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Some Halophyte Plants of Saudi Arabia, Their Composition and Relation to Soil Properties

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Abstract: Twelve species of halophyte plants were collected from Al-Jubail, Eastern Saudi Arabia to determine their mineral composition and relationship with soil chemical composition. The soil salinity ranged between 6.80 dS m^{-1} and 43.60 dS m^{-1} in the surface (0-15 cm depth) soil and between 8.25 dS m^{-1} and 37.65 dS m^{-1} in the whole profile (0-60 cm depth) of soil. The $CaCO_3$ contents varied between 9.12 to 84.03% in the surface soil. The dominant cations and anions in soils were Na^+ and Cl^-. The available P, Fe, Cu and Mn were low in soil. The amount of Cu was in excess of toxic limits with respect to animal feed in all the plant species. Chenopods showed moderate level of crude protein (CP) than grass, sedge and rush halophytes with low CP level. Ash contents were high in all the halophyte plants with the exception of *Taverniera spartea, Sporobolus ioclados, Juncus rigidus and Cyperus conglomeratus*. A poor correlation was observed between mineral composition of soils and plants which could be attributed mainly to high soil salinity.
In conclusion, the halophyte plants showed an excellent potential not only for the development of sustainable rangelands in an arid environment but also highlighted a promising source of livestock food.

Key words: Halophytes, desert environment, soil salinity, plant composition, Saudi Arabia

Introduction

Saudi Arabia is an arid country which is located at 16° N and 32° E. Its climate is characterized by long, hot, dry summer and mild, cool and short winter. The agricultural lands of Saudi Arabia, which are coarse textured containing salts to varying degrees and mostly irrigated with saline groundwater, are not considered suitable for some of the commonly grown crops. This situation is further aggravated due to the shortage of irrigation supplies. Many researchers advocated the cultivation of some halophytes for forage production under saline soil and saline irrigation in different regions of the world (Malcolm 1969, O'Leary 1984; Modie, 1974). Besides this, encroachment by wind blown sand over agricultural lands, roads and other important infrastructure is a serious problem in desert environment (Abdulwahid, 1979; Abolkhair, 1981). Many halophyte plants of animal forage importance are found growing along seashore and inland marshes in Saudi Arabia. Information on halophyte plant communities, their composition and relationship with soil physical and chemical properties are inadequate. The main objective of this study was to gather some of this information in order to establish viable plant communities for an arid environment.

Materials and Methods

Plant samples of different halophyte plants growing in Al-Jubail, Eastern Saudi Arabia were collected from seven different locations. The plant samples consisted of new vegetative growth of plants. A total of 12 plant species were collected from seashore or at the boundaries of inland salt marshes as determined by visual observation on the basis of their abundance. The nomenclature, of plant species was according to Mandaville (1990). The description of plant species is presented in Table 1.
Soil samples from 0-5, 5-15, 15-30 and 30-60 cm depth of soil were collected in the vicinity of plant root zone. The soil samples were air-dried, passed through 2 mm sieve and stored for analyses. Soil texture was determined by hydrometeric method (Chapman and Pratt, 1961) EC_e and pH in the soil saturation paste extract, available phosphorus by modified $NaHCO_3$ method (Watanabe and Olson, 1965) Micro elements (Fe, Cu, Mn, Zn) by DTPA method (Lindsay and Norvell, 1978), potassium and sodium by flame photometer, and calcium and magnesium by AA Spectrophotometer (Perkin-Elmer, 603).
The plant samples were prepared by rinsing through tap water followed by cleaning with dilute HCl (0.1 N) and finally washing with deionized water. Then plant samples were dried at 65 °C for 48 hours to a constant weight, ground to pass through 20 mm sieve and stored for analyses. One gram of sample was digested by following the method of Issac and Kerber (1971). Phosphorus (P) was determined by vanadate-molybdate-yellow method (Chapman and Pratt, 1961), Sodium (Na) and potassium (K) were determined by flame photometer and all the other elements like Ca, Mg, Fe, Cu, Mn and Zn were determined by AA-Spectrometer, model Perkin-Elmer 603. Plant samples were also analyzed for crude protein (Kjeldahl method) ash and ether extract (A. O. A. C., 1984) and neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to the method described by Van Soest *et al.* (1991).

