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Halophytic Forage Plants in Response to Irrigation with Diluted Seawater

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Abstract: Biomass production and some chemical constituents of different halophytic forage grasses namely: *Sporobolus virginicus* (Dixe), *Sporobolus virginicus* (Smyrna) and *Spartina patens as exotic species,* as well as, *Leptochloa fusca* as a local species were irrigated with different diluted seawater (12.5, 25.0 and 50.0%) at the greenhouse of the National Research Centre, Dokki, Cairo, Egypt. Fresh biomass production of both types halophytic plants *Sporobolus virginicus* (Dixe) and *Leptochloa fusca* was increased due to increasing seawater concentration in irrigation water up to 50%, however *Spartina patens* and *Sporobolus virginicus* (Smyrna) gave the highest grasses production with 12.5 and/or 25.0%. Further increase in salinity level tended to increase dry grass production in *Sporobolus virginicus* (Smyrna), while the lowest record was found at local halophytic plants *Leptochloa fusca.* Proline content (μ mole/g fresh weight), as well as, crude protein (%) were much more accumulated in fresh and dry grass of *Sporobolus virginicus* (Smyrna), respectively than the other local species *Leptochloa fusca* under high salinity level. Total soluble carbohydrates (%) was only increase at low or high seawater concentration at the same species, but tended to decrease in *Sporobolus virginicus* (Smyrna) at the same condition. Increasing salinity level up to 50.0% also increased Na content and decreased K content in both types of plants.

Key words: Halophytic plants · fresh and dry biomass · proline · crude protein

INTRODUCTION

Salt tolerant plants may provide a logical alternative for many developing countries. In some cases, saline farmlands are used without costly remedial measures. The thousands of kilometers of coastal deserts and salt affected lands in the developing countries may serve as a new Agricultural land with the use of seawater for irrigation [1].

The increase of salinity in arid and semi arid lands has become a problem of great concern in agriculture. It is believed that about 7% of the total surface over the world is salt affected [2]. Egypt, like other developing countries of the arid and semi arid regions faces four major problems namely, high rate of population increase, limited natural sources of good quality water, existence of salt affected land, shortage of food and feed. Halophytes have attracted the attention of several workers, a number of plant species have been screened for their productivity and/or nutritional potential when irrigated with saline water and even diluted seawater [3, 4]. Some halophytic plants have been demonstrated as potential forage plants [1, 5].

The main objective of this study was to evaluate the effect of different concentrations of diluted seawater on the biomass production and chemical composition of some halophytic plants grown in the greenhouse, Egypt.

MATERIALS AND METHODS

A greenhouse experiment was carried out from Feb. 2004 to July 2005 in the Greenhouse of National Research Centre, Dokki, Cairo, Egypt in order to investigate the effect of irrigation with different concentrations of diluted seawater on biomass and chemical composition of some halophytic forage plants. The tested grass species were *Leptochloa fusca* (L.) (Kunth) as a local species; *Spartina patens* (Aiton) Muhl, *Sporobolus virginicus* (L.) Kunth (Smyrna smooth) and *Sporobolus virginicus* (Dixe coarse) as exotic species. Rhizomes of *Leptochloa fusca* were collected from the wetland of Qaroun Lake Coast, Fayoum Governorate, Egypt. The rhizomes were transplanted in February 2004 at the greenhouse. *Spartina patens*, *Sporobolus virginicus* (Smyrna) and *Sporobolus virginicus* (Dixe) were kindly supplied from Prof. John. L. Gallagher,

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Table 1: Physical and chemical properties of the soil used

Characters	Value
Sand (%)	94.6
Silt (%)	3.7
Clay (%)	1.7
Texture	Sandy
pH	8.5
E.C (dSm^{-1})	1.3
Ca CO_3 (%)	1.6

Table 2: Chemical analysis of the diluted seawater used for irrigation in the greenhouse

