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EVALUATION OF FORAGE QUALITY AMONG COASTAL AND INLAND GRASSES FROM KARACHI

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Abstract

Four grasses (coastal: *Aeluropus lagopoides* & *Sporobolus tremulus*, and inland: *Paspalum paspalodes* and *Paspalidium geminatum*) were evaluated for biomass production, mineral composition and forage quality under optimal non-saline conditions. Vegetative shoots were collected from natural populations and allowed to grow under ambient environmental conditions for about six weeks. Forage quality parameters included neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), dry matter digestibility (DMD), and metabolizable energy (ME). Coastal species had higher ADF and crude protein values in comparison with inland species whereas, DMD were highest in *Paspalum paspalodes* followed by *Sporobolus tremulus*, *Paspalidium geminatum* and *Aeluropus lagopoides*. Estimated metabolizable energy (ME) was highest in *Paspalum paspalodes* with similar values in other test species. *Sporobolus tremulus* had the highest sulphur (1.42%) while the other three species had considerably lower values ($\leq$ 0.45) which are within acceptable fodder limits for ruminants. Inland grasses (particularly *Paspalum paspalodes*) appeared to be better forage species producing higher biomass, DMD, ME and crude protein and low ADF and S than the coastal ones. However, with careful rationing all test species could be used as supplementary fodder for livestock.

Introduction

Global population is expected to reach 9.3 billion by 2050 with about 4% or 335 million in Pakistan alone. However, crop production cannot keep pace at the same rate as increasing population, poverty and decreasing arable land (Anon., 2001). Cost of food items increased by 28% in 2009 with ~85% Pakistanis living on less than two dollars per day (Anon., 2004). Naturally occurring inland and coastal salt tolerant grasses have considerable potential as low cost non-conventional fodder crop particularly C_4 grasses with high nutritive value (Khan *et al*., 2009; El-Shaer, 2010). About 68 halophytic grasses occur in Pakistan with 18 species along the coast (Khan & Qaiser, 2006). Halophytic grasses exhibit considerable variation in growth (Chen *et al*., 2009; Gulzar & Khan, 2006) and appear to have high nutritive value even under stressful conditions (Grattan *et al*., 2004; Robinson *et al*., 2004). *Thinopyrum ponticum* showed higher (85%) relative yield than conventional forges such as alfalfa (43%) when irrigated with saline water (Suyama *et al*., 2007). *Panicum turgidum* was found to be a promising fodder alternative to maize and could produce considerable biomass with brackish (~10 dS/m) water irrigation. However, monitoring of anti-nutritive factors such as toxic levels of S, Mo and lignin (Arzani *et al*. 2006, Arzani, 2008; Abd El Rehman, 2008) in plant tissue and of Se, B and NO_3-N in irrigation water and soil (Suyama *et al*., 2007) also need to be considered. Since field studies on forage quality are difficult to manage laboratory studies have been carried out by many workers.

Nutritive value parameters of forage species such as metabolizable energy (ME) appear to depend strongly on plant maturity (Minson, 1990) and better ME values and digestibility of some salt tolerant forage grasses appeared to be linked to their potential for slower growth among young plants (McDonald *et al*., 1995). High ADL and ADF have been considered as the most important livestock constituents for the selection of forage plants for quality and digestibility (Van Soest & Jones, 1994; Le Houerou, 1993; 1994). Successful growth and biomass production of potential forage species on saline soils would depend on the regulation of salt balance, its ability of osmotic adjustment and maintenance of favorable water potential (Nedjimi, 2009). Little data is available on the comparative growth and nutritive value among coastal and inland grasses of Pakistan.

The present study aims to evaluate the growth and nutritive potential of two coastal [*Aeluropus lagopoides* (Linn.) Trin. Ex Thw. and *Sporobolus tremulus* (Willd.) Kunth.] and 2 inland [*Paspalum paspalodes* (Michx.) Scribner and *Paspalidium geminatum* (Forssk.) Stapf.] grasses under non-saline conditions. It was assumed that in the absence of salinity 1) coastal grasses will exhibit lesser growth than inland ones and 2) nutritive value of coastal grasses will also be better than the inland species due to slower growth.