Results and Discussion

Soil Analysis: Description of the collected plant species are given in Table 1. These include six shrubs, two annual herbs, two perennial grasses, one perennial rush and one perennial sedge. *Seidlitzia rosmarinus, Salicornia europaea, Bienertia cycloptera, Anabasis setifera* and *Aeluropus lagopoides* were found on coastal and inland marshes, *Suaeda fruiticosa* Forssk, ex J.F. Gmel. and *Suaeda vermiculata* Forssk were found on disturbed saline sites, *Taverniera spartea* DC., *Zygophyllum qatarense* Hadidi, *Sporobolus ioclados* (Nees ex trin) Nees and *Juncus rigidus* Desf. were found on grazed/non-grazed coastal inland marshes, flat depressions and poorly drained saline ground near the coast or inland marshes. *Cyperus*

Table 1: Some botanical and ecological information on the halophyte species under study

Species	Family	Life from	Suitability for grazing and habitat
Seidlitzia rosmarinus Bunge ex Boiss	Chenopodiaceae	Shrub	Grazed, usually forms hummocks, bordering coastal and inland salt Marshes Farms extensive community in Eastern Empty Quarter.
Suaeda fruiticosa Forssk. Ex J.F. Gamel	do	Shrub	Grazed, common on distributed saline sites
Suaeda vermiculata Forssk.	do	Shrub	Grazed, common on distributed saline sites
Anabasis setifera Moq.	do	Shrub	Grazed, coastal or inland saline soils
Salicornia europaea L.	do	Annual herb	Grazed, coastal salt marshes in protected bays
Bienertia cycloptera Bunge. ex Bioss.	do	Annual herb	Grazed, coastal and inland salt marshes
Taverniera spartea DC	Fabaceae	Shrub	Grazed, flat depressions near the coast in saline soil
Zyogphyllum qaterense Hadidi	Zygophyllaceae	Shrublet	Grazed, shallow sand overlying saline soil
Aeluropus lagopoides (L.) Trin. ex Thwaites	Poaceae	Perennial grass	Grazed, edges of coastal and inland salt marshes. Also occurs in salt soils.
(*S. arabicus* Bioss) iocIados (Nees es trin's) Nees	do	do	Grazed, mostly found on poorly drained saline ground near the coast or around inland salt marshes edges.
Juncus rigidus Desf.	Juncaceae	Perennial rush	Not grazed, found in poorly drained soils near irrigation run-offs.
Cyperus conglomertus Rottb.	Cyperaceae	Perennial sedge	Grazed, found on coastal sands, but also known to occur in sand dunes far from the sea or salt marshes

Table 2: Texture and chemical analysis of soil profiles associated with collected plnat samples

