion. The distribution of soil traps and measuring stands were arranged in different directions on various sand dunes unstabilized and stabilized by cultivated plants in four directions (North, East, South and West). Soil particle size and the depth (cm) of soil burial accumulations on cultivated plants were also determined.

4- Phytological data:

The economical plants cultivated on stabilized El-Maghara sand dunes were analyzed as follows:-

4-1- The growth parameter

Dominant plant height (cm), shoot diameter (cm), number of shoots, shoot length (cm), number of leaves on shoot, and leaf area (cm^2). Moreover, the plant crown cover (m^2) and crown volume (m^3) were calculated according to the formula of Thalen (1979) as follows:-

Crown cover (m^2) = ¼ M. D1. D2

Crown volume (m^3) = 1/6 M. D1. D2 .H

Where:

D1 = the largest diameter of the crown.

D2 = the smallest diameter of the crown.

M = 22/7 and,

H = height of the tree.

4-2- Chemical constituents of the plant organs (leaves and stems) were detected as follows:-

Crude dry weight was measured according to official Agricultural Chemical (A. O. A. C., 1970). Sodium and potassium were determined according to the method of Johonson and Ulrich (1959), by the use of flame photometer (Perken – Elmer, model 149). Data were presented as gram per 100 grams dry weight. Phosphorus was colorimetrically determined by ascorbic acid method as described by John (1970). Total nitrogen was detected by Kjeldahl method (A. O. A. C. 1970).

Method of tabulated data and Statistical analysis

The tabulated data were presented as the probable relations between three economical plants. i.e. {*Acasia saligna*, *Prosopis jullflora* and *Morus alba*}. Statistical analyses were conducted as randomized complete blocks design. New L.S.D. at 5% level and simple correlation coefficients (r) between certain environmental factors and collected data were calculated using "Computer, Co-Stat program" according to the method described by Snedecor and Cochran (1980).

Results and discussion:

Meteorological factors: The climatologic data were collected from El-Maghara station (Table 1).These data show:

i)- There is no doubt that the climatic data are quite different from one season to another and from month to another.

ii)- Wind speed is considered the main factor affecting the formation of sand dunes and their activity of mobilization. Its direction may affect the shape type of sand dunes.

iii)- The total rainfall and evapo-transpiration in relation to air temperature and sunshine affect distribution of plants and their growth.

iv)- The total rainfall is generally below 80cm/ year, there fore the area may be considered under semi arid conditions and most of rainfall is found in autumn and winter seasons, while others seasons are dry.

Edaphic data:

Soil moisture percentage to unstabilized and stabilized sand dunes (Table 3), Soil moisture percentage is considered as one of the most soil properties affecting sand dune stabilized through its direct effect as adhesive agent of soil particles or indirect through vegetation stabilization. As a general, soil moisture level was higher under sand dune stabilization than unstabilized during different seasons of both annuals.

Soil chemical analysis (Table 4)

Soil (pH). The pH values are generally high in the soil of the unstabilized plot compared to the cultivated plots. The average recorded values vary from 9.5 to 9.6 for the former and from 8.30 to 8.47 for the latter. The lower pH values in the cultivated plots can be explained on the basis of the higher content of organic matter which affects the soil reaction, (Aggarwal and Lahiri, 1977 and Draz and El-Maghraby, 1997). In stabilized dunes, the pH values showed significant difference related to the soils of the different plant species.

Organic matter content (O.M). The average percentage of organic matter content of soils is generally low, not exceeding 0.27% has recorded its maximum amount in the stabilized plot (0.21%), while being at minimum in the unstabilized one (0.18%). In stabilizes plots, the O.M values are some what higher at depth (0-10cm). The variation of the O.M. content with respect to the different dunes is presumably due to the variable amount of leaf litter and root decay in such locations.

Soil salinity (E.C). Table (4) shows the values of the E.C, anions and cations in the unstabilized and stabilized dunes. Generally, the E.C values of the stabilized plot are higher compared to the unstabilized ones. Such increment of the E.C values in the stabilized plot is essentially due to the irrigation water (Draz and El-Maghraby, 1997). In the stabilized plot, the E.C values are higher under *Prosopis jullflora* (0.96dS/m³) compared to the other plants. In general, E.C values indicate non-saline soil condition. In most cases, the concentration of the cations and anions, especially Ca++, Mg++ and Na+ are higher under *Prosopis jullflora* and (Cl^{-} and SO4^{--}) under *Morus alba* compared to another. Such trend may be explained on the bass of different growth behavior of the plant as well as the variation in particle size distribution of soil which affect the evapo-transpiration rate and salt accumulation, (Keng *et al.*, 1979).

Table (3) Mean values of seasonal changes of soil moisture percentage (%) in relation to: -plant species, seasons and sand samples depths of unstabilized and stabilized sand dunes of El-Maghara in North Sinai during two annuals.

Dunes	Scientific name	Depths (cm)	First annual				Mean	Second annual				Mean
			Winter	Spring	Summer	Autumn		Winter	Spring	Summer	Autumn	
Un stabili-zed		0-10	0.407	0.036	0.495	0.418	0.339	1.749	1.955	0.346	1.143	1.298
		10-20	0.510	0.117	0.584	0.485	0.424	1.242	1.71	0.710	0.219	0.970
		20-30	0.392	0.768	0.549	1.469	0.795	1.432	1.713	0.862	0.311	1.080
		Mean	0.436	0.307	0.543	0.791	0.519	1.474	1.793	0.639	0.558	1.116
Stabilized	*Acasia saligna*	0-10	1.053	1.053	0.542	1.273	0.980	3.097	2.001	0.337	1.197	1.658
		10-20	1.346	0.710	1.049	1.208	1.078	3.911	2.116	2.581	1.209	2.454
		20-30	1.993	1.001	1.576	1.226	1.449	4.001	2.749	2.660	2.258	2.917
		Mean	1.464	0.921	1.056	1.236	1.169	3.670	2.289	1.859	1.555	2.343
	Prosopis jullflora	0-10	2.061	0.713	0.399	1.549	1.181	3.046	2.053	1.537	2.239	2.219
		10-20	2.100	1.116	1.841	1.542	1.650	3.735	2.346	1.731	1.274	2.272
		20-30	2.034	1.955	1.798	2.584	2.093	4.215	2.710	2.011	2.283	2.805
		Mean	2.065	1.261	1.346	1.892	1.641	3.665	2.370	1.760	1.932	2.432
	Morus alba	0-10	2.036	1.346	0.397	1.601	1.345	3.061	2.242	0.997	1.219	1.880
		10-20	2.097	1.576	1.901	1.532	1.777	3.991	2.049	2.110	1.278	2.357
		20-30	2.046	1.901	1.599	2.489	2.009	3.993	2.576	2.984	2.253	2.952
		Mean	2.060	1.608	1.299	1.874	1.710	3.682	2.289	2.030	1.583	2.396
	Average		1.863	1.263	1.234	1.667	1.507	3.672	2.316	1.883	1.690	2.390
	New L.S.D. at 5%:-Species		0.483	0.061	0.034	0.501	-	N.S.	N.S.	N.S.	N.S.	-
	Depths		N.S.	0.053	0.043	0.449	-	0.741	0.393	N.S.	0.501	-

Table (4) – Chemical analysis of soils stabilized sand dunes under plant species and unslabilized dunes of El-Maghara in North Sinai during two annuals.