Materials and Methods

Ramets of the inland grasses *Paspalum paspalodes* and *Paspalidium geminatum* were collected from Korangi industrial area (24^0 51’03.2 N; 67^0 05’60.4 E) and Malir River Karachi (24^0 49’ 41.1N; 67^0 05’ 54 E) respectively, and of the coastal grasses *Aeluropus lagopoides* and *Sporobolus tremulus* from Sandspit (24^o 49’06. 70” N; 66 ^{o} 56’06. 80” E). Plants were grown in plastic pots (26 x 20 cm) containing thoroughly washed coastal dune sand and placed in 2 L plastic trays for sub-irrigation with half strength Hoagland solution (Epstein, 1972). Pots were flushed with nutrient solution every week and trays were replenished with fresh nutrient solutions which were maintained to constant 2 L volume with tap water. Plants were cut at 15 cm above soil surface and initial biomass (fresh and dry) of five individual plants was recorded which were then allowed to grow for about 6 weeks. Plants were harvested and soil particles adhering to roots were thoroughly cleaned with the respective nutrient solution and then with tap water. Plant material was separated into above-ground and below-ground parts and dried to constant weight in a micro-wave oven alongside a half filled beaker of water for 15 to 20 min (Popp *et al.*, 1996). Growth parameters such as height, fresh and dry biomass were also measured. Hot water extracts were prepared by boiling 0.5 g dry shoot and root in 10 ml of de-ionized water to determine Ca^{++} and Mg^{++} by atomic absorption spectrometry (Perkin Elmer, USA). Ash content was determined by AOAC 923.03 method after igniting dried plant material in a muffle furnace at 550°C for 3 h (Anon., 1990).

Nutritive value: Acid digestible fiber (ADF), Neutral digestible fiber (NDF) and Acid digestible lignin (ADL) were determined according to Van Soest *et al.*, (1991). N and S were analyzed by CNS Analyzer (Elementar Vario EL III).

Crude protein (CP) was calculated as
CP = Total nitrogen (N) x 6.25 [Newman *et al.*, 2003]

Dry matter digestibility (DMD) was estimated by and calculated as
DMD% = 83.58 – 0.824 ADF% + 2.626 N% [Oddy *et al.*, 1983]

Digestible energy (DE) was estimated as follows:
DE (kcal / kg) = 0.27 + 0.0428 DMD% [Fonnesbeck *et al.*, 1984]

Metabolizable energy (ME) was calculated as:
ME (Mcal / kg) = 0.821 x DE (Mcal / kg) [Khalil *et al.*, 1986]

All values of proximate analysis and cations are expressed on percent dry biomass basis. Variation in growth and chemical composition among the four test species was subjected to one-way ANOVA while individual means compared by post-hoc Bonferroni test. Pearson's Rank Correlation was performed between ADF and DMD and between ADL and DMD. All statistical analyses were carried out by SPSS for Windows Ver. 11.0 (Anon., 2001).

Results

Growth parameters: A one-way ANOVA showed significant differences in plant biomass (F value = 40.3; p<0.001) and shoot height (F = 74.69; p<0.001) among the four test species with highest dry biomass in *Paspalum paspalodes* (35 g/pot). In general, inland grasses had higher dry biomass and shoot height (Figs. 1 a & b).

Fiber: NDF varied significantly (F = 4.77; p<0.001) among test species. *Aeluropus lagopoides* had the highest NDF (69%) followed by *S. tremulus* (63%) and *P. paspalodes* (61%) and lowest in *P. geminatum* (55%) (Table 1). ADF also varied significantly (F = 37.11; p<0.01) among test species with higher values in the coastal species *A. lagopoides* (34%) and *S. tremulus* (35%) than the inland *P. paspalodes* (24%) and *P. geminatum* (33%) (Table 1). Although ADL varied significantly (F = 21.70; p<0.001) among the test species but did not follow the same trend as that of ADF. *Paspalidium geminatum* had highest ADL (59%), followed by *A. lagopoides* (10%), *S. tremulus* (5%) and *P. paspalodes* (2%) (Table 1).

Chemical composition: Considerable (F = 40.73; p<0.001) variations were noted for CP among species with higher values in the coastal species *S. tremulus* (15%) and *A. lagopoides* (9%) than the inland *P. paspalodes* (5%) and *P. geminatum* (8%) (Table 1). DMD also varied significantly (F = 16.01; p<0.001) with highest values in *P. paspalodes* (66%) followed by *S. tremulus* (61%), *P. geminatum* (60%) and *A. lagopoides* (59%) (Table 1). One way ANOVA showed significant differences (F = 15.6; p<0.001) in ME with highest values in *Paspalum paspalodes* (2.53 Mcal Kg^{-1} dry biomass) (Table 1). A negative correlation was found between DMD and ADF (r^2 = 0.92) and also between ADL and DMD (r^2 = 0.72).