Plant samples	Soil Depth	Texture	pH	Ece dSm^{-1}	$CaCO_3$%	p	Ca	Mg	Na	K ppm	Cl	Fe	Zn	Cu	Mn
Siedlteia rosmarmus	0-15	S	8.9	31.25	59.17	8.00	250	352.35	7404	379	7622	2.35	0.50	0.18	0.55
Sueada fruticosa	0-60	S	8.90	24.05	60.25	6.1	195	315.90	5956	219	5885	1.93	0.48	0.25	0.58
Suaeda vermiculata	0-15	SL	7.85	13.25	16.10	2.22	1141	346	2827	76	2996	2.48	0.60	0.45	1.75
Anabsis setifera	0-60	SL	7.93	14.09	14.36	2.43	983	307	3116	75	2995	4.48	0.51	0.38	1.41
Salicornia europaea	0-15	SL	8.75	43.60	29.68	3.69	701	9269	9269	321	14345	6.63	0.73	0.30	0.30
	0-60	SL	7.93	37.65	30.85	3.16	591	303.75	8073	277	12137	8.68	0.75	0.35	0.30
Binenertia cycloptera	0-15	S	8.9	23.75	33.95	2.95	240	510.30	5616	207	7729	2.44	0.53	0.20	0.55
	0-60	S	9.13	16.58	31.81	2.21	170	331.09	4115	144	5158	2.70	0.45	0.19	0.56
Zygophyllum qaternse	0-15	LS	9.1	19.45	21.73	1.90	511	249	4298	116	13295	2.28	0.30	0.15	0.60
	0-60	LS	8.85	13.98	24.15	1.90	325	161	3298	117	12054	2.55	0.30	0.18	0.50
Sporobolus iodados	0-15	LS	9.85	32.15	84.03	3.05	511	589	7495	962	8881	1.50	0.20	0.20	0.50
	0-60	S	9.60	17.25	84.70	2.58	313	337	3978	507	4813	1.78	0.21	0.24	0.45
Tavertniera spartes	0-15	LS	8.25	6.80	11.45	2.32	721	103	993	49	1418	2.55	0.48	0.28	0.95
Cyperus conglomeratus	0-60	LS	8.20	8.25	11.06	2.11	691	140	1487	51	7490	2.19	0.39	0.26	0.94
Aleuropus lagopoides	0-15	LS	8.35	39.95	9.12	6.00	1452	571	8158	157	13738	3.68	0.88	0.25	2.08
	0-60	LS	8.33	25.35	8.44	7.21	1076	374	5070	103	7941	3.74	0.68	0.24	1.70
Juncus rigidus	0-15	SL	7.95	24.05	12.03	1.32	771	601	4877	164	5531	1.75	0.38	0.73	1.58
	0-60	SL	7.88	15.35	12.90	1.63	736	389	2693	102	3306	4.76	0.36	0.99	1.18

*Symbols: S=Sandy, SL= Sandy Loam, LS=Loamy Sand

Table 3: Mineral Composition of halophyte plants

Species	p	K	Na	Ca	Mg	Fe	Cu	Mn	Zn
	%					ppm			
Siedlitizia romarinus	0.06	0.08	9.29	0.52	1.08	334.02	250.02	-	108.55
Suaeda rosmarinus	0.08	1.55	6.99	0.41	0.41	621.24	200.40	20.04	86.17
Suaeda vermiculata	0.06	0.16	4.43	0.38	0.34	738.52	159.68	29.94	95.8
Anabasis setifera	0.09	0.09	9.20	0.77	0.98	167.28	130.11	20.44	11.15
Salicornia europaea	0.12	1.15	11.05	0.17	0.72	263.63	244.82	35.78	24.48
Bienertia cycloptera	0.11	0.25	10.05	0.12	0.46	346.02	224.91	-	69.20
Taverniera spartea	0.08	0.64	0.04	0.19	0.14	638.29	255.31	-	-
Zygophyllumqatarense	0.10	0.77	1.64	0.07	1.64	1082.16	220.44	30.06	12.02
Aeluropus lagopoides	0.07	0.38	1.14	0.19	0.16	1053.67	218.68	-	13.91
Sporobolus iocIados	0.05	0.47	0.31	0.13	0.27	729.61	278.97	17.16	-
Juncus rigidus	0.08	0.50	0.19	0.09	0.10	278.33	178.92	23.85	87.47
Cyperus conglomeratus	0.06	1.00	0.22	0.12	0.12	1006.56	021.88	15.31	6.56

