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Combating Desertification Through Sustainable Use of Saline Habitats

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Abstract: Saline habitats are one of the main factors for inducing desertification especially in arid zones. Various approaches have been taken to combat desertification. Among these, revegetation of the arid lands, using plant species that are more tolerated and adapted to stressful conditions of the salt affected deserts is probably the most effective practice owing to its affordability in combating desertification. Vegetation cover not only prevents desertification process, but also significantly improves soil and, in turn, the environmental condition of the region, since these plants can bioremediate the soil. Halophytes are particularly effective in this regard by reducing salinity level of the soil via removing the salts or by utilizing saline and low quality waters for their growth. Growing halophytes for forage production on salt-affected soil under organic fertilization was suggested as a new approach to combat desertification. Field trials were carried out at the Model Farm of National Research Centre, El Tour, South Sinai, Egypt to evaluate growth and productivityof some local and exotic halophytic plants grownunder drip irrigation system with saline water(EC: 8.7 dSm^{-1}). The tested halophytic plants were *Leptochloa fusca* (local), *Spartina patens*, *Sporobolus virginicus* (exotic). Six organic fertilization treatment were applied (control, chicken manures, cattle manures, farm waste, fresh grinded *Atriples nummularia* mixed with cerialene + phosphorene and fresh grinded *Leucaena leucocephala* mixed with cerialene+ phosphorene).Significant differences were reported for fresh cuttings and total productivity as well as nutritional values of the tested plants with superiority to chicken manures and the grinded *Atriplex nummularia* mixed with (cerialene+ phosphorene). Moreover, successive cuttings have positive impact on soil bioremediation process by decreasing of EC as well as the content of Na^+ and Cl^- in the soil. All the tested plants can tolerate cutting 5-6 times per year and capable of recovering and maintaining a productive stand *Leptochloa fusca*, *Spartina patens* and *Sporobolus virginicus* seemed to be promising halophytic plants for feeding goats and sheep in desert area by using saline water in irrigation. It can be concluded that some halophytes may be used not only as a tool for combating desertification in arid and semi-arid regions through depleting soil salts, but also offering a new salt-tolerant forage crops can grow better under organic agriculture.

Key words: Combating desertification · Saline habitats · Halophytes · Organic fertilizers

INTRODUCTION

Desertification is one of the greatest challenges facing mankind. Its extent and impact on human welfare and the global environment are now greater than ever before. Particularly, in arid regions, the rate of desertification is frighteningly high and indeed, crop production and livestock husbandry are alarmingly at high risk [1].In such circumstances, a whole mixture of initiatives should be undertaken to curtail further desertification processes. Desertification is a process of land degradation in areas vulnerable to severe edaphic or climatic aridity. This degradation leads to the reduction or destruction of the land's biological potential, to a

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deterioration of living standards and to the intensification of desert-like conditions [2]. Desertification is essentially a result of soil degradation. The direct effect of land degradation is either a decrease of land productivity or the complete abandonment of agricultural land, which leads to the food crisis confronted by arid regions [3]. Severe soil degradation may ultimately result in complete desertification, as in the case of wind erosion. The main causes for desertification include drought, deforestation, overgrazing [4].

So use of low-quality water for irrigation of some halophytic plant species will be a good solution under these circumstances. Using low-quality water imposes more stress on plants which are already under stress. Thus, there is an urgent need for finding stress tolerant plant species to survive under such stressful conditions [5]. Since halophytic plants are already growing under such conditions and are adapted to these stresses, they are the most suitable candidates to be manipulated under the minimum cultural practices and minimum inputs for use under stress [6].

One of the main strategies to combat desertification is using organic fertilizer to help in building soil layers and reduce erosion. Organic manures apart from reducing moisture losses through evaporation can also have other positive effects on soil productivity, including reducing wind and water erosion, reducing the mechanical impact of rain, hail and wind, increasing water infiltration, slowing down runoff, reducing soil temperature fluctuations, reducing weed growth, increasing seed germination and improving plant growth [7]. Organic fertilizers help in building and maintaining soil fertility primarily through their basic farming practices. They depend on multicropping systems and crop rotations, cover crops, minimum tillage to maintain and improve soil quality [8]. The natural fertilizers they use, such as green manure, farmyard manure, compost and plant residues, build organic content and increase the soil's capacity to circulate nutrients, air and water [9].