Dunes	Scientific name	Depth (cm)	Soil pH	E.C ds/m³	O.M (%)	Soluble cations (p.p.m)				Soluble anions (p.p.m)			
						Ca++	Mg++	Na+	K++	CO3^{--}	HCO3^{-}	Cl^{-}	SO4^{--}
Unstabiliz-Ed		0-10	9.51	0.37	0.09	1.20	2.00	4.95	43.93	-	3.37	4.49	3.77
		10-20	9.65	0.33	0.09	1.11	1.98	4.98	44.85	-	3.69	4.51	3.72
		20-30	9.60	0.35	0.08	1.11	1.99	5.01	42.99	-	3.92	4.43	3.75
		Mean	9.62	0.35	0.09	1.14	1.99	4.98	43.92	-	3.77	4.48	3.73
		L.S.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	-	N.S.	N.S.	N.S.
Stabilized	*Acasia saligna*	0 - 10	8.30	0.94	0.27	0.47	8.39	4.24	113.59	-	3.99	3.20	3.30
		10 - 20	8.22	0.86	0.24	0.37	8.44	4.80	112.89	-	4.27	3.00	3.07
		20 - 30	8.47	0.75	0.24	0.33	8.28	4.51	114.53	-	2.72	3.01	3.08
		Mean	8.33	0.85	0.25	0.39	8.37	4.64	113.67	-	3.66	3.07	3.15
	Prosopis jullflora	0 - 10	8.40	0.94	0.26	0.62	13.11	5.15	96.00	-	3.10	3.75	3.79
		10 - 20	8.29	0.95	0.23	0.61	15.05	3.95	98.01	-	3.03	3.59	3.99
		20 - 30	8.21	0.99	0.23	0.66	14.11	4.65	89.00	-	3.20	3.84	3.09
		Mean	8.30	0.96	0.24	0.63	14.09	4.65	94.33	-	3.11	3.66	3.49
	Morus alba	0 - 10	8.46	0.92	0.20	0.60	4.43	4.80	65.71	-	3.80	3.96	3.50
		10 - 20	8.38	0.89	0.14	0.55	4.43	4.70	67.15	-	3.11	3.59	3.71
		20 - 30	8.57	0.99	0.14	0.56	4.19	4.01	69.13	-	3.30	3.49	3.32
		Mean	8.47	0.44	0.16	0.57	4.35	4.50	66.33	-	3.40	3.68	3.51
	Average		8.42	0.65	0.18	0.43	7.23	4.70	79.67	-	3.66	3.07	3.15
	New L.S.D. at 5%:- Species		0.10	0.01	0.02	0.01	0.06	N.S.	0.97	-	N.S.	N.S.	N.S.
	Depths		0.08	0.03	0.01	0.11	0.03	N.S.	0.84	-	N.S.	N.S.	N.S.
	Species × Depths		N.S.	0.43	0.10	0.21	3.22	0.06	N.S.	-	0.05	0.59	0.11

Migration of sand dunes: Migration of soil particles under unstabilized and stabilized of sand dunes, (Table 5) differed greatly according to differed factors, i. e. active dunes, directions, seasons and annuals as follows.

Unstablized sand dunes: The highest soil migration is associated with South and North directions (14.89 and 15.86 kg) during the first annual and second ones, respectively. The least ones were recorded at North directions (13.81) in spring of the first annual. Therefore, it may be concluded that soil migration varied at different directions.

Stabilized sand dunes: Soil migration (Table 6) is differed greatly according to several factors, i. e., plant species, directions, seasons and years. The highest values of soil migration were recorded under *Morus alba* (4.745 and 6.612 kg) during the first and second years, respectively. The highest values of soil migration (4.472 and 6.456) are shown at North and East directions during the first and second years respectively. On the contrary, the lowest values of soil migration (2.681 and 4.594) are shown during winter in both annuals.

Table (5) - Mean values of seasonal changes of migrated soil in sand collectors (traps, kg.) at different directions in relation to: - plant species and seasons of stabilized of El-Maghara sand dunes in North Sinai during two annuals.

Dunes	Seasons	Scientific name	First annual					Second annual				
			N.	E.	S.	W.	Mean	N.	E.	S.	W.	Mean
Unstabili-zed	Winter		10.89	13.15	11.30	12.42	11.940	13.40	14.26	13.47	11.63	13.190
	Spring		9.93	10.31	12.77	11.81	11.205	19.29	18.78	17.73	19.15	18.738
	Summer		22.32	22.24	23.22	21.85	22.408	16.77	15.43	15.56	15.19	15.738
	Autumn		12.09	11.65	12.26	11.50	11.875	13.98	13.68	13.64	13.72	13.755
	Mean		13.81	14.34	14.89	14.40	14.36	15.86	15.54	15.10	14.92	15.36
Stabilized	Winter	*Acasia saligna*	2.19	2.34	2.34	1.89	2.19	4.30	4.88	4.13	3.94	4.31
		Prosopis jullflora	2.87	3.06	2.85	3.44	3.06	4.53	5.07	4.37	4.23	4.55
		Morus alba	2.59	3.01	2.82	2.77	2.79	4.63	5.30	4.99	4.75	4.92
	Mean		2.55	2.81	2.67	2.70	2.68	4.49	5.08	4.50	4.31	4.59
	Spring	*Acasia saligna*	5.68	2.38	3.84	3.80	3.93	7.40	8.53	7.70	7.35	7.75
		Prosopis jullflora	4.10	3.82	3.96	5.81	4.42	8.45	8.53	8.37	8.22	8.39
		Morus alba	5.05	3.92	3.04	4.77	4.20	9.14	8.56	8.43	8.52	8.66
	Mean		4.93	3.37	3.61	4.79	4.18	8.33	8.54	8.17	8.03	8.27
	Summer	*Acasia saligna*	5.55	5.03	5.28	5.27	5.15	6.04	6.12	6.11	6.21	6.12
		Prosopis jullflora	6.20	6.15	5.74	6.25	6.09	6.75	6.83	6.76	6.58	6.73
		Morus alba	6.58	6.46	6.10	6.44	6.40	7.16	7.27	7.20	6.93	7.14
	Mean		5.93	5.88	5.71	5.99	5.88	9.18	8.91	8.91	8.73	8.93
	Autumn	*Acasia saligna*	2.65	1.92	2.63	2.70	2.48	5.03	5.01	4.950	4.96	4.99
		Prosopis jullflora	4.65	4.5	4.5	4.46	4.53	5.73	5.65	5.560	5.63	5.64
		Morus alba	5.55	5.63	5.62	5.57	5.60	5.69	5.72	5.750	5.75	5.73
	Mean		4.28	4.02	4.25	4.24	4.20	7.61	7.52	7.48	7.52	7.53
	Average		4.472	4.018	4.060	4.431	4.234	6.238	6.456	6.193	6.089	6.244