Table 4: Nutrient compostion of some halophyte plants from Al-Jubail area

Species	Dry matter	Crude protein	Neutral detergent fiber	Acid detergent fiber	Ether extract	Ash	Nitrgoen free extract
				%			
Seidilitizia rosmarinus	32.8	9.9	32.1	17.6	0.62	35.77	39.7
Suaeda fruiticosa	34.9	10.6	37.6	22.6	1.74	33.02	39.2
Suaeda vermiculata	33.2	9.8	35.6	10.1	2.36	34.97	33.2
Anabasis setifera	33.7	7.8	25.8	15.3	1.03	36.69	42.2
Salicornia europaea	18.6	6.9	26.2	13.4	1.02	44.66	36.8
Bienertia cycloptera	14.3	8.9	18.7	12.8	3.06	45.91	32.5
Taverniera spartea	51.0	7.6	48.1	43.3	1.38	8.06	45.8
Zygophyllum qatarense	31.2	7.4	30.1	24.8	3.12	26.75	44.5
Aleuropus lagopoides	68.8	4.7	63.5	41.3	2.65	34.87	36.3
Sporobolus iocIados	62.7	3.0	57.8	45.4	2.60	9.36	46.5
Juncus rigidus	43.4	5.2	79.2	47.0	1.65	6.14	44.5
Cuperus conglomeratus	59.9	3.3	65.9	44.9	1.35	9.49	54.2

Soil Tab/DAJ

conglomeratus Tottb. was found on coastal sand and also known to exist in sand dunes, far from the sea or salt marsh.

Composition of Halophyte Plants:

Macro-elements: Phosphorus concentration ranged between 0.05% (*Sporobolus ioclados*) and 0.12% (*Salicornia europaea*). The poor P contents of plants could be due to highly saline soils surrounding the plants. Because under highly saline soils, P solubility is greatly restricted resulting in poor plant uptake.

Potassium is an essential plant growth element and its availability in coastal or inland marshy lands may hinder plant growth. Potassium concentration varies between 0.08% being the lowest in *Seidlitzia rosmarinus* and a maximum of 1.55% in *Suaeda fruticosa*. The high K requirements of some of the halophyte plants may restrict their growth on coastal and inland marsh soils.

Sodium contents ranged between 0.04% (*T. spartea*) and 11.5% (*S. europaea*). It was highest than all other elements in plant material. This high level of Na in plant tissues could be due to high soil salinity in the plant growth environment.

Calcium concentration of plants ranged between 0.07% (*Z. qatarense*) and 0.77% (*A. setifera*). The plant tissue Ca contents did not correlate well with soil analyses. This might be due to high soil salinity which predominantly contains more Na followed by Ca and Mg in that order. On the other hand, plant has its own mechanism for element selectivity based on soil concentration.

Magnesium contents ranged between 0.10% (*Juncus rigidus*) and 1.64 % (*Z. qatarense*). Similar to Ca, the Mg contents of plant tissues did not relate very well with soil Mg contents.

A correlation analysis was run on data in Tables 2 and 3 to determine the relationship between soil properties and plant composition. There was no significant correlation between soil composition and the plant mineral composition. There may be several reasons for poor correlation between soil composition and the mineral concentration in plants. Since it was a preliminary study to gather information on plant composition and soil properties regarding habitats of coastal and inland salt marshes hence the results collected were presented and interpreted.

Micro-elements: Copper (Cu) concentration ranged between 167 mg kg^{-1} (*C. conglomeratus*) and 279 mg kg^{-1} (*S. ioclados*).

Manganese (Mn) concentration ranged between 15 mg kg^{-1} (*C. conglomeratus*) and 36 mg kg^{-1} (*S. europaea*).

Zinc (Zn) contents of plant tissue varied between 7 mg kg^{-1} (*C. conglomeratus*) and 109 mg kg^{-1} (*S. rosmarinus*).

Iron (Fe) contents of halophytes ranged between 167 mg kg^{-1} (*A. setifera*) and 1082 mg kg^{-1} (*Z. qatarense*).

Overall, among the different micro-elements, concentration of Fe was the highest followed by Cu, Zn and Mn in that order. This suggests a good relationship between concentration of these element in soils and plants.