	Seawater concentration (%)		
Characters	12.5	25.0	50.0
pH	8.0	8.0	8.0
TDS ($mg\ L^{-1}$)	6.0	13.5	25.5
Na ($mg\ L^{-1}$)	1910.0	3660.0	7180.0
K ($mg\ L^{-1}$)	54.6	117.0	217.0
Ca ($mg\ L^{-1}$)	96.0	160.0	252.0
Mg ($mg\ L^{-1}$)	216.0	420.0	806.0
HCO_3 ($mg\ L^{-1}$)	597.0	683.0	767.0
Cl ($mg\ L^{-1}$)	3690.0	7460.0	13490.0

Table 3: Effect of irrigation with diluted seawater on fresh biomass of some halophytic forage plants grown in the greenhouse (kg/ m^2 /month)

	Seawater concentration (%)			
Species	12.5	25.0	50.0	Mean
Sporobolus virginicus (Dixe)	1.109	1.044	1.145	1.099
Sporobolus virginicus (Smyrna)	1.444	1.389	1.185	1.339
Spartina patens	0.887	0.736	0.624	0.749
Leptochloa fusca	0.584	0.588	0.635	0.602
Mean	1.006	0.939	0.897	

LSD 5%: Species 0.195, Seawater 0.093, Species x Seawater NS

University of Delaware, Lewes, USA since 1992. The rhizomes of these grasses were first transplanted in pots under greenhouse conditions. These grasses were retransplanted in Feb. 2004 in the plastic flats (50 x 25 x 25 cm) filled with 40 kg sandy soil. The analysis of soil used was carried out following the methods described by Jackson [6] and data presented in Table 1.

Three salinity levels of diluted seawater being 12.5, 25.0 and 50.0% were used for irrigation. Potable water available in the experimental site was used to dilute seawater in order to get water with different salts concentrations. Chemical analysis of the diluted seawater used in irrigation water was carried out according to the procedures applied by the US Salinity Laboratory Staff [7] and results are presented in Table 2.

Several cuttings were taken from all tested species during 12 months. Fresh and dry weights of the biomass were estimated in kg m^{-2}, two species from the four grasses *Leptochloa fusca* as a local and *Sporobolus virginicus* (Smyrna) as exotic species were chosen to determine samples from the crude protein and total soluble carbohydrates % using the methods of A.O.A.C. [8]. Proline content in fresh shoots (μ mole/g fresh weight) was estimated according to Bates *et al.* [9]. Sodium and potassium contents in dry shoots powder were also estimated using Flamephotometer apparatus.

The obtained data were statistically analyzed in factorial experiments in complete randomize according to Snedecor and Chocran [10] and the treatments means were compared using LSD test and 5% of probability.

RESULTS AND DISCUSSION

Table 3 shows that fresh biomass of different halophytic forage plants grown in the greenhouse was affected by irrigation with different diluted seawater concentrations. Fresh biomass production of both halophytic grasses namely *Sporobolus virginicus* (Dixe) and also local species *Leptochloa fusca* was increased due to increasing the concentration of seawater in irrigation water from 12.5 up to 50.0%. However, *Sporobolus virginicus* (Smyrna) and *Spartina patens* produced the highest amount of fresh grasses when irrigated with 12.5 or 25.0% of seawater and a slightly decrease was recorded by increasing salinity level up to 50.0%. Further increase in salinity levels in irrigation water tended to decrease the fresh weight of the halophytic grasses. The stimulatory effect of moderate salinity on the growth of some halophytic plants was reported by Ashour *et al.* [5]. This may be also attributed that to the low plant growth which it's adversely affected of a specific ion concentration exceeds their thresholds and become toxic. Salts may be also reducing plant growth by reducing the water potential or by interfering with nutrient uptake. In general, the halophytic plants used seem to be more tolerating to increasing the seawater concentration in irrigation water up to 50%, then *Sporobolus virginicus* (Smyrna) produced more fresh biomass at low and/or moderate salinity levels, while *Leptochloa fusca* and *Spartina patens* had the lowest fresh biomass when irrigated with high level of salinity.