The objectives of this study were to domesticate some salt tolerant halophytic plant species under organic agriculture systems, for using salt affected arid regions, where limited water supplies coupled with saline soils result in salinity and aridity stresses.

MATERIALS AND METHODS

Field trials were carried out at the Model Farm of National Research Centre, El Tour, South Sinai, Egypt to evaluate the growth and productivity of some local and exotic halophytic plants were grown under drip irrigation system with saline water (EC: 8.7 dSm^{-1}) Table (1). Rhizomes of the tested halophytic plants *Leptochloa fusca* (local), *Spartina patens*, *Sporobolus virginicus* (exotic) were transplanted at 15th May 2015. The experiment was laid out in complete randomized Block Design (CRBD) (1.5 x 0.5 m distance between plants) i.e. 5600 plants /fed. Five organic fertilization treatments were applied (chicken manures, cattle manures, farm waste, fresh grinded *Atriples nummularia* mixed with cerialene+ phosphorene and fresh grinded *Leucaena leucocephala* mixed with (cerialene+ phosphorene) at the rate of (10 ton /h), in addition to control treatment (recommended mineral fertilization). Chemical composition of organic manures is presented in Table (2). Physical and chemical analysis of the soil site was carried out before plant transplantation and after three cuttings for each plant species, by using the standard method described by [10] (Table, 3). Three equal doses of calcium superphosphate (15.5% P_2O_5), (48.0 % K_2O) and urea (46.5% N) at the rate of 20.55 kg P_2O_5/ha., 7.92 kg K_2O/ha. and 34.72 kg N/ha., respectively were added after each cutting in the control treatment, while half of this dose were added for each organic treatment plus 10 ton /ha of the specified organic manure. Three cuttings were taken at 50 days' intervals. Three replicates were taken for each treatment to determine fresh weight as (Kg/m^2) as well as total productivity of the three cuttings (Kg/m^2). Total nitrogen percentage was determined according to [11] and the crude protein content was calculated by multiplying nitrogen percentage by 5.75 in the second cuttings. Crude fiber and ash % was determined according to [11]. The obtained results were subjected to statistical analysis of variance according to [12].

Table 1: Water analysis of Abo Kalam well, El Tour, South Sinai.

pH		7.49
EC dSm^{-1}		8.7
Soluble cations meq/L	K^+	0.5
	Na^+	69.2
	Mg^{++}	11.9
	Ca^{++}	21.6
Soluble anions meq/L	SO_4^{-}	26.6
	Cl^-	74.2
	HCO_3^-	2.4
	CO^{-}	-

Table 2: Chemical composition of organic manures

Organic Manures	pH	EC (dSm^{-1})	C/N ratio	Organic matter %	Organic carbon %	Nitrogen %	Available P (ppm)	Available K (ppm)
Cattle manures	7.29	0.34	14.88	40.67	23.64	1.98	225.2	171.3
Chicken manures	7.96	0.32	14.35	46.37	26.95	2.17	247.0	193.5
Farm waste	7.36	0.37	15.02	35.69	33.69	1.12	151.7	154.1
Grinded *Atriplex numularia* + (Cerialene + Phosphorine)	7.12	0.36	14.66	-	32.58	1.45	184.8	168.5
Grinded *Leucaena leucocephala* + (Cerialene+ Phosphorine)	7.65	0.31	14.91	-	34.6	1.32	165.3	159.8

