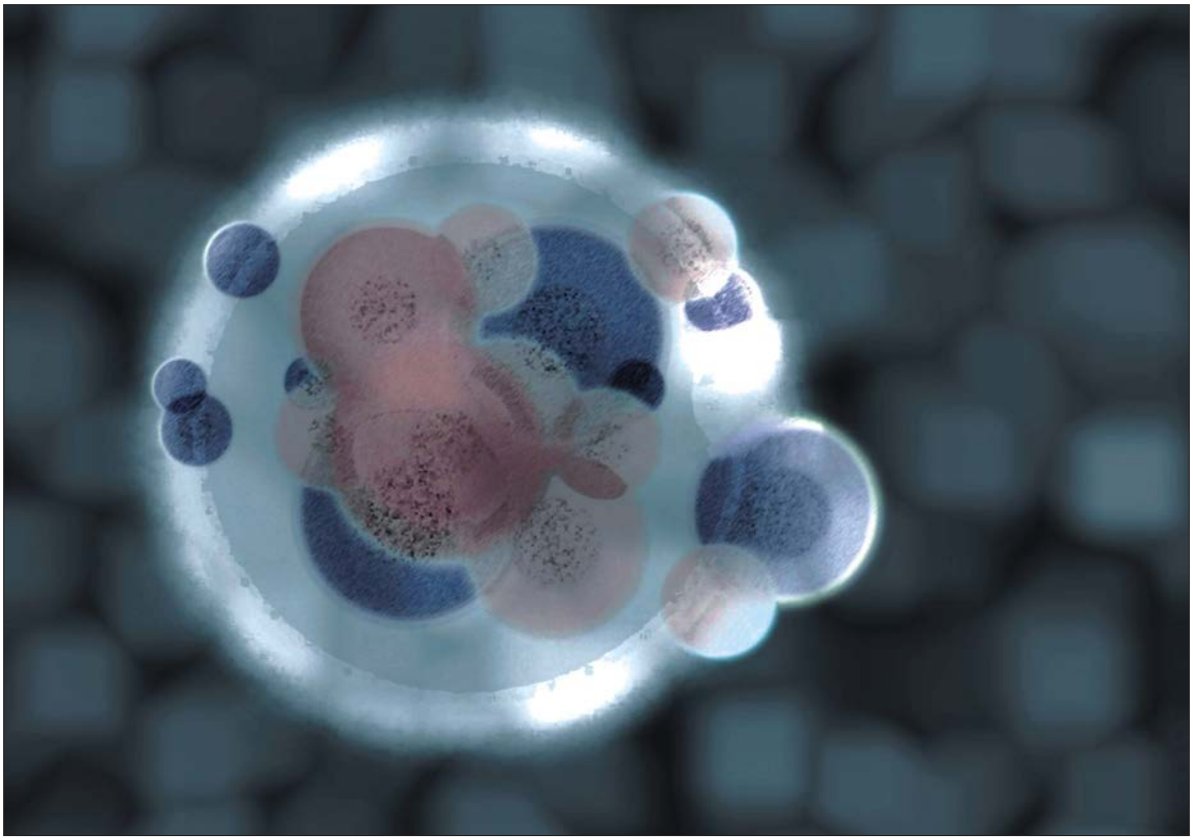

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Non-traditional Fodders from the Halophytic Vegetation of the Deltaic Mediterranean Coastal Desert, Egypt

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Abstract: The Deltaic Mediterranean coastal desert extends for about 180 km from Abu Qir westward to Port Said. The soil of this coastal belt is generally salt-affected vegetated with different plant communities recognized into zones dominated mainly by halophytes e.g., *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Limbarda crithmoides*, *Aeluropus brevifolius*, *Sporobolus spicatus*, *Limoniastrum monopetalum*, *Zygophyllum aegyptium*, *Limonium pruinosum*, *Cressa cretica*, *Tamarix tetragyna* and *Bassia indica* etc. However, in the sand dune habitat psammophytes predominate e.g., *Elymus farctus*, *Lotus polyphyllos* and *Thymelaea hirsuta*. In the non-saline soil of the most landward zone, non-salt tolerant species predominate e.g., *Lygos raetam*, *Lycium europaeum* etc. For the present paper six halophytes have been selected and chemically analysed to determine their nutritive values as fodder producing plants, these are: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Limoniastrum monopetalum*, *Tamarix tetragyna*, *Cressa cretica* and *Bassia indica*. The latest species is the only palatable plant, the other five species are not palatable but their vegetative yields may be considered as the main part of the raw materials for fodder production. The results, so far, are promising all studied plants are rich with their carbohydrates and protein contents. The establishment of *Bassia indica* in the salt affected land of the study area had been successively experimented.