Data in Table 4 show that the dry weights of some halophytic plants were significantly affected due to irrigation with diluted seawater. *Sporobolus virginicus* (Smyrna) had the highest dry mass of grasses under all seawater concentrations as compared with the other species. On the other hand, *Leptochloa fusca* recorded the lowest value at 12.5 or 25.0% of seawater, whereas increasing seawater concentration up to 50.0% did not

Table 4: Effect of irrigation with diluted seawater on dry biomass of some halophytic forage plants grown in the greenhouse (kg/ m^2 / month)

	Seawater concentration (%)			
Species	12.5	25.0	50.0	Mean
Sporobolus virginicus (Dixe)	0.500	0.443	0.538	0.494
Sporobolus virginicus (Smyrna)	0.684	0.690	0.581	0.652
Spartina patens	0.387	0.315	0.230	0.311
Leptochloa fusca	0.227	0.244	0.267	0.246
Mean	0.450	0.423	0.404	

LSD 5%: Species 0.087, Seawater NS, Species x Seawater 0.101

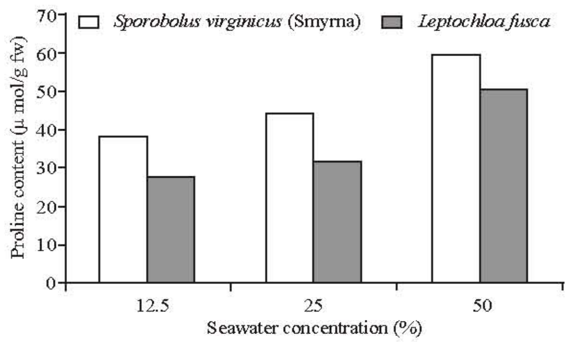

Fig. 1: Effect of irrigation with diluted seawater on proline content of two halophytic plants

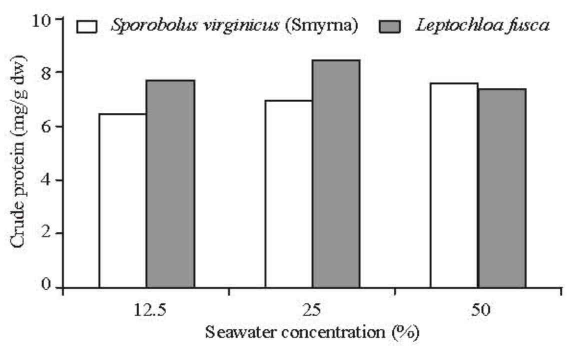

Fig. 2: Effect of irrigation with diluted seawater on crude protein of two halophytic plants

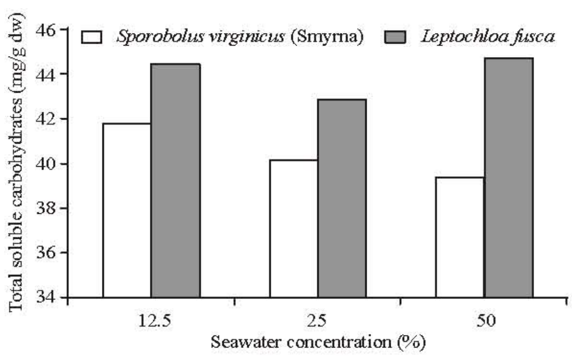

Fig. 3: Effect of irrigation with diluted seawater on total soluble carbohydrates of two halophytic plants

significantly affect the dry weight of biomass. Ashour *et al.* [1] and Abdullah *et al.* [11] supported these results. In general, *Sporobolus virginicus* (Smyrna) seem to be producing the highest amount of dry grasses followed by *Sporobolus virginicus* (Dixe) and the lowest amount was recorded by the local species *Leptochloa fusca*.