RESULTS AND DISCUSSIONS

Bioremediation of Salt Affected Soil Through Revegetation of *Leptochloa fusca*, *Spartina patens*, *Sporobolus virginicus*: Data presented in Table (3) cleared that, K and organic carbon increased by the end of the three cuttings. On the contrary, all cations, all anions and electrical conductivity E.C. were decreased in the soil analysis after three cuttings as compared with the initials characters, this may be due to the leaching and to the accumulation of salts by *Leptochloa fusca*, *Spartina patens*, *Sporobolus virginicus,* since halophytic plants are capable of accumulating salts into their leaves' vacuoles by their salt glands. These results are in agreement with those obtained by [13]. In this concern, [14]. Indicated that there are different adaptive strategies for halophytic seedlings in organic acid metabolism under salt and alkali stress. Furthermore, [15] stated that kallar grass accomplished the best removal of salts from the soil.Numerous suggestions have been advanced to remediate the effects of salts in the soil by some halophytic plant species by their ability to mitigate salts in soil solution either by plant uptake or chemical alteration of the soil. Remediation methods as the most environmentally sustainable method in dealing with the saline-sodic conditions. In this concern, [16] hypothesized that beneficial effects of plants in reclamation are not well understood but appear to be related to the physical action of the plant roots, the addition of organic matter, the increase in dissolution of $CaCO_3$ and crop uptake of salts. They added that *Suaeda maritima* and *Sesuvium portulacastrum* exhibited greater accumulation of salts in their tissues as well as higher reduction of salts in the soil medium. Data in Table (3) cleared that, *Leptocloa fusca*, *Sporobolus virginicus* and *Spartina patens* are very useful on salt-affected soils as they can improve saline and alkaline conditions, they are good biological method for the reclamation of salt affected soils so that many commercial and forage crops can be grown. They excrete salts through specialized glands and are therefore reasonably palatable to farm animals. However, *Leptochloa fusca* surpass the other two species in soil bioremediation.

Table 3: Soil analysis of the experiment site before transplantation and after three cuttings

			After three cuttings					
	Before transplantation		*Leptochloa fusca*		*Sporobolus virginicus*		*Spartina patens*	
Soil characteristics	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
EC (m mohs/cm)	9.58	9.88	7.36	7.68	7.85	8.01	8.03	8.12
HCO_3%	3.65	4.02	3.02	3.45	3.24	3.55	3.38	3.68
SO_4%	75.35	25.65	64.36	21.35	66.31	22.34	67.89	23.95
Cl%	187.68	121.65	168.6	111.85	171.58	113.25	174.35	115.84
Ca (ppm)	75.65	35.65	69.58	31.25	70.35	32.02	71.36	32.58
Mg (ppm)	28.21	15.68	28.69	15.99	28.3	15.89	27.69	15.92
K (ppm)	0.48	0.36	0.55	0.42	0.52	0.4	0.49	0.39
Na (ppm)	155.36	47.65	129.36	39.98	135.36	43.21	141.02	44.2
pH	7.89	7.92	7.41	7.66	7.48	7.77	7.52	7.81
Organic C	3.58	3.45	5.09	4.56	5.12	4.87	5.36	4.77
Soil Texture	Sandy soil		Sandy soil		Sandy soil		Sandy soil	

Table 4: Effect of different organic treatments on fresh weight cuttings and total productivity of three halophytic plant species

Cuttings	Organic manures	Plant species: *Spartina patens* (Kg/m^2)	*Sporobolus virginicus*(Kg/m^2)	*Leptochloa fusca*(Kg/m^2)
First cutting	Control	1.30	1.38	2.00
	Cattle manures	1.28	1.35	1.94
	Chicken manures	1.35	1.43	2.14
	Farm waste	1.19	1.28	1.85
	Grinded *A. numularia*+ (Cer+ Phos)	1.31	1.41	2.01
	Grinded *L. leucocephala* + (Cer+ Phos)	1.23	1.29	1.9
	LSD 5%	0.08	0.09	0.11
Second cutting	Control	1.39	1.41	2.34
	Cattle manures	1.33	1.35	2.25
	Chicken manures	1.40	1.48	2.39
	Farm waste	1.22	1.28	2.05
	Grinded *A. numularia*+ (Cer+ Phos)	1.45	1.43	2.38
	Grinded *L. leucocephala* + (Cer+ Phos)	1.31	1.35	2.13
	LSD 5%	0.09	0.09	0.13
Third cutting	Control	1.36	1.4	2.25
	Cattle manures	1.31	1.35	2.13
	Chicken manures	1.39	1.44	2.3
	Farm waste	1.22	1.29	1.99
	Grinded *A. numularia*+ (Cer+ Phos)	1.37	1.41	2.27
	Grinded *L. leucocephala* + (Cer+ Phos)	1.25	1.3	2.08
	LSD 5%	0.07	0.08	0.11
Total productivity	Control	4.05	4.19	6.59
	Cattle manures	3.92	4.05	6.32
	Chicken manures	4.14	4.35	6.83
	Farm waste	3.63	3.85	5.89
	Grinded *A. numularia*+ (Cer+ Phos)	4.13	4.25	6.66
	Grinded *L. leucocephala* + (Cer+ Phos)	3.79	3.94	6.11
	LSD 5%	0.20	0.21	0.32