N. = North E. = East S. =S south W. = West

Migrated soil percentage under unstabilized and stabilized (Table 6). Migrated soil percentage differed greatly according to differed factors, i. e., active dunes, directions, seasons and years.

Unstablized dunes. The soil migration percentage is shown to be generally high at the different directions (100%) during four seasons in the first and second years.

Stablized dunes. Migration soil percentage (%) differed greatly according to different factors, i. e., plant species, directions, seasons and years. The highest values of soil migration were recorded under *Morus alba* (34.361% and 42.681%kg) during the first and second annuals, respectively (Table 6). Moreover, the highest values of soil migration percentage may be shown at North and East (33.795% and 41.179%) directions during the first and second annuals, respectively. On the contrary the least values of soil migration percentage (22.526% and 34.886%) are recorded during winter in both annuals.

Percentage of soil particles size of migrated sand under unstabilizated and stabilized sand dunes. (Table 7)

Unstabilized sand dunes: The soil particle size (mm) of migrated sand differed according to the directions of such migration. It must be mentioned here, that the soil particle size seemed to be mostly from those of 0.5 - 0.063 mm, the highest proportion of soil particle size is mainly concerned with 0.5 - 0.25mm, 19.94%, 0.25 - 0.125 mm, 49.62% and 0.125 - 0.063mm 23.72%, while migration of other soil particle sizes seemed to be negligible.

Stabilized sand dunes: The soil particle size (mm) of migrated sand differed according to the directions of such migration. It must be mentioned here, that the soil particle size seemed to be from those of 0.5 -

0.063 mm, the highest proportion of soil particle size is mainly concerned with 0.25 - 1.25mm, 52.17%, 0.125 - 0.063 mm, 25.12% and 0.5 - 0.025mm 15.65%, while other soil particle sizes seemed to be negligible.

Table (6) - Mean values of seasonal changes of migrated soil percentage (%) in sand collectors (traps) different directions in unstabilized and stabilized of El-Maghara sand dunes in relation to plant species and seasons in North Sinai during two annuals

Dunes	Seasons	Scientific name	First annual					Second annual				
			N.	E.	S.	W.	Mean	N.	E.	S.	W.	Mean
Barren			100%	100%	100%	100%	-	100%	100%	100%	100%	-
Stabilisation	Winter	*Acasia saligna*	20.110	17.795	20.708	15.217	18.458	32.090	34.222	30.661	33.878	32.712
		Prosopis jullflora	26.354	23.270	25.221	27.697	25.636	33.806	35.554	32.442	36.371	34.543
		Morus alba	23.783	22.890	24.956	22.303	23.483	34.552	37.167	37.045	40.843	37.402
	Mean		23.416	21.318	23.628	21.739	22.526	33.483	35.648	33.383	37.031	34.886
	Spring	*Acasia saligna*	57.200	23.084	30.070	32.176	35.633	38.362	45.421	43.429	38.381	41.398
		Prosopis jullflora	41.289	37.051	31.010	49.196	39.637	43.805	45.421	47.208	42.924	44.840
		Morus alba	50.856	38.021	23.806	40.390	38.268	47.382	45.580	47.547	44.491	46.250
	Mean		49.782	32.719	28.295	40.587	37.846	43.183	45.474	46.061	41.932	44.163
	Summer	*Acasia saligna*	22.401	22.617	22.739	24.119	22.969	36.017	39.663	39.267	40.882	38.957
		Prosopis jullflora	27.778	27.653	24.720	28.604	27.189	40.25	44.264	43.445	43.318	42.819
		Morus	29.480	29.047	26.270	29.474	28.568	42.695	47.116	46.272	45.622	45.426
	Mean		26.553	26.439	24.576	27.399	26.242	39.654	43.681	42.995	43.274	42.401
	Autumn	*Acasia saligna*	21.919	16.481	21.452	23.478	20.832	35.980	36.623	36.290	36.152	36.261
		Prosopis jullflora	38.462	38.627	36.705	38.783	38.144	40.987	41.301	40.762	41.035	41.021
		Morus alba	45.906	48.326	45.84	48.435	47.127	40.701	41.813	42.155	41.910	41.645
	Mean		35.429	34.478	34.666	36.899	35.368	39.223	39.912	39.736	39.699	39.642
	Average		33.795	28.739	27.791	31.656	30.495	38.886	41.179	40.544	40.484	40.273

Table (7) Average changes in soil particles size (%) of unstabilized and stabilized sand dunes at collection from the different directions on El-Maghara sand dunes in relation to: - trap directions and plant species