Figure 1 shows the proline content in the fresh grasses of the two halophytic plants. Proline accumulation in the leaves of two halophytic species were increased by increasing seawater concentration in irrigation water up to 50%, however, the exotic species *Sporobolus virginicus* (Smyrna) accumulated more proline in their leaves under all salinity levels in comparison to other local species *Leptochloa fusca*. This means that *Sporobolus virginicus* (Smyrna) seem to be more tolerate to salt stress than that of the local species. In general the phenomenon of free proline accumulation in plants exposed to diverse environment stresses has considerable eco-physiological significance. Proline has also been known to accumulate in the leaves of many higher species subjected to salt stress [12].

According to Greenway and Munns [13], the response of different plants to salt stress depends on the degree of their tolerance, as well as, type level and duration of osmotic substrate. Also Delauney and Verma [14] indicated that the proline over production during salt stress is assumed to be very important because it is recognized that it influences not only the osmotic potential but also minimizes the effect of salt damage.

Figure 2 illustrated that crude protein of *Sporobolus virginicus* (Smyrna) was increased with increasing seawater concentration in the irrigation water up to 50%, but in other species *Leptochloa fusca*. Protein % was only increased when it irrigated with 25.0% seawater. These results are supported by Ashour *et al.* [5]. In this concern Leigh [15] stated that the increase of salinity resulted in a high crude protein content of several halophytic plants.

Figure 3 illustrated that the total soluble carbohydrates were increased at low and / or high salinity concentrations in local species, however in other exotic species tended to decline at high level of salinity. The increase of total soluble carbohydrates with increasing salinity was reported by Munns and Termaat [16]. The metabolism of carbohydrates in plants is affected by a general increase in salinity, as well as by the type of ions present, however the level of soluble sugars deceased with increasing in salinity [17].

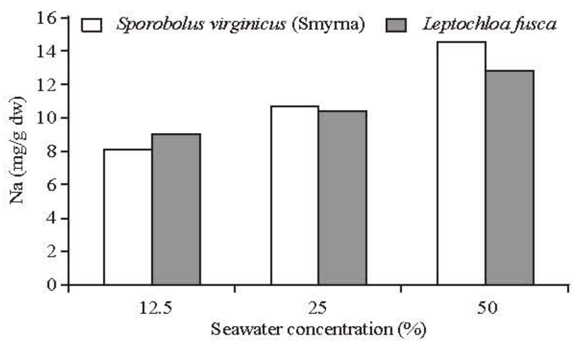

Fig. 4: Effect of irrigation with diluted seawater on Na content of two halophytic plants

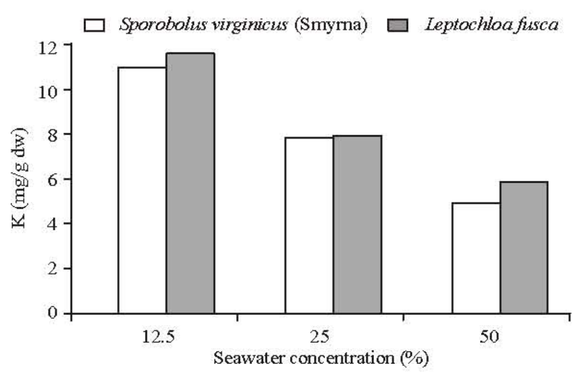

Fig. 5: Effect of irrigation with diluted seawater on K content of two halophytic plants

Figure 4 shows that increasing salinity concentration in irrigation water from 12.5 up to 50.0% tended to increase of Na^+ content in dry grasses in both halophytic plants used. On contrast Fig. 5 illustrated that an opposite trend in K content, it was decreased gradually due to increasing the salinity level in both species. Harvey *et al.* [18] found that a large accumulation of Na^+ in the vacuole of *S. maritima* grown in the presence of 350 mM NaCl. At the same time, halophytic plants such as *S. maritima* that accumulate of Na^+ decrease K^+ content with increasing external salt concentration without concomitant damage. The decrease seems to be related to the replacement of vacuolar K^+ and with Nå [19].

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