Effect of Different Organic Treatments on Fresh Weight of Three Cuttings and Productivity of the Tested Halophytic Plant Species: Application of different organic treatments significantly (0.05) affected the fresh weight of the three cuttings and consequently total productivity. This was true for the three studied halophytic plant species, regardless organic fertilization treatments with superiority to *Leptochloa fusca* over the other two plant species.As for the effect of organic treatments,in a descending order, the highest values of fresh weight for the three cuttings and their productivity were recorded under (chicken manures, *Atriplex nummularia* mixed with cerialene+ phosphorene, control (full dose of mineral fertilizers), cattle manures, fresh grinded, fresh grinded *Leucaena leucocephala* mixed with cerialene + phosphorene and finally farm waste). Similar results were obtained by [17]. This increase could be to the favorable condition as a result to addition of different organic treatments. In this concern, [18] proved that, some amendments could likely be considered for soil remediation in the salt-affected areas due to their high organic matter content. They added organic matter has several beneficial effects on agricultural fields, such as the slow release of nutrients, soil structure improvement and the protection of soils against erosion. Moreover, [19] stated that, compost (animal wastes and plant residues) decreasing EC and sodium adsorption ratios of the saturation extracts of the soils. Who added that, organic amendments co-applied with chemical amendments seemed to have a high value for reducing soil pH, soil salinity and soil sodicity. [20] Added that, farmyard manure + saline water (EC 2.25 mS•cm^{-1}), cause improvement of infiltration rate by about 89% and decreasing soil sodicity by 41.3%. They also added, decreasing soil bulk density, allowing an enhancement of soil porosity and aeration and improving saline water leaching. Furthermore, [8] stated that, mixture of green waste compost, sedge peat and furfural residue, decreasing bulk density, EC and ESP and increasing total porosity and organic carbon. They also added the combination of amendments had substantial potential for ameliorating saline soils, working better than each amendment alone. Therefore, proper selection of organic fertilizers as nutrient sources can help plants to grow better in saline habitats.

Effect of Different Organic Treatments on Nutritional Values of Three Halophytic Plants: Halophytic plant species vary considerably in their nutritive value i.e. the content of crudeprotein, crude fiber and crude ash in respond to different organic fertilization treatments as indicated in Figs (1-3). There were significant differences in the content of crude protein (CP), crude fiber (CF) and crude ash among the tested halophytic forage species. These plants attained a wide range of crude protein content (CP). However, the highest (CP) % was recoded in *Leptochloa fusca* plants treated with fresh grinded