Dunes	Scientific name	Trap directions	Percentage of particle size distribution (mm)							Texture class
			> 2	2 - 1	1 - 0.5	0.5 - 0.25	0.25 - 0.125	0.125 - 0.063	< 0.063	
Unstab-ilized		N.	0.00	0.06	2.34	27.85	48.10	18.27	3.38	Sand
		E.	0.00	0.08	2.64	22.69	53.79	18.06	2.74	Sand
		S.	0.22	0.14	4.04	15.34	45.26	30.94	4.06	Sand
		W.	0.43	0.12	3.12	13.87	51.34	27.59	3.53	Sand
		Mean	0.16	0.10	3.04	19.94	49.62	23.72	3.43	Sand
Stabilized	*Acasia saligna*	N.	0.00	0.00	0.32	3.80	57.86	34.05	3.97	Sand
		E.	0.00	0.38	1.94	16.84	55.81	22.05	2.98	Sand
		S.	0.00	0.06	1.40	15.74	53.56	25.9	3.34	Sand
		W.	0.00	0.17	2.89	19.76	52.3	21.18	3.7	Sand
		Mean	0.00	0.15	1.64	14.04	54.88	25.80	3.50	Sand
	Prosopis jullflora	N.	0.11	0.10	3.19	21.60	46.68	24.61	3.72	Sand
		E.	0.23	0.11	2.87	18.27	52.56	22.84	3.14	Sand
		S.	0.11	0.07	2.18	9.57	51.56	32.50	4.02	Sand
		W.	0.20	0.26	2.55	15.34	53.58	24.82	3.26	Sand
		Mean	0.16	0.14	2.70	16.20	51.10	26.19	3.54	Sand
	Morus alba	N.	0.08	0.03	0.86	9.77	55.71	29.90	3.66	Sand
		E.	0.00	0.28	2.42	18.30	54.06	21.62	3.34	Sand
		S.	0.06	0.08	2.30	18.67	50.12	25.25	3.53	Sand
		W.	0.10	0.14	2.89	19.01	52.43	22.31	3.10	Sand
		Mean	0.06	0.13	2.12	16.44	53.08	24.77	3.41	Sand
	Average		0.10	0.13	2.37	16.65	52.17	25.12	3.47	Sand

Depth of erosion under unstabilized sand dunes. Data in (Table 8) indicated that the tested factors, i.e. directions, seasons and years affected the depth of erosions. The highest erosion seemed to occur during autumn season of the two annuals (7.577 and 9.532cm).

Table (8) Mean seasonal changes in soil depth of erosion (cm) on unstabilized sand dunes of El-Maghara, North Sinai during two annuals

Seasons	First annual	Second annual
Winter	6.565	7.642
Spring	6.783	7.917
Summer	7.558	9.023
Autumn	7.577	9.532
Mean	6.995	8.529

- Sand accumulation on cultivated plants (cm) (Table 9). The amount of sand accumuled on cultivated plant, is shown to be plant morphogenesis and its architecture must have a role on the amounts of accumulated sand under sand dune system. The highest amounts were accumulated on *Acasia saligna* followed by those accumulated on *Prosopis jullflora* and finally the least amounts were shown on *Morus alba.*

Table (9) Mean values of seasonal changes in soil accumulation on cultivated plants (cm) on stabilized sand dunes of El-Maghara in North Sinai during two annuals

Scientific name	First annual					Second annual				
	Winter	Spring	Summer	Autumn	Mean	Winter	Spring	Summer	Autumn	Mean
Acasia saligna	14.565	20.915	22.684	22.177	22.177	40.054	42.782	46.045	48.217	44.195
Prosopis jullflora	14.856	18.845	22.246	20.509	20.509	38.936	40.963	43.127	44.051	41.824
Morus alba	13.451	17.987	18.927	18.189	18.189	31.534	32.963	36.639	38.483	35.553
Mean	14.291	19.249	21.286	26.340	20.291	36.841	38.903	41.435	41.937	40.191
New L.S.D. at 5%	N.S.	1.640	2.666	0.577	-	3.503	2.521	2.564	2.639	-

Ecophsiological behaviuor of cultivated plants, (Table 10):- The results obtained concerning the growth behaviour of *Acasia saligna, Prosopis jullflora* and *Morus alba* are affected by the seasons and years are displayed in the following manner:-

The plant height (cm), in both study seasons and annuals showed variable effective differences among the three plants species. In general, the trees was grown ascending with age. The ultimate recorded values vary from 146cm to 420cm in *Acasia saligna*, 151cm to 326cm in *Prosopis jullflora* and 119cm to 199cm *Morus alba,* respectively.

The diameter of shoot (cm), for the trees grown during the two annuals displayed the highest values for the trees grown in summer of the second annual. Generally, the highest values of shoot diameter were recorded in *Acasia saligna* followed by *Prosopis jullflora* while the least values were attained for *Morus alba.*

The number of lateral shoots, the maximum and the minimum values of the number of lateral shoots are 54 and 25.667 in *Acasia saligna* and *Morus alba* for the trees grown in summer of the second annual.

The Shoot length (cm), varied significantly between three cultivated plants *Acasia saligna, Prosopis jullflora* and *Morus alba* during winter at the first annual and during winter, spring and summer of the second annual.

The number of the leaves/ shoot, varied significantly among the trees grown during all seasons except spring of the second annual.

The leaf area (cm^2), the leaf area of different tested plants increased gradually during the spring season of the first annual and during the summer season of the second annual. In general, the plants grown in the different seasons during the two annuals displayed significant variations in leaf area.

The crown cover (C.C. m^2) and the crown volume (C.V. m^3), were found to be significantly variable in the plants grown in the different seasons and during the two annuals. In general, *Prosopis jullflora* have the highest values of both crown cover (C.C. m^2) and the crown volume (C.V. m^3) followed by *Acasia saligna* while *Morus alba* attains the least values of both parameters.

Dry matter percentage of the different cultivated trees, Table (11), both stems and leaves of the cultivated trees showed slight differences during the different seasons. In winter season, the extreme values vary from 48.01 to 38.82% for the stem (*Acasia saligna* and *Morus alba*) and from 40.80 to 23.34% for the leaves (*Acasia saligna* and *Morus alba*).

In summer season, the extreme values vary from 48.86 to 44.26% for the stem (*Acasia saligna* and *Morus alba*) and from 41.84 to 32.77% for the leaves (*Acasia saligna* and *Morus alba*), i. e., being somewhat higher, on average, during summer relative to winter. Noteworthy to mention that dry matter percentage in both stem and leaves followed the descending order *Acasia saligna, Prosopis jullflora* and *Morus alba*. Morover, dry matter content of stem of all plant species is considerably higher than that of leaves.