Key words: Fodder, halophytic vegetation, deltaic coast, wetlands, phytochemical

INTRODUCTION

In Egypt, low meat production is one of the major food problems which is often exacerbated by the increasing demands due to increasing population. The production of conventional fodders (alfalfa and clover) is not enough (Zahran *et al*., 1999). On the other hand, the natural vegetation of Egypt's deserts comprises considerable number of palatable species and/or species rich with their nutritive values that may be considered reliable natural resources for fodder production if their vegetative yields are high enough to maintain a continuous fodder supply (Zahran and Willis, 2009). Unfortunately, this cannot be secured in Egypt's desert where rainfall is, generally, scarce and the vegetative yields of these fodder producing plants are not high enough to meat the requirements of the needed livestock. Apart from that, it will not be possible to find pure natural vegetation of plants with high nutritive values only. Usually, unwanted and/or harmful species also occur in the same area. Thus, the best solution is to widen the desert areas occupied by the fodder producing plants by propagating them under aridity (drought) and/or salinity stress of the deserts. Water requirements of these plants are very small (xerophytes), some of them could be grown with saline water or even with sea water directly (halophytes).

In Egypt's deserts the frequency of the salt affected lands makes their utilization necessary. This could be achieved by vegetating these lands with salt tolerant plants of economic values. That is the aim of the present paper. Six halophytes naturally growing in the deltaic Mediterranean coastal desert of Egypt had been studied ecologically and their nutritive values as fodder producing plants were determined shown in Table 2. These plants are: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Limoniastrum monopetalum*, *Tamarix tetragyna*, *Cressa cretica* and *Bassia indica*. The establishment of *Bassia indica* was also experimented in a salt affected land of the deltaic Mediterranean coast.

MATERIALS AND METHODS

Physiography: The Mediterranean coastal desert of Egypt extends from Sallum (Libyan border) eastward to Rafah (Palestine border) for about 970 km. It is the narrow less

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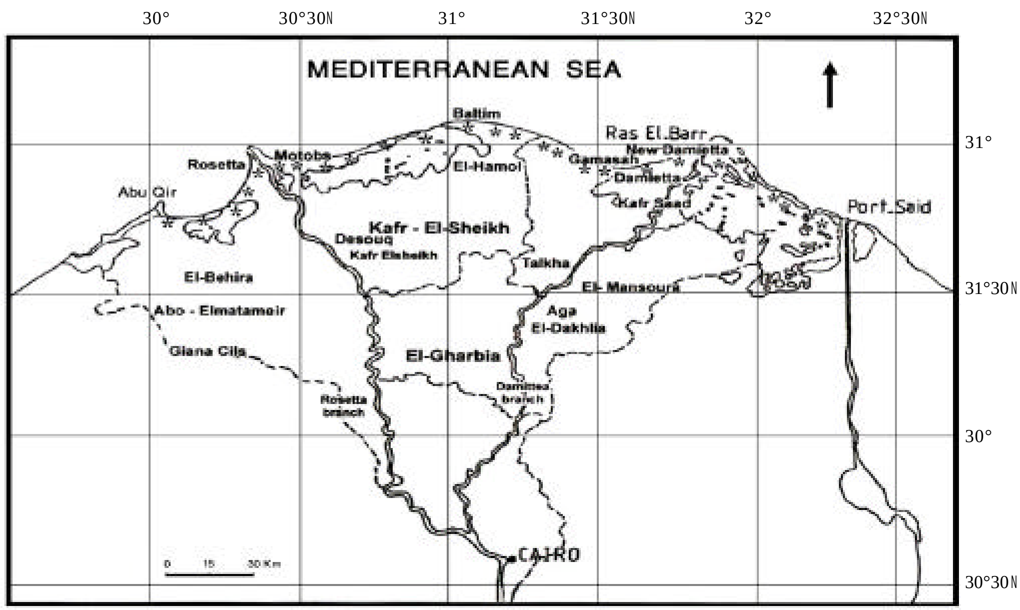

Fig. 1: Map of the Nile Delta region showing the study area indicated by (*)

arid desert of Egypt influenced greatly by the sea. It is divided ecologically into three sections: western, middle and eastern. The western section, the northern coast of the Western Desert (Mariut Coast) extends from Sallum to Abu Qir for about 550 km, the middle sections (the Deltaic Coast) runs from Abu Qir to Port Said for about 180 km and the eastern section (Sinai northern Coast) stretches from Port Said to Rafah for about 240 km (Fig. 1).