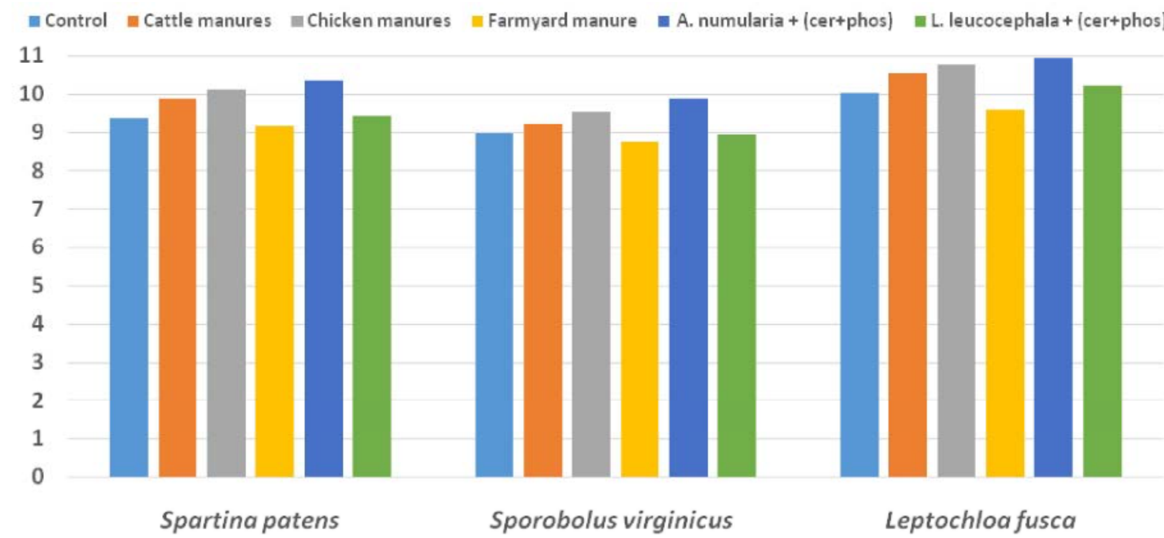

Fig. 1: Effect of different organic treatments on crude protein% of three halophytic plants. (LSD 5% = 0.98)

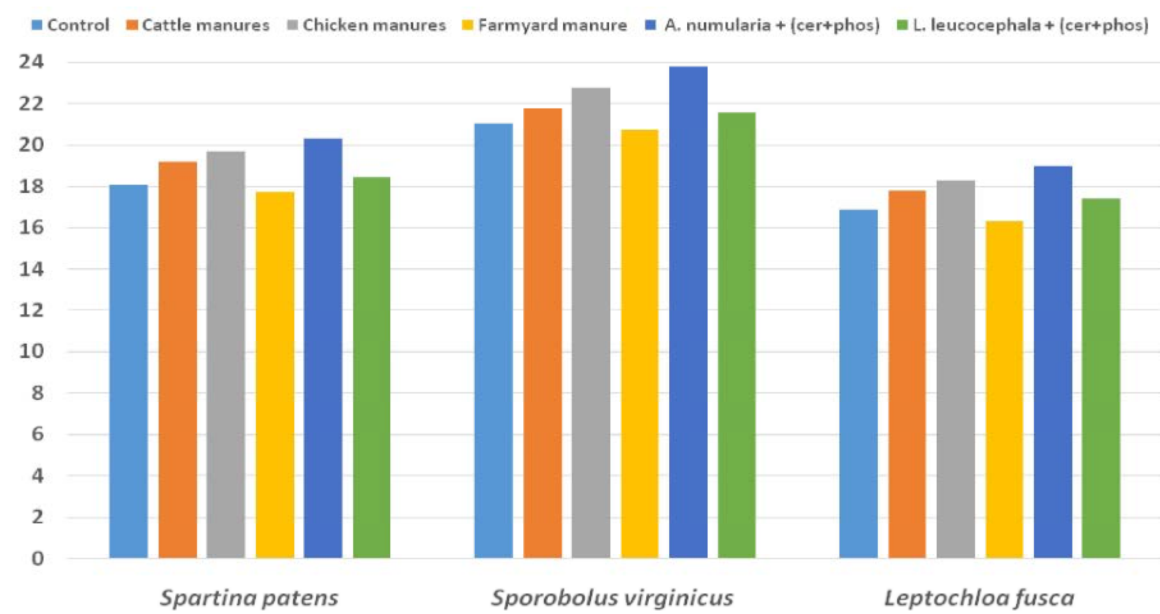

Fig. 2: Effect of different organic treatments on crude fiber % of three halophytic plants (LSD 5% = 2.14)