Table (10) Mean seasonal changes in some growth parameters of the different tree species cultivated during growth seasons on stabilized sand dunes of El-Maghara in North Sinai during two annuals

Annuals	Seasons	Scientific name	Plant height (cm)	Shoot diameter (cm)	No. of shoots	Shoot length (cm)	No. of leaves on shoot	Leaf area (cm²)	C.C (m²)	C.V (m³)
First	Autumn	*Acasia saligna*	146.000	1.400	3.330	119.500	259.333	99.500	1.386	4.351
		Prosopis jullflora	151.670	0.750	4.330	117.380	263.000	101.767	5.282	8.504
		Morus alba	119.000	0.660	5.670	87.500	100.000	0.000	0.634	0.828
		Mean	138.890	0.937	4.443	108.127	207.444	67.089	2.434	4.561
		New L.S.D. at 5%	6.115	N.S	1.630	3.463	93.889	1.277	0.485	0.795
	Winter	*Acasia saligna*	149.670	1.680	8.330	120.500	246.330	93.610	1.448	4.481
		Prosopis jullflora	150.000	0.820	10.000	117.540	441.000	85.993	4.948	8.491
		Morus alba	118.000	0.620	9.330	88.000	48.670	34.457	0.614	0.897
		Mean	139.223	1.040	9.220	108.680	245.333	71.353	2.337	4.623
		New L.S.D. at 5%	N.S.	1.040	N.S.	N.S.	159.480	3.900	1.150	0.513
	Spring	*Acasia saligna*	161.333	1.840	12.333	129.250	274.330	137.757	1.525	4.468
		Prosopis jullflora	156.667	0.950	12.333	117.210	421.670	104.000	5.434	8.499
		Morus alba	121.670	0.900	8.333	94.200	231.000	46.700	0.632	0.852
		Mean	146.557	1.230	11.000	113.553	309.000	96.152	2.530	4.606
		New L.S.D. at 5%	N.S.	1.213	N.S.	N.S.	139.900	9.811	0.950	0.811
	Summer	*Acasia saligna*	178.670	1.990	20.000	141.750	296.000	71.433	1.332	4.281
		Prosopis jullflora	168.330	1.320	21.667	126.370	458.000	101.167	4.596	8.665
		Morus alba	124.330	1.060	13.667	97.060	276.000	60.100	0.650	0.877
		Mean	157.110	1.457	18.445	121.727	343.333	77.567	2.193	4.608
		New L.S.D. at 5%	N.S.	N.S.	N.S	N.S.	164.070	3.888	0.487	0.829
Second	Autumn	*Acasia saligna*	171.000	1.975	23.333	138.167	316.667	123.457	1.251	4.380
		Prosopis jullflora	161.667	1.082	35.000	136.250	457.000	94.710	4.223	9.418
		Morus alba	125.667	1.356	18.667	102.422	228.330	0.000	0.652	0.879
		Mean	152.778	1.471	25.667	125.613	333.999	72.722	2.042	4.892
		New L.S.D. at 5%	N.S.	N.S.	7.632	N.S.	169.879	7.462	0.554	0.676
	Winter	*Acasia saligna*	398.333	3.387	33.333	375.778	631.333	131.543	2.653	10.472
		Prosopis jullflora	307.000	3.347	26.333	292.028	494.667	104.000	7.748	16.669
		Morus alba	186.667	1.472	21.667	141.111	286.667	48.023	0.975	1.300
		Mean	297.333	2.735	27.111	269.639	470.889	94.522	3.792	9.480
		New L.S.D. at 5%	32.188	1.099	7.997	44.511	1.309	19.455	0.510	0.398
	Spring	*Acasia saligna*	277.000	3.713	50.000	393.833	694.000	126.670	2.021	7.835
		Prosopis jullflora	235.333	3.323	43.000	336.361	579.333	107.623	6.117	13.203
		Morus alba	152.667	1.518	21.667	152.656	417.333	59.357	0.793	1.067
		Mean	221.667	2.851	38.222	294.283	563.555	97.883	2.977	7.368
		New L.S.D. at 5%	78.477	0.695	20.375	71.035	N.S.	11.262	3.628	7.033
	Summer	*Acasia saligna*	420.000	3.737	54.000	402.639	208.944	110.290	3.151	11.666
		Prosopis jullflora	326.000	3.362	46.667	213.528	198.361	96.520	9.545	17.667
		Morus alba	199.667	1.541	25.667	164.406	91.389	63.857	1.378	1.392
		Mean	315.222	2.880	42.111	260.191	166.231	90.222	4.691	10.242
		New L.S.D. at 5%	11.547	0.896	21.299	2.267	56.257	9.837	2.329	0.590

Table (11) Mean values of seasonal changes in dry weight (%) of the different tree species cultivated on stabilized sand dunes of El-Maghara in North Sinai during two annuals

Scientific name	Stem			Leaves		
	Winter	Summer	Mean	Winter	Summer	Mean
Acasia saligna	48.01	48.86	48.44	40.80	41.84	41.32
Prosopis jullflora	41.58	44.97	43.28	25.69	33.92	29.81
Morus alba	38.82	44.26	41.54	23.34	32.77	28.06
Mean	42.80	46.03	44.42	29.94	36.18	33.06
New L.S.D. at 5%						

Concentrations of some nutrients in shoots and leaves of different cultivated plants (Table 12)

i) In shoots:

Total Nitrogen (N): The highest concentration of N was found in *Acasia saligna* stem, followed by *Prosopis jullflora*, while the lowest values were found in *Morus alba*. It must be mentioned here that *Acasia saligna* is one of "fabaceae" family members. Accordingly, its stem must contain higher concentration of nitrogenous compounds. There were significant differences between the concentrations of N due to the kind of plants.

Phosphorus (P) concentration in shoots of *Prosopis jullflora* seemed to be the highest one followed by *Acasia saligna*, while the least one was found in *Morus alba* shoots.

Potassium (k). Concentration of K in shoots of *Acasia saligna* seemed to be the highest followed by *Morus alba*, whereas the least one was found in *Prosopis jullflora* shoots.
Sodium (Na). The least concentration of Na was found in *Acasia saligna* and increased in *Prosopis jullflora* while the highest one was found in *Morus alba.*
From (Table 14) the highest proportion of the studied elements in shoots of the concerned plant species is as follows.
Acasia saligna Na, K, N and P
Prosopis jullflora Na, N, K and P
Morus alba Na, N, K and P
ii) In leaves:
Total nitrogen (N). The highest concentration of N was found in *Prosopis jullflora* leaves, followed by *Acasia saligna*, while the lowest values were found in *Morus alba*.