The deltaic Mediterranean coast has a width from sea landward (southwards) for about 15 km. It is characterizied by 3 shallow natural lakes: Manzala (in the east), Burullus (in the middle) and Idku (in the west). These lakes are receiving the main bulk of the drainage water from the Nile Delta lands.

The climate of the whole stretch of the Mediterranean coastal desert is, generally, less arid than the remaining southern parts of Egypt. According to the Bioclimatic Map of UNESCO/FAO (1963), it belongs to the subdesertic warm climate. In the deltaic Mediterranean section annual rainfall ranges between 160 mm in Rosetta and 102.3 mm in Damietta. Maximum air temperature in both coastal cities ranges between 18.1 and 30.2°C and 18.4 and 31.3°C whereas minimum temperatures range between 11.3, 23, 8.2 and 21.5°C in January and July respectively. Relative humidity does not vary widely between the two cities being 76, 74, 83 and 75% in January and July, respectively (Zahran and Willis, 2009).

Habitats and vegetation types: The deltaic Mediterranean coast, being directly affected by sea water, is generally, salt affected land divided ecologically into four main habitats in a landward zonation pattern. The extent and plant life of these zones vary depending upon: distance from the sea and landform. These habitats are: 1. sand formation, 2. salt marshes, 3. reed swamps and 4. potentially cultivated land. The sand formation comprises the low and small sandy mounds that form low sand bars along the shore-line. In this habitat *Zygophyllum aegyptium* predominates with no associated species and with very thin cover. Also, there are the huge mobile sand dunes of Abu Madi area (up to 60 m high) which are barren except of a very few plants of *Phragmites australis* which may be an indicator of a previously swampy habitat. The partially stabilized sand dunes are dominated by the pioneer psammophytes: *Stipagrostis ciliata* and *Elymus farctus* with abundant presence of *Alhagi graecorum* and *Echinops spinosissimus* etc. Stabilized sand dunes are dominated by *Asparagus stipularis*, *Echinops spinosissimus* and *Thymelaea hirsuta*. In the saline patches of the runnels within the sand dunes, there are areas dominated by *Arthrocnemum macrostachyum*, *Sporobolus spicatus*, *Imperata cylindrica* and *Cressa cretica* etc. The semi-wild *Phoenix dactylifera* is also a characteristics feature of the sand dune habitat of this coastal belt.

The vegetation of the salt marsh habitats is formed of communities dominated or co-dominated by *Arthrocnemum macrostachyum*, *Cressa cretica* (widespread), *Halimione portulacoides*, *Halocnemum strobilaceum*, *Limbarda crithmoides*, *Juncus acutus*, *J. rigidus*, *Aeluropus brevifolius*, *Sporobolus spicatus*, *Limoniastrum monopetalum*, *Suaeda vera*, *Tamarix tetragyna* and *Zygophyllum aegyptium*. The frequent swampy habitats are usually in low areas of the landward zone where the water seeping from the lakes and/or drained from cultivated lands accumulate. *Typha domingensis* dominates in these swamps with the common presence of *Phragmites australis*. In the saline-saturated fringes of these swamps rushes e.g., *Juncus acutus*, *J. rigidus* and sedges, e.g., *Carex extensa*, *Cyperus laevigatus* and *Scirpus tuberosus*, grow. *Bassia indica* predominates on the dry saline banks of these swamps.

The potentially cultivated land occupies the most landward zone of this coastal belt. Being less saline, this habitat supports the growth of annual weeds. Cakile maritima is the most abundant weed, common ones include: *Amaranthus ascendens*, *Launaea angustifolia* and *Senecio desfontainei*.

Field works: Six halophytes have been chosen for the present study, namely: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Limoniastrum monopetalum*, *Tamarix tetragyna*, *Cressa cretica* and *Bassia indica*. Samples of the shoot systems of these plants were collected for chemical analysis. Also, 2 soil samples at 0-20 cm and 20-40 cm depth were collected from the grounds of the study plants for physical and chemical analysis.

Field experiment: The establishment of *Bassia indica* in a salt affected land of the study area was experimented.