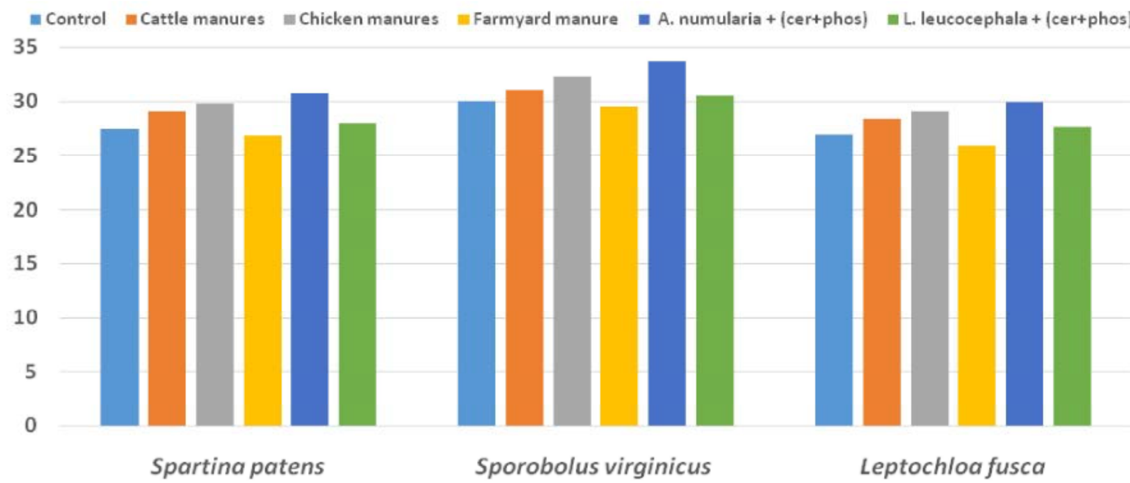

Fig. 3: Effect of different organic treatments on crude Ash % of three halophytic plants (LSD 5% = 0.2.87)

Atriples nummularia mixed with cerialene + phosphorene, while the least value amounted to 9.15% was recorded in *Spartina patens* plants treated with farm waste. These halophytic plants could be considered as good fodders because of their palatability for all animal species, in addition to their moderate content of protein. Meanwhile the highest values of CF and and ash amounted to 23.82 % and 33.70% respectively were recorded in *Sporobolus virginicus* treated with fresh grinded *Atriplex nummularia* mixed with cerialene + phosphorene, as compared with the other plant species and fetilization treatment. Similar results were obtained by [21] and [5]. Some of these plants have a considerable nutritive value which compete that of the traditional forage plants [22]. In this regards, the nutritive value of five halophytic shrubs (*Acacia saligna*, *Atreplex nummularia, Atreplex semibaccata, Atreplex halimus* and *Pasbalum distichum*) naturally grown in the Mediterranean coastal zone in Egypt was evaluated by [23]. Nutrient contents varied among all halophytic plants including. Major research topics are to identify and select plant species tolerant to salt stress by selecting and using biomarkers to characterize halophytes, to evaluate the possible use of non conventional water such saline water, to select halophytes of a potential importance in the field of human or animal nutrition [24]. Who added that, recent advances in selecting species with high biomass and protein levels and the ability to survive a wide range of environmental conditions including salinity.

CONCLUSION

Our results proved that, *Leptochloa fusca*, *Spartina patens* and *Sporobolus virginicus* plant species have excellent drought and salinity tolerance features with a great potential to be used under harsh environmental conditions. These plant species can sufficiently remediate the land to the point where native plants can re-establish. As well as the potential benefits for nature conservation and agriculture and for rehabilitation and reclamation of salt-affected soil. Moreover, could be an appropriate option for alleviating desertification problems and providing alternative good quality and economic unconventional feed materials for animals.

Organic Agriculture should be a key component of programs aimed at stopping land degradation processes and bringing degraded lands back into production. Governments, development agencies and donors should promote organic agriculture in their agricultural development efforts to reverse desertification where it has occurred and to prevent it from expanding.

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