The potential of salt-tolerant plants and marginal resources indeveloping an integrated forage -livestock production system

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Introduction

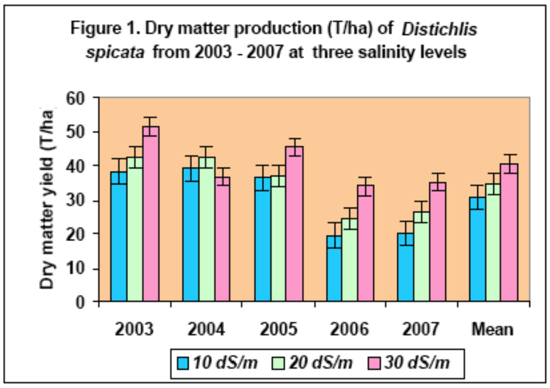
The increased demands on agricultural products, particularly in developing countries, are growing so quickly that the land and water resources are unable to sustain them. In most developing countries, prime farmland and fresh water are already fully utilized. Maximizing the efficiency of resources utilization and finding alternative resources to support agricultural production are becoming a priority in many developing countries. In arid environments resources are very limited, therefore marginal land and water resources have been used extensively. However, the extensive use led in most cases to degradation and depletion of such resource s. One of the main reasons for failure is the adoption of conventional production systems on marginal environments. M any arid and semi -arid regions in the world contain soils and water resources that are too saline for most of the common conventional crop systems (Pitman and Lauchli, 2002). An alternative approach to the use of saline water and soil resources is the use of non-conventional plant production systems. However, the challenge in this case is the identification of economic and sustainable methods for the use of such plants. Salt -tolerant plants and halophytes can utilize land and water unsuitable for conventional systems for the economic production of food, fodder, fuel, and other products (Masters et al, 2007). Arid environment also characterized by the existence of extensive coastal deserts where only seawater or highly saline water and sandy soils are available. Halophytes grown in such desert environments showed levels of biomass and seed production comparable to conventional crops (Galvani, 2007). The use of such marginal resources for the development of salt-tolerant plants -livestock production systems can provide a feasible and economic option (Glenn and Watson, 1993). Many non-conventional plant species were demonstrated to have good growth potential and economic production under high saline conditions (Masters et al, 2007). In the arid Near East and North Africa region (WANA) many salt -tolerant species have been identified with potential for economical use (Alhadrami et al., 2003, Gihad and El Shaer, 1994), however the evaluation of such plants on a large -scale under irrigation with water of high salinity for forage production and animal us are very limited. This work aims at the long-term evaluation of the productivity and sustainability of forage production systems that are based on the use of non -conventional salt-tolerant grasses, *Sporobolus virginicus* and *Distichlis spicata,* in marginal environments with highly saline water resources.