Laboratory analysis

Plant analyses: Immediately after collection, the plant samples were washed several times with distilled water and oven dried in an oven (at 60°C) to constant dry weight, their fresh and dry weights were determined. After desiccation the dry samples were ground to fine powder ready for different analysis. Samples were replicated and each test was repeated twice, the mean values are given (±) to the standard errors of means. Estimation of succulence and carbohydrates, were according to Tiku (1975) and Thyumanavan and Sadasivan (1984), respectively and total protein was calculated by multiplying the total nitrogen by the factor 6.25, crude fat (Ether extract) (AOAC, 1990) The total digestible nutrient was estimated according to the equation described by Abu-El-Naga and El-Shazly, 1971). The Digestible Protein (DP) was calculated according to the regression equation of Demarquilly and Weiss (1970). Macroelements (Na, K and Ca) were estimated according to Allen *et al*. (1974).

Soil analyses: The collected soil samples were air dried, thoroughly mixed and passed through 2 mm sieve to remove gravels and debris and packed in plastic bags for physical and chemical analyses. Sieving method was used to get the weight of sand, silt and clay. Moisture content of the fresh soil samples were determined by weighting sealed tins before and after drying the samples in an oven at 105°C to constant weights. Soil chemical properties were determined following the methods described by Piper (1947) and Jackson (1962).

Statistical analyses: One-way Analysis of Variance (ANOVA) was applied to assess the significance of variation in the environmental variables and nutritive values with equal replication using the COSTAT program. A test (LSD) was applied to determine the least significance of difference in the salinity tolerance of *B. indica* plant.

RESULTS

The study halophytes: *Arthrocnemum macrostachyum* is a leafless, jointed succulent shrublet halophyte with flowers in terminal spicate inflorescence. It is a densely branched, robust plant with decumbent rooting base. Its community is wide spread in both the coastal and inland deserts of Egypt. *Halocnemum strobilaceum* is a richly branched shrub with woody continuous branches, rudimentary leaves and perfect flowers. It is easily recognized by its numerous small, decussate green tubercles along the branches, composed of small-rudiments. Both *A. macrostachyum* and *H. strobilaceum* are closely related halophytes belonging to the Mediterranean, Irano-Turanian and Saharo-Sindian elements. However, *H. strobilaceum* is not widespread in the Egyptian salt marshes. It is absent from the oases of the Western Desert as well as from the southern section of the Red Sea coastal land.

Limoniastrum monopetalum is a halophytic shrub of whitish-grey aspect. Leaves narrowly spathulate, as well as stems and branches, densely beset with white calcareous tubercles. It is an excretive halophyte that seems to be intolerant to arid climate as it flourishes only in the Mediterranean littoral salt marshes, absent elsewhere in Egypt. *Limoniastrum* is a pure Mediterranean element. *Tamarix tetragyna* is a woody tall shrub (3-5 m high) with very small scale-like leaves and large pink flowers. It is an excretive halophyte that grows in a variety of habitats but it prefers wet salt marshes. *T. tetragyna* belongs to the Saharo-Sindian extending to the Mediterranean and Irano-Turanian regions. In Egypt, this species occurs in both coastal and inland salt marshes.

Cressa cretica is a mat-shaped excretive halophyte with sessile, white flowers. It is a hairy plant of grey appearance, herbaceous or frutescent, prostrate, rarely erect. Leaves 3 mm long, crowded, acute. It is one of the Mediterranean and Palaeotropical elements. In Egypt, *C. cretica* is very common in both coastal and inland dry salt marshes. *Bassia indica* is an annual bushy richly branched herb, under favourable conditions reaching a height of 2 m. more or less densely hairy. Leaves on sterile branches linear-lanceolate, 3-4 mm long, on flowering branches very narrow, only a few mm long. *B. indica* belongs to the Irano-Turanian and Sudano-Zambezian areas. It may be slightly extending into Saharo-Sindian regions. Its native home is India and have been non-intentionally introduced to Egypt (Drar, 1952). *B. indica* is usually seen in the waste ground and salt affected lands throughout Egypt (El-Dingawi, 1990).

Soil properties: The results shown in Table 1 elucidate that the soil supporting the growth and domination of the study plants are generally moist, slightly alkaline (pH = 7.4-7.97), sandy to sand-silty in texture with low amount of clay. Organic carbon contents are generally low (0.12-1.5%), and calcium carbonate contents are relatively high (56.0-70.0%) in the soil of *Limoniastrum* than those of the other species. Total soluble salts are generally high particularly in the surface layers (up to 11.2% in the soil of *Halocnemum*), mainly chlorides and partly sulphates and bicarbonates.