Nutritional Composition of Halophyte Plants: Crude protein ranged between 3.3 and 10.6% especially in grasses, sedge and rush plants. Crude protein was particularly higher in shrubs and herbs than other plants which showed low concentration. This could be related to fiber contents of the halophyte plants where it showed an increase in direct proportion with fiber contents of plants. Fats and fatty acids were generally low in all the plants. This could be attributed to abnormal plant growth conditions. The results were comparable to those of Al-Noaim *et al.* (1991), Gihad and El-Shaer (1994). The ash contents varied between 6.14 to 45.91% in various halophytes. The higher Cl^- contents of soil helps to build up high ash contents in plants which are being grown on coastal and inland salt marshes.

All the halophyte plants contain an appreciable amount of easily available carbohydrates as determined by nitrogen-free extract. Dry matter contents of halophyte plants ranged between 14.3% in *Bienertia cycloptera* and 68.8% in *Aeluropus lagopoides*. Data shows that halophytes plant grown on highly saline media accumulated more dry matter than those grown on less saline soils and water conditions such as *Salicornia europaea* and *B. cycloptera*.

There exists a lot of potential for these halophyte plants as an animal forage. Because these plants contain different nutrient elements essential for animal feed. The only limitation could be the high salt concentration of these halophytes, but this could be minimized by mixing these plant materials with high quality forage crops.

Soil Properties: Soil texture varied between sandy to loamy soil. The soil was sandy where *Siedlteia rosmarinus*, *Sueada fruticosa* and *Bienertia cycloptera* plant species found, sandy loam under *Sueada vermiculata*, *Anabasis setifera*, *Salicornia europaea* and *Juncus rigidus* plant species and loamy sand under *Zygophyllum qatarense*, *Sporobolus ioclados*, *Taverniera spartea* a.DC., *Cyperus conglomeratus* and *Aeluropus lagopoides* plant species.

The weighted mean values for pH of soil saturation paste extract ranged between 7.95 to 9.85 for 0-15 cm depth and between 7.88 to 9.60 for 0 to 60 cm depth, The ranges for weighted mean average EC, (dS m^{-1}) of soil ranged between 6.80 to 43.6 dS m^{-1} for the surface 0-15 cm depth and 8.25 to 37.65 dS m^{-1} for 0 to 60 cm depth. The mean ranges for different mineral elements (expressed as mg L^{-1}) in the surface soil were from 240 to 1452 (Ca), 103 - 601 (Mg) 1 993- 9269 (Na), 1.50-6 6 (Fe), 0. 2-0. 88 (Zn), 0.15-0. 73 (Cu) and 0. 3-2.08 (Mn).

The chloride (Cl^-) contents of surface 0-15 cm depth of soil ranged between 1418 to 14345 mg L^{-1}. The $CaCO_3$ contents of soil varied between 9.12 to 84.03% for the surface 0 to 15 cm depth of soil indicating that the soils in this area are highly calcareous. The dominant cation was sodium and the dominant anion was chloride. This indicates typical characteristics of marsh lands.

Regression analysis was run to determine the relationship between elemental composition of soil and plants. The values of correlation coefficient (r) were low and negative for most of plant nutrients except K, Na and Ca where it was positive (Table 5).

Table 5: Values of correlation (r) indicating magnitude of relationship among different mineral contents in Soil and Plants

Mineral	Correlation Coefficient (r)
P	-0.190
K	0.085
Na	0.398
Ca	0.164
Mg	-0.199
Fe	-0.165
Cu	-0.399
Mn	-0.114
Zn	-0.242

This indicates that there was a decrease in plant uptake of nutrients with an increase in their concentration in soils. This negative relationship could be attributed to high soil salinity.

Because under high soil salinity conditions, the availability of essential plant nutrients will be less on selective basis due to the excess of other salts in the soil solution.

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