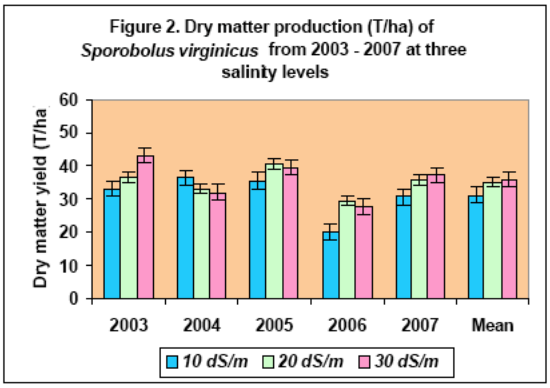
Materials & methods

The two grass species, *Sporobolus virginicus* and *Distichlis spicata* were selected based on previous evaluation of their salinity tolerance, nutritional value, suitability for mechanical harvesting and handling for economical large-scale production. Thee two species were established in 2 001/02 on a 0.6 –hectare field for research and demonstration at ICBA's headquarters in collaboration with the United Arab Emirates in Al -Ain (UAEU). Differe nt combinations of management inputs were applied to determine optimum production packages. They include three salinity levels (10, 20 and 30 dS/m), three irrigation levels (ET_0, 1.5 x ET_0 and 2 x ET_0) and four fertilizer levels: F1= 0 fertilizer added, F2= NPK at 20 -10-10 units, F3= NPK at 40 -20-20 units and F4= NPK at 60 -30-30 units. Minimum plot size for each treatments combination was 24 m^2, with three replications. Irrigation was done with a micro sprayer system. Treatments arranged in a split plot design where salinity is the main plot and species, irrigation, salinity and fertility levels are the sub-plots. Prior to mechanical field harvest and baling, three 0.5 m^2 samples were taken from each treatment to estimate dry matter production under each combination of the treatments mentioned above. Statistical analyses were performed on the data. Each salinity level was mechanically harvested and baled. Selected harvests were chemically analyzed for quality estimation. Soil and irrigation water salinity were monitored by periodic sampling and by an automated soil salinity monitoring system. Produced forage materials used in sheep and goat feeding trials at UAE University Research Farm. A total of 40 male and female indigenous or exotic lambs or goats were used in each of the different feeding trials evaluated in this project. The animals were randomly and equally assigned to four deity treatments, which were initially formulated to have 100, 70, 30 or 0.0% Sporobolus grass hay, in a replacement series with the conventional forage Rhodes grass commonly used in the region. The feed was provided free of choice and a mineral block was placed for each group. The total weight of the feed offered, adjusted for refusal and wastage, provided an estimate of the average hay consumed by each group per day throughout the study. The animals had free access to water and the volume of water offered each time was recoded daily and the remaining was recorded on the following morning. Daily water intake, corrected for losses, provided an estimate of the average water intake per day for each group. The following measurements were recorded or calculated: average daily gain (ADG, g/day); dry matter intake (DMI, g/day); feed conversion ratio (FCR) and water consumption per unit feed intake (l/kg).

Results & discussion

A total of 17 cuts were completed. Large scale field dry yields achieved in both *S. virginicus* and *D. spicata* in each cut were in the range of 12 -13 tones per hectare for a total of 35 -40 t/ha/year. Yield under all salinity levels were highest during the first year where it reached up to 45 t/ha in *S. virginicus* and 50 t/ha in *D. spicata*. Although yield declined afterwards, maximum yield after five seasons remained in the range of 30 -40 t/ha for both species (Figures 1 & 2). Average dry matter production over five seasons ranged from 30 -40 t/ha in *D. spicata* and 30 -36 t/ha in *S. virginicus.* Yield increased with the increase in salinity level in both species (Figures 1 & 2). However, the trends in *D. spicata* were more evident, whilein *S. virginicus* maximum growth was achieved at 20 dS/m in many cuts. Increase in biomass production in *S. virginicus* with increase in salinity levels were also documented by Bell and O'Leary (2003).





Figs 1&2. Dry matter production of *Distichlis spicata* and *Sporobolus virginicus* from 2003-2007

Seasonal variations in yield were observed for both species. Highest yield were obtained during summer and fall harvest and lower yields during spring harvest (winter growth). Low temperature in winter limits considerably the growth in both species. Dry matter yield based on sampling from the field prior to each harvest were similar to the large scale yields described above.

Influence of the different levels of fertility, irrigation and salinity on yield

Yield in *S. virginicus* and *D. spicata* respond positively to increased fertility levels. However, the impact was minimum at the low salinity and became very significant at higher salinity levels (data are not shown). At the medium salinity, *S. virginicus* yield increased by 5 tones/ha between the low fertility level (F0) and the highest level (F4). In *D. spicata* the impact was highest at the high salinity level, at which yield increased by nearly 4 tones/ha at the high fertility level in comparison with the low one. Influence of different irrigation levels was less significant in comparison with nutrient levels (data are not shown). *S. virginicus* yields were higher at the low and medium irrigation levels (ET_0 and 1.5 ET_0) in comparison with the high level (2 x ET_0), while *D. spicata* yields were higher at the medium and high irrigation levels. It is concluded that for *S. virginicus* medium fertility and irrigation levels are optimum for yield under al l salinity levels, while in *D. spicata* higher irrigation and fertility the optimum combination for higher yields particularly at high salinity levels.

Forage quality

Analysis of basic forage quality traits in both species included: crude protein percentage, ash contents, NDF and ADF. Results showed that crude protein percentage increased with the increase in fertility in both Distichlis and Sporobolus and reached 7.7% (Table 1). Ash percentage also increased with fertilizers application; however it stayed within a modest level of 10 to 11 % even at the high salinity level. Such values are comparable with conventional crops grown under normal conditions . Similar to seasonal variations in yield, protein and ash contents vary with the season. Lower levels associated with higher biomass production.