Nutritive values of the study plants: Table 2 contains the results of the chemical analyses of the shoot samples of the study six species that elucidate the following facts:

- All species are rich in their carbohydrate contents ranging between 434.79 mg g^{-1} DW in *Cressa* followed by those of *Bassia* (331.2 mg g^{-1} DW),

Table 1: Physical and chemical properties of 12 soil samples collected from the habitats of the study halophytes, deltaic Mediterranean coastal desert, Egypt

			Physical properties				Chemical properties (%)						
				Particle sizes									
Species	SN	Depth	MC	Sand	Silt	Clay	pH	OC	CC	TSS	Cl	SO_4	HCO_3
Arthrocnemum macrostachyum	1	0-20	35.60^{c}	60.1^{bc}	35.0^{ef}	4.9^{f}	7.97^{a}	1.1^{d}	37.0^{c}	3.9^{cd}	1.07^{c}	0.02^{hi}	1.4^{a}
	2	20-40	39.60^{c}	58.4^{c}	36.2^{de}	5.1^{f}	7.72^{a}	0.55^{e}	34.0^{c}	3.5^{d}	0.89^{c}	0.01^{i}	1.2^{b}
Halocnemum strobilaceum	3	0-20	25.13^{de}	25.5^{g}	54.7^{c}	20.8^{b}	7.8^{a}	1.5^{a}	24.0^{d}	11.2^{a}	3.9^{a}	0.58^{b}	0.52^{de}
	4	20-40	29.20^{d}	21.3^{g}	60.0^{c}	18.7^{bc}	7.53^{a}	1.4^{ab}	4.0^{ef}	5.0^{b}	1.58^{b}	0.25^{e}	0.39^{f}
Limoniastrum monopetalum	5	0-20	8.77^{g}	66.2^{ab}	30.6^{ef}	3.2^{f}	7.4^{a}	1.3^{bc}	70.0^{a}	3.6^{d}	0.56^{d}	0.84^{a}	0.38^{f}
	6	20-40	17.00^{f}	68.4^{a}	28.2^{f}	3.4^{f}	7.91^{a}	1.2^{cd}	56.0^{b}	4.3^{c}	1.42^{b}	0.38^{d}	0.47^{ef}
Tamarix tetragyna	7	0-20	59.40^{a}	36.0^{ef}	60.4^{c}	3.6^{f}	7.84^{a}	1.3^{bc}	8.1^{e}	1.3^{f}	0.27^{e}	0.07^{gh}	0.55^{de}
	8	20-40	53.20^{b}	42.1^{de}	43.7^{d}	14.2^{d}	7.5^{a}	0.53^{e}	2.0^{f}	0.5^{g}	0.28^{e}	0.08^{fg}	0.61^{d}
Cressa cretica	9	0-20	8.80^{g}	10.2^{h}	72.9^{b}	17.3^{c}	7.43^{a}	0.24^{fg}	8.0^{e}	2.56^{e}	0.53^{d}	0.29^{e}	1.01^{c}
	10	20-40	10.00^{g}	9.4^{h}	81.3^{a}	9.3^{e}	7.97^{a}	0.12^{g}	7.5^{e}	1.96^{e}	0.50^{d}	0.13^{f}	0.58^{de}
Bassia indica	11	0-20	21.50^{ef}	35.5^{f}	35.7^{ef}	28.8^{a}	7.75^{a}	0.27^{f}	5.5^{ef}	2.5^{e}	0.03^{f}	0.37^{d}	0.59^{d}
	12	20-40	38.70^{c}	44.6^{d}	32.7^{ef}	17.7^{c}	7.49^{a}	0.3^{f}	4.0^{ef}	2.3^{e}	0.14^{ef}	0.52^{c}	0.54^{de}
LSD	-	-	4.91	6.59	7.5	2.18	1.14	0.14	4.57	0.65	0.21	0.06	0.11

MC: Moisture content, OC: Organic carbon, CC: Calcium carbonate, TS: Total soluble salt, SN: Sample number. Mean of the variables have the letters which are significantly different according to the LSD-test ($p \leq 0.05$)

Table 2: Nutritive values of the shoots of halophytes naturally growing in the Deltaic Mediterranean coastal desert, Egypt