Phosphorus (P). P concentrations in leaves of *Prosopis jullflora* seemed to be highest one followed by *Acasia saligna* and *Morus alba* leaves in a descending order.
Potassium (k). Concentration of K in leaves of *Prosopis jullflora* seemed to be highest one followed by *Morus alba*, while the least content is that of in *Acasia saligna* leaves.
Sodium (Na). The lowest concentration of Na was found in *Acasia saligna* followed by *Prosopis jullflora* whereas the highest one is that of *Acasia saligna* leaves.
In brief, the highest proportion of the studied elements in leaves of plant species seemed to be as follows in descending order:-
Acasia saligna: N%, K%, P%, Na p.p.m
Prosopis jullflora: N%, K%, P%, Na p.p.m
Morus alba: N%, K%, P%, Na p.p.m

Table (12) - Nutrient contents of the different plant species

Scientific name	Shoots				Leaves			
	(%)			Na	(%)			Na
	N	P	K	(p.p.m)	N	P	K	(p.p.m)
Acasia saligna	1.13	0.32	1.25	24.0	1.55	0.35	0.90	34.0
Prosopis jullflora	1.04	0.34	0.65	33.0	2.04	0.37	1.40	50.0
Morus alba	0.99	0.31	0.84	41.0	1.06	0.30	1.00	64.0
Mean	1.05	0.32	0.92	32.67	1.55	0.34	1.10	49.33
New L.S.D. at 5%	0.08	0.02	0.03	2.99	0.14	0.02	0.12	1.89

Simple correlation coefficients (r) between some factors interrelationships

Significant (*) simple correlation coefficients (r) is those of 0.622 to 0.707, while the highly significant (**) simple correlation coefficients (r) is those of 0.707 and over.

1- Simple correlation coefficients (r) between some meteorological factors under the variable conditions of El-Maghara sand dune (Table 13).

Significant and highly significant simple correlation coefficients are eight. The positive relationships are four and the negative relationships are four simple correlation coefficients. On the other hand, no significant simple correlation coefficients are seven. The highest simple correlation coefficients (r= -0.956) is found between total rainfall (mm) and sun shine (Kw/m²) indicates highly significant negative correlation. The least simple correlation coefficients (r= 0.635) is found between sun shine (Kw/m²) and evapo-transpiration (mm/day), indicates positive significant correlation.

- Wind speed (Km/h) is highly significant negatively correlated with air temperature (ºC) and evapo-transpiration (mm/day) (r= -0.737 and -0.861) respectively, highly significant positively correlated with air relative humidity (%).

- Air temperature (ºC) is highly significant positively correlated with sun shine (Kw/m²) and evapo-transpiration (mm/day) (r= 0.802 and 0.894) respectively.
- Air relative humidity (%) is significant negatively correlated with evapo-transpiration (mm/day) (r= -0.700).
- Total rainfall (mm) is highly significant negatively correlated with sun shine (Kw/m²) (r= -0.956).
- Sun shine (Kw/m²) is significant positively correlated with evapo-transpiration (mm/day) (r= 0.635).

2- Simple correlation coefficients (r) between some edaphic factors under the variable conditions of El-Maghara sand dune (Table 14).

Significant and highly significant simple correlation coefficients are eight. The positive relationships are five and the negative relationships are three simple correlation coefficients. On the other hand, no significant simple correlation coefficients are twelve. The highest correlations (r= 0.989) is found between soil migration (traps kg) in unstabilized dunes and soil migration (traps kg) of stabilized dunes during the second annual, indicates positive highly significant correlation. The least simple correlation coefficients (r= 0.772) is found between soil migration (traps kg) in sand dunes stabilized and erosion depth (cm) in un stabilized during first annual, indicates positive highly significant correlation.

-Soil moisture (%) 2007 is highly significant negatively correlated with soil migrated (traps kg.) in sand dunes stabilized (-0.821).
- Soil moisture (%) 2008 is highly significant negatively correlated with erosion depth (cm) in sand dunes un stabilized and soil accumulation in sand dunes stabilized (r= -0.851 and -0.953) respectively.

- Soil migrated (traps kg) in sand dunes un stabilized 2007 and 2008 is highly significant positively correlated with soil migration (traps kg.) in sand dunes stabilized (r= 0.818 and 0.989) respectively.
- Soil migration (traps kg) in sand dunes stabilized 2007 is highly significant positively correlated with erosion depth (cm) (r= 0.772).
- Erosion depth (cm) 2007 and 2008 is highly significant positively correlated with erosion depth (cm) and soil accumulation in sand dunes stabilized (r= 0.878 and 0.963) respectively.

Table (13) - Simple correlation coefficients (r) between some meteorological factors under the variable conditions of El-Maghara

Meteorological factors	Wind speed Km/h)	Air temperature (ºC)	Air relative humidity (%)	Total rainfall (mm)	Sun shine (Kw/m²)
Air temperature (ºC)	- 0.737 **	-	-	-	-
Air relative humidity (%)	0.916 **	- 0.426	-	-	-
Total rainfall (mm)	- 0.069	- 0.590	- 0.365	-	-
Sun shine (Kw/m²)	- 0.222	0.802 **	0.106	- 0.956 **	-
Evapo-transpiration (mm/day)	- 0.861 **	0.894 **	- 0.700 *	- 0.407	0.635 *

Table (14) - Simple correlation coefficients (r) between some edaphic factors under the variable conditions of El-Maghara sand dunes under two annuals

Edaphic factors	Sand dune	Soil moisture (%)		Soil migration (traps kg)				Erosion depth (cm)	
				Un stabilized		Stabilized			
		2007	2008	2007	2008	2007	2008	2007	2008
Soil migrated (traps kg.)	Un stabilized	- 0.539	- 0.312	-	-	-	-	-	-
	Stabilized	- 0.821**	- 0.450	0.818**	0.989**	-	-	-	-
Erosion depth (cm)	Un stabilized	- 0.333	-0.851**	0.568	- 0.233	0.772**	- 0.084	-	-
Soil accumulation	Stabilized	- 0.256	-0.953**	0.134	0.030	0.553	0.180	0.878**	0.963**

3- Simple correlation coefficients (r) between some growth behaviour factors under the variable conditions of El-Maghara stabilized sand dune (Table 15).

Significant and highly significant simple correlation coefficients are eighteen all that are positive relationships. On the other hand, no significant simple correlation coefficients are teen. The highest simple correlation coefficients (r= 0.998) between plant height (cm) and plant crown cover (C.v³). The least simple correlation coefficients (r= 0.670) is found between No. of shoots and C.V (m³).
- Plant height (cm) is highly significant positively correlated with shoot diameter (cm), shoot length (cm), C.C (m²) and C.V (m³) (r= 0.852, 0.748, 0.992 and 0.998) respectively and significant positively correlated with No. of shoots (r= 0.695).