Table 1. Effects of fertility level on mean crude protein and ash percentages in *Sporobolus virginicus* and *Distichlis spicata* (values are means over three salinity levels)

CP %					
Species	F1*	F2	F3	F4	Mean
Sporobolus virginicus	6.4	6.6	7.6	7.7	7.1
Distichlis spicata	6.6	7.1	7.5	7.7	7.2
Ash %					
Sporobolus virginicus	9.7	9.9	10.3	10.1	10.0
Distichlis spicata	10.0	10.7	10.7	11.1	10.6

* F1= 0, F2= NPK at 20 -10-10 units, F3= NPK at 40 -20-20 units and F4= NPK at 60 -30-30 units

Increase in salinity level led in general to increase in crude protein and ash percentages, while ADF and NDF % were not affected by salinity level (Table 2). Values of both ADF and NDF were similar to the values reported for the conventional Rhodes grass , commonly used in the region (Al hadrami et al. 2003).

In general halophyte plants are characterized by high accumulation of minerals in the above ground tissues which limit their use in animal feeding, particularly as the sole source of forages. The relatively low ash contents in *S. virginicus* and *D. spicata* make the two species similar in quality to many conventional forage plants and consequently make them an attractive alternative.

Table 2. Effects of salinity level on some nutritional values in *Sporobolus virginicus* and *Distichlis spicata* (values are means over four fertility levels)

Salinity dS/m	Dry Matter %	Crude protein %	ADF%	NDF%	Ash%
		Sporobolus virginicus			
10	94.4	6.3	35.2	73.9	10.0
20	94.6	6.5	35.9	75.0	9.2
30	94.5	8.5	34.7	73.0	10.8
		Distichlis spicata			
10	94.4	6.8	36.3	74.5	10.6
20	94.4	6.4	36.2	74.7	9.6
30	94.3	8.4	35.4	72.5	11.7

Feeding trials

As described in the materials and methods, several feeding trials were performed on indigenous and exotic lamb and goat strains using each species in combination with conventional forages. A representative example will be shown here. In general no health problem was noticed throughout the study in all treatment groups. Animals fed 70% Sporobolus or Distichlis performed much better than those animals in the other groups fed either high or low portion or fed only Rhodes grass. Average daily gain did not differ significantly ($P>0.05$) between the two groups at all stages (Table 3). In addition, there was no significant difference (P> 0.05) between birth weight of dams and those of their offspring in both treatment groups. Animals fed the slat -tolerant forages consumed 20% more forage compared to the control group. Body composition and meat: fat: bones ratios were better (or similar) in animals fed 70 % salt-tolerant forages in comparison with the animals fed 100 % conventional forages (data not shown).

Table 3. Least square means (± SE) of growth rate and feed efficiency in indigenous sheep lambs fed different levels of Sporobolus grass.

Item	Treatment			
	0.0% Sporobolus	30% Sporobolus	70% Sporobolus	100% Sporobolus
Initial body weight (Kg)	14.05±1.292	14.50±1.245	14.25±1.33	14.30±1.133
Final body weight (Kg)	21.7±1.579	22.6±1.496	22.95±1.826	22.35±1.616
Average daily gain (g)	121.43±11.101	128.57±10.095	138.09±12.019	127.78±12.657
Body weight gai n (Kg)	7.65±0.699	8.1±0.636	8.7±0.757	8.05±0.797
Feed conversion ratio	6.9±0.613	6.9±0.483	6.6±0.358	7.5±1.744

Values in rows with different litter s are significantly differ ent (P < 0.05).

Conclusions

The long-term field evaluation of the productivity of two non -conventional highly salt -tolerant species, *S. virginicus* and *D. spicata ,* showed that, when managed properly, the two species has the economic and environmental potential of using them in an integrated forage -livestock system particularly in marginal environments with low quality soil and water resources. Many coastal and sub -coastal areas in arid desert have ample saline water resources, but their use is limited due to lack of suitable plant species that can be productive under such conditions. The system which has been evaluated for over five years prove that such an opportunity exists. Currently the two grasses are widely evaluated in several places in coastal environments in the Arabian Peninsula.

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