							Macro-elements (mg g^{-1} dry weight)			Calculated parameters (%)	
Species	FW (%)	DW (%)	Suc. (%)	EE (%)	Prot. (%)	Carb. (%)	Na	K	Ca	DP	TDN
Arthrocnemum macrostachyum	52.7±0.5	14.5±0.1	3.6±0.18	1.2±0.04	5.34±0.27	300.69±1.0	34.2±0.5	19.2±0.4	22.6±0.2	1.4±0.001	59.09±0.19
Halocnemum strobilaceum	190.0±0.4	67.7±0.7	2.8±0.04	2.13±0.06	9.44±1.6	143.54±4.78	19.4±0.28	16.3±0.3	25.0±0.3	5.3±0.03	56.85±0.31
Limoniastrum monopetalum	14.0±0.01	6.31±0.6	2.2±0.03	2.96±0.08	6.98±0.001	320.8±15.9	25.3±0.3	11.7±0.2	14.8±0.14	2.9±0.01	59.27±0.19
Tamarix tetragyna	17.8±1.00	9.8±0.09	1.8±0.04	1.9±0.04	4.43±0.14	319.76±17.99	23.7±0.46	10.0±0.6	15.0±0.14	0.6±0.001	60.28±0.22
Cressa cretica	0.95±0.09	0.7±0.05	1.67±0.03	3.1±0.01	14.79±0.3	434.79±33.35	31.6±0.2	15.0±0.5	32.4±0.4	10.2±0.06	53.75±0.3
Bassia indica (5 months age)	683.6±36.8	312.3±27.8	3.6±0.2	2.9±0.1	9.25±0.54	331.2±59	28.8±0.38	23.4±0.09	10.2±0.2	6.0±0.02	56.87±0.18
LSD ($p \leq 0.05$)	37.35	3.92	3.75	0.19	1.44	2.12	0.10	0.11	0.13	0.08	0.73

FW: Fresh weight, DW: Dry weight, Carb.: Total carbohydrates, Prot.: Proteins, Suc.: Succulence, EE: Ether extract, DP: Digestible protein, TDN: Total digestible .nutrients, Mean±standard errors

Limoniastrum (320.8 mg g^{-1} DW), *Tamarix* (319.7 mg g^{-1} DW), *Arthrocnemum* (300.69 mg g^{-1} DW) and *Halocnemum* (143.54 mg g^{-1} DW). On the other hand, the relatively highest amount of protein had been also detected in *Cressa* (14.79%) and the lowest amount was that of *Tamarix* (4.43%). In *Bassia* branches the protein content was 9.25%, whereas in *Halocnemum* it was 9.44%, in *Limoniastrum* was 6.98% and *Arthrocnemum* was 5.34%

- The amounts of the macro-elements (Na, K and Ca) varied considerably between the study six species. The highest amount of sodium (34.2 mg g^{-1} dry weight) was that of *Arthrocnemum* followed by that of *Cressa* (31.6 mg g^{-1} dry weight), *Bassia* (28.8 mg g^{-1} dry weight), *Limoniastrum* (25.3 mg g^{-1} dry weight) and *Tamarix* (23.7 mg g^{-1} dry weight). On the other hand, *Bassia* contains the relatively highest amount of potassium (23.4 mg g^{-1} dry weight) and the least was that of *Tamarix* (10.0 mg g^{-1} dry weight). The amounts of potassium detected in the other species were: 19.2, 16.3, 15.0 and 11.7 mg g^{-1} dry weight in *Arthrocnemum*, *Halocnemum*, *Cressa* and *Limoniastrum*, respectively. The relatively highest amount of calcium was detected in *Cressa* (32.4 mg g^{-1} dry weight) and the least was that of *Bassia* (10.2 mg g^{-1} dry weight). Almost similar amounts of calcium (25.0 and 22.6 mg g^{-1} dry weight) were detected in *Halocnemum* and *Arthrocnemum* whereas small amounts (15.0 and 14.8 mg g^{-1} dry weight) were detected in *Tamarix* and *Limoniastrum,* respectively

Establishment experiment: To introduce the six studies halophytes as non-traditional fodder producing plants, their propagation under salinity and/or aridity stress should be tested. *Bassia indica* was the first for such experiments to be followed by the five remaining plants.