- Shoot diameter (cm) is highly significant positively correlated with No. of shoots, shoot length (cm), No. of leaves/shoot, C.C (m²) and C.V (m³) (r= 0.854, 0.958, 0.803, 0.877 and 0.860) respectively.
- No. of shoots is highly significant positively correlated with C.C (m²) (r=0.779) and significant positively correlated with, shoot length (cm) and C.V (m³) (r=0.693 and 0.670) respectively.
- Shoot length (cm) is highly significant positively correlated with leaf area (cm²) C.C (m²) and C.V (m³) (r= 0.900, 0.751 and 0.774) respectively.
- No. of leaves/ shoot is highly significant positively correlated with leaf area (cm²) (r= 0.786)
- C.C (m²) is highly significant positively correlated with C.V (m³) (r= 0.983).

4- Simple correlation coefficients (r) between some meteorological factors and some edaphic factors under the variable conditions of El-Maghara cultivated sand dune (Table 16).

Significant and highly significant simple correlation coefficients are thirty. The positive relationships are sixteen and the negative relationships are fourteen simple correlation coefficients. On the other hand, no significant simple correlation coefficients are thirty. The highest simple correlation coefficients (r= 0.998) is found between air temperature (ºC) and soil migration (traps kg.) stabilized dunes during first annual, indicates highly significant positive correlation. The least simple correlation coefficients (r= - 0.633) is found between total rainfall (mm) and sand migration (traps kg.) in sand dunes stabilized during first annual, indicates negative significant correlation.

In the first annual

- Wind speed (Km/h) is highly significant negatively correlated with sand migrated (traps kg.) in sand dunes unstabilized, erosion depth (r= - 0.724 and - 0.926) and significant negatively with migrated (traps kg.) in sand dunes stabilized and soil accumulation (r= - 0.670 and - 0.655).
- Air temperature (ºC) is highly significant negatively correlated with soil moisture (%) (r= -0.790) and positively with sand migration (traps kg.) in sand dunes unstabilized and stabilized and erosion depth (r= 0.822, 0.998 and 0.804) respectively.
- Air relative humidity (%)) is highly significant negatively correlated with erosion depth (r= -0.730).
- Total rainfall (mm) is highly significant positively correlated with soil moisture (%) (r= 0.922) and significant negatively with sand migrated (traps kg.) in sand dunes stabilized (r= -0.633).
- Sun shine (Kw/m²) is highly significant negatively correlated with soil moisture (%) (r= -0.966), positively with sand migrated (traps kg.) in sand dunes stabilized (r= 0.833) and significant positively with sand migrated (traps kg.) in sand dunes unstabilized (r= 0.696).
- Evapo-transpiration (mm/day) is highly significant positively correlated with sand migrated (traps kg.) in sand dunes unstabilized, stabilized and erosion depth (r= 0.968, 0.880 and 0.755) respectively.

In the second annual

- Wind speed (Km/h) is highly significant negatively correlated with erosion depth and soil accumulation (r= - 0.877 and - 0.931).
- Air temperature (ºC) is highly significant negatively correlated with soil moisture (%) (r= -0.810), positively with soil accumulation (r= 0.807) and significant positively with and erosion depth (r= 0.660).
- Air relative humidity (%)) is highly significant positively correlated with sand migrated (traps kg.) in sand dunes unstabilized (r= 0.702) and negatively with erosion depth (r= -0.721).
- Total rainfall (mm) is highly significant negatively correlated with sand migrated (traps kg.) in sand dunes unstabilized and stabilized (r= -0.847 and - 0.848).
- Sun shine (Kw/m²) is highly significant positively correlated with sand migrated (traps kg.) in sand dunes unstabilized and stabilized (r= 0.744 and 0.788).
- Evapotranspiration (mm/day) is significant positively correlated with soil accumulation (r= 0.667).

Table (15) - Simple correlation coefficients (r) between some growth behaviour factors under the variable conditions of El-Maghara sand dunes during two annuals

Factors	Plant height (cm)	Shoot diameter (cm)	No. of shoots	Shoot length (cm)	No. of leaves/ shoot	Leaf area (cm²)	C.C (m²)
Shoot diameter (cm)	0.852**	-	-	-	-	-	-
No. of shoots	0.695*	0.854**	-	-	-	-	-
Shoot length (cm)	0.748**	0.958**	0.693*	-	-	-	-
No. of leaves/shoot	- 0.068	0.329	- 0.024	0.574	-	-	-
Leaf area (cm²)	0.396	0.803**	0.599	0.900**	0.786**	-	-
C.C (m²)	0.992**	0.877**	0.779**	0.751**	- 0.097	0.422	-
C.V (m³)	0.998**	0.860**	0.670*	0.774**	- 0.011	0.427	0.983**

Table (16) - Simple correlation coefficients (r) between some meteorological factors with some edaphic factors under the variable conditions of El-Maghara

Annuals	Factors	Sand dunes	Wind speed (Km/h)	Air temperature (ºC)	Air relative humidity (%)	Total rainfall (mm)	Sun shine (Kw/m²)	Evapotrans-piration (mm/day)
First	Soil moisture (%)		0.167	- 0.790**	- 0.212	0.922**	- 0.966**	- 0.520
	Sand migration (traps kg.)	Un stabilized	- 0.724**	0.822**	- 0.591	- 0.522	0.696*	0.968**
		Stabilized	- 0.670*	0.998**	- 0.379	- 0.633*	0.833**	0.880**
	Erosion depth		- 0.926**	0.804**	- 0.730**	- 0.004	0.294	0.755**
	Soil accumulation		- 0.655*	0.580	- 0.430	0.137	0.100	0.371
Second	Soil moisture (%)		0.639*	- 0.810**	0.309	0.252	- 0.473	- 0.548
	Sand migration (traps kg.)	Un stabilized	0.371	0.346	0.702*	-0.847**	0.744**	- 0.020
		Stabilized	0.237	0.465	0.601	-0.848**	0.788**	0.086
	Erosion depth		- 0.877**	0.660*	- 0.721**	0.189	0.097	0.603
	Soil accumulation		- 0.931**	0.807**	- 0.580	- 0.070	0.341	0.667*

5- Simple correlation coefficients (r) between some meteorological factors and some growth behaviour factors under the variable conditions of El-Maghara cultivated sand dune (Table 17).

Significant and highly significant simple correlation coefficients are thirteen. The positive relationships are nine simple correlation coefficients. The negative relationships are four simple correlation coefficients. On the other hand, no significant simple correlation coefficients are thirty five. The highest simple correlation coefficients (r= 0.999) of air temperature (ºC) and leaf area (cm²). The least simple correlation coefficients (r = -0.642) is found between air relative humidity (%) and the No. of shoots.

- Wind speed (Km/h) is highly significant negatively correlated with No. of shoots and leaf area (cm²) (r = - 0.807 and - 0.711).