In its natural stands, *B. indica* usually produce large amounts of seeds which are short-lived and do not remain viable in the soil more than one year (Sadek, 1974). However, Hammad (1989) succeeded to germinate 3-years old *B. indica* seeds using six concentrations of sodium chloride solutions (50, 150, 300, 500, 800 and 1000 mM) and found that the increase in salt concentrations from 500 to 800 mM was associated with succession decrease in the rate of seed germination. Seeds treated with 1000 mM failed to germinate. Salinity tolerance of *B. indica* plants was tested in 80 young seedlings collected from its natural stands of the deltaic Mediteranean coast. On 10 April 2010 the seedlings were transplanted in 16 pots, 8 were filled with silty soil and the remainder were filled with sandy soil. Irrigation was carried out with equal amounts of fresh water (1 L) as control set, 0.5, 2 and 3% NaCl solutions for the second, third and fourth sets, respectively. Application of NaCl was only once and afterwards all pots were irrigated with fresh water at 3-day's intervals to keep the soil at its field capacity. The experiment continued for 3 months and the shoots of *B. indica* were harvested on July 2010. Plant height and fresh and dry weights were determined. The results (Table 3) show that *B. indica* seedlings succeeded to grow normally after being treated with saline solution as high 3% NaCl. The results were analyzed statistically (Poole, 1974) and the correlation coefficients (r) were determined. Positive correlations (0.5 for sand and 0.6 for silty soils) occurred between the measured parameters and the concentrations of NaCl solutions up to 3%. The relatively highest fresh and dry weights were recorded in pots filled with silty soil and watered with 3% NaCl solution, the means of fresh and dry weights were 1.14 and 0.24 kg pot^{-1}, respectively.

Field establishment experiment of *B. indica* was conducted in the salt affected land of the deltaic Mediterranean coast of Egypt. This land which was dominated by *Zygophyllum aegyptium* was cleared from its natural vegetation, prepared and divided into plots (35 plots, 7×7 m each). On 7 February 2011, a soil profile was dug and soil samples were collected and analyzed. The result indicate that the soil is alkaline (pH = 8.1, 8.8 and 8.9 in the surface, subsurface and bottom layers, respectively). The highest amounts of soluble salts (EC = 12 mmohs cm^{-1}) were detected in the surface layer. Salinity decreased in the middle and bottom layers to 2.5 and 1.85 mmohs cm^{-1}, respectively. The soil texture varies from sandy to sandy-loam.

On February 10, 2011, seeds of *B. indica* were sown and seated at 3-4 cm depth in the soil. Plots were irrigated with saline artesian water (total saline salts = 4851.2 ppm) at weekly intervals. After about 3 weeks, only a few seeds

Table 3: Salinity tolerance of *B. indica* plant

	Fresh water		0.5% NaCl		2% NaCl		3% NaCl		
Parameters	Silt	Sand	Silt	Sand	Silt	Sand	Silt	Sand	LSD
Height (cm)	19.7	8.50	16.4	15.4	17.1	11.2	16.2	8.40	0.27
Fresh weight (kg)	2.93	0.69	2.98	1.42	2.84	2.42	3.67	1.14	0.05
Dry weight (kg)	0.83	0.20	0.88	0.38	0.66	0.43	0.99	0.24	0.01

($p \leq 0.05$)

of *B. indica* germinated. Low germination was attributed to the non-viability of most *Bassia* seeds and/or deep sowing of seeds in the soil. Thus, sowing was repeated on March 3, 2011 by planting *Bassia* seeds at less than one cm depth. This time the germination percentages was high, most of the seeds germinated after 4 days. Growth of plants continued normally. On May 2011, after irrigation with artesian water for 11 weeks, a second profile was dug and soil samples were collected and analyzed. The results revealed that soil salinity (expressed by EC) increased from 12 to 20 mmohs cm^{-1} in the surface layer, from 2.5 to 5 mmohs cm^{-1} in the second layer and from 1.85 to 3 mmohs cm^{-1} in the bottom layer. Although associated with high air temperature, such an increase in soil salinity did not show adverse effects on the growth of *B. indica* individuals. At the end of May 2011, the plant cover of the plots was more than 80%. The plants reached their maximum vegetative growth during the July-August period, i.e summer forage production. On August 20, 2011, the height, horizontal extension and fresh weights of 20 representative bushes of *B. indica* were determined. The means of these parameters were as follow: 235, 280 cm and 8.5 kg $bush^{-1}$, respectively. Statistical assessment of the data obtained from this experiment indicates that there is a positive correlation between the vegetative yields (forage production) and the other parameters measured: height of plants and branch extension ($r = 0.55$). *B. indica* plants changed to brownish yellow during September and dried in October. The newly produced seeds could be collected during December.

DISCUSSION

The population density of the Egyptian desert is generally, low, hundreds of square kilometers may be devoid of human habitation. The reverse is true in the River Nile region which covers only less than 4% of Egypt's lands and in the same time it has very dense population that expected to be hundred millions by 2020. Thus, areas of desert vacant to-day should be habitated. Land use with shortage of fresh water in the deserts may limit agriculture and farming. Conventional crops need lot of fresh water and their cultivation in the deserts will, certainly, cause quick depletion of the ground water. Thus, trials to introduce non-conventional crops by growing desert plants capable of living by the least amount of fresh water or by sea water directly may be the possible and promising way to overcome such acute population problem.

The forage values of any plant to be good fodder for livestock, apart from being palatable and non-toxic, it must contain adequate levels of proteins, fats, carbohydrates, vitamins and mineral nutrients for satisfactory growth (Heneidy, 1996; Zahran and Willis, 2003). The palatable plant species are always over grazed due to the grazing pressure of animals particularly in the deserts (El-Shaer, 1981). However, unpalatable and less-palatable halophytes are widely distributed in the desert throughout Egypt. Factors influencing grazing and nutritive values of halophytes are: the plant species, ecotypes, stage of growth (Abd El-Aziz, 1982; El Shaer, 1986), season of use (wet season versus dry season), environmental factors (El Bassosy, 1983), and location (Gihad and El Shaer, 1994). Halophytic plants differ in their nutritive value as from one species to another.

The total protein is proposed to be an indicator of the nutritional value of plants as food for ruminants (Bryant *et al*., 1983). In the present study, the selected species contained total protein comparable with reported by Kadi (1987). Although, lipids are a concentrated source of energy, they do not constitute a major source of energy from forages (Chesworth, 1996; Henneidy, 2002). The lipid content found in the plants of the current work were similar to those reported by El-Halawany *et al*. (2008), Kadi (1987) and Zahran *et al*. (1999). On the other hand, the total carbohydrate which provides the plant itself as well as the animal by energy were, relatively, higher in the study plants than that the study of El-Shamy (1995) and relatively comparable to that study of El-Halawany *et al*. (2008), Kadi (1987) and Omar (2006). Jeroch *et al*. (1999) reported that, the optimal contents of carbohydrates for producing high quality silage is 8-10%, thus, most of the selected halophytes may considered as good species for fodder production.

The Digestible Protein (DP) of the study plants, calculated as a percentage of dry matter, was about 4.51%. With this value their forage qualities is realized as having a good protein content according to the scale suggested by Boudet and Riviere (1968). Heneidy (1986) calculated that the percentage of DP in the forage plants of the Western Desert of Egypt is about 5.4%. The Total Digestible Nutrient (TDN) is an approximate measure of the food energy available to animals after digestion (Lofgreen, 1951) and can be used as a measure of energy requirement of animals and the energy value of feeds. Abdel-Razik *et al*. (1988) reported that the annual average of TDN value was 75% DM. In the studied species, the annual average of TDN is about 57.69% DM which are comparable to those of clover (56%), barley (64%) and corn (68%) as reported by Soliman and EL-Shazly (1978). Also the results of the present study show that the concentration of macroelements (Sodium, Potassium and Calcium) in the selected species are enough for the requirements of animals which reflects the findings of Mayland and Hankins (2001).

It is worth to state here that, according to the obtained result, the six halophytes, namely: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Limoniastrum monopetalum*, *Tamarix tetragyna*, *Cressa cretica* and *Bassia indica* naturally growing in the salt affected lands of the deltaic Mediterranean coastal desert of Egypt are of high potentialities as fodder producing plants. They are rich with their nutritive values and their water requirements are low. Thus, mass production of their vegetative yields will certainly help to maintain reasonable quantities of raw materials for fodder industries.

Establishment of *B. indica* in a piece of salt affected land of the study coastal desert is actually encouraging. Vegetatively, the plant produced high amounts of fresh and dry materials and, accordingly, the extension of its cultivation in such saline non-productive land will, hopefully, change the land to be productive and secure reasonable amounts of raw materials to establish fodder industries. The establishment of the other five halophytes and even other xerophytes and halophytes in Egypt's desert could play the main role for the welfare of Egypt's people.

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