- Air temperature (ºC) is highly significant positively correlated with shoot diameter (cm), shoot length (cm), No. of leaves/shoot and leaf area (cm²) (r = 0.785, 0.880, 0.785 and 0.999) respectively.

- Air relative humidity (%)) is significant negatively correlated with No. of shoots (r = -0.642).

- Total rainfall (mm) is highly significant negatively correlated with No. of leaves/shoot (r = -0.924).

- Sun shine (Kw/m²) is highly significant positively correlated with No. of leaves/shoot and leaf area (cm²) (r = 0.974 and 0.813) and significant with shoot length (cm) (r = 0.695).

- Evapo-transpiration (mm/day) is highly significant positively correlated with No. of leaves/shoot and leaf area (cm²) (r = 0.718 and 0.871).

Table (17) - Simple correlation coefficients (r) between some meteorological factors with some growth behaviour factors under the variable conditions of El-Maghara sand dunes during two annuals

	Wind speed (Km/h)	Air temperature (ºC)	Air relative humidity (%)	Total rainfall (mm)	Sun shine (Kw/m²)	Evapotranspir-ation (mm/day)
Plant height (cm	- 0.182	0.362	0.104	- 0.023	0.133	- 0.023
Shoot diameter (cm)	- 0.600	0.785**	- 0.265	- 0.249	0.461	0.504
No. of shoots	- 0.807**	0.600	- 0.642*	0.229	0.043	0.500
Shoot length (cm)	- 0.529	0.880**	- 0.147	- 0.516	0.695*	0.586
No. of leaves/shoot	- 0.289	0.785**	- 0.015	- 0.924**	0.974**	0.718**
Leaf area (cm²)	- 0.711**	0.999**	- 0.387	- 0.607	0.813**	0.871**
C.C (m²)	- 0.289	0.393	- 0.021	0.051	0.091	0.043
C.V (m³)	- 0.166	0.391	0.138	- 0.089	0.192	- 0.006

6- Simple correlation coefficients (r) between some edaphic factors and some growth behaviour factors under the variable conditions of El-Maghara cultivated sand dune (Table 18).

Significant and highly significant simple correlation coefficients are forty. The positive relationships are thirty simple correlation coefficients. The negative relationships are teen correlations. On the other hand, no significant simple correlation coefficients are forty. The highest simple correlation correlations (r = - 0.999) between soil migration (traps kg.) in stabilized dunes and leaf area (cm²) during first annual and between soil moisture (%) and shoot diameter (cm) during second annual. The least simple correlation coefficients (r = -0.643) is found between soil migrated (traps kg) in dunes stabilized and No. of leaves/shoot during second annual.

In the first annual

- Soil moisture (%) is highly significant negatively correlated with shoot length (cm), No. of leaves/shoot and leaf area (cm²) (r = -0.806, -0.884 and -0.811) respectively.

- Soil migrated (traps kg) in dunes unstabilized is highly significant positively correlated with No. of leaves/shoot and leaf area (cm²) (r = 0.808 and 0.797).

- Soil migrated (traps kg) in dunes stabilized is highly significant positively correlated with shoot diameter (cm), shoot length (cm), No. of leaves/shoot and leaf area (cm^2) (r = 0.775, 0.883, 0.812 and 0.999) respectively.
- Erosion depth (cm) is highly significant positively correlated with shoot diameter (cm) and No. of shoots (r = 0.833, 0.991) and significant with shoot length (cm), leaf area (cm^2) and C.C (m^2) (r = 0.690, 0.654 and 0.670) respectively.
- Soil accumulation (kg) is highly significant positively correlated with plant height (cm), shoot diameter (cm), No. of shoots, shoot length (cm), C.C (m^2) and C.V (m^3) (r = 0.853, 0.925, 0.968, 0.778, 0.910 and 0.835) respectively.

In the second annual

- Soil moisture (%) is highly significant negatively correlated with shoot diameter (cm), shoot length (cm), No. of shoots, leaf area (cm^2), C.C (m^2) and C.V (m^3) (r = -0.824, -0.999, -0.865, -0.959, -0.826, -0.854 and -0.832) respectively.
- Soil migrated (traps kg) in dunes stabilized is highly significant positively correlated with shoot length (cm) and No. of leaves/shoot (r = 0.658 and 0.643).
- Erosion depth (cm) is highly significant positively correlated with shoot length (cm), No. of shoots, leaf area (cm^2), C.C (m^2) and C.V (m^3) (r = 0.852, 0.945, 0.766 and 0.795) respectively.
- Soil accumulation (kg) is highly significant positively correlated with shoot diameter (cm), No. of shoots, No. of leaves/shoot, leaf area (cm^2) and C.C (m^2) (r = 0.939, 0.954, 0.858, 0.809 and 0.754) respectively and significant with plant height (cm) and C.V (m^3) (r = 0.687 and 0.681).

Table (18) - Simple correlation coefficients (r) between some edaphic factors with some growth behaviour factors under the variable conditions of El-Maghara sand dunes during two annuals

Annuals	Growth behaviour factors	Soil moisture (%)	Soil migrated (traps kg)		Erosion depth (cm)	Soil accumulation (kg)
			Dunes un stabilized	Dunes stabilized		
First	Plant height (cm)	- 0.369	- 0.224	0.358	0.535	0.853**
	Shoot diameter (cm)	- 0.604	0.316	0.775**	0.852**	0.925**
	No. of shoots	- 0.147	0.268	0.564	0.945**	0.968**
	Shoot length (cm)	- 0.806**	0.454	0.883**	0.766**	0.778**
	No. of leaves/shoot	- 0.884**	0.808**	0.812**	0.269	- 0.018
	Leaf area (cm^2)	- 0.811**	0.797**	0.999**	0.795**	0.591
	C.C (m^2)	- 0.316	- 0.175	0.382	0.620	0.910**
	C.V (m^3)	- 0.426	- 0.199	0.390	0.524	0.835**
Second	Plant height (cm)	- 0.824**	0.384	0.478	0.609	0.687*
	Shoot diameter (cm)	- 0.999**	0.338	0.473	0.833**	0.939**
	No. of shoots	- 0.865**	- 0.200	- 0.054	0.991**	0.954**
	Shoot length (cm)	- 0.959**	0.537	0.658*	0.690*	0.858**
	No. of leaves/shoot	- 0.359	0.607	0.643*	0.055	0.272
	Leaf area (cm^2)	- 0.826**	0.384	0.503	0.654*	0.809**
	C.C (m^2)	- 0.854**	0.278	0.384	0.670*	0.754**
	C.V (m^3)	- 0.832**	0.443	0.535	0.586	0.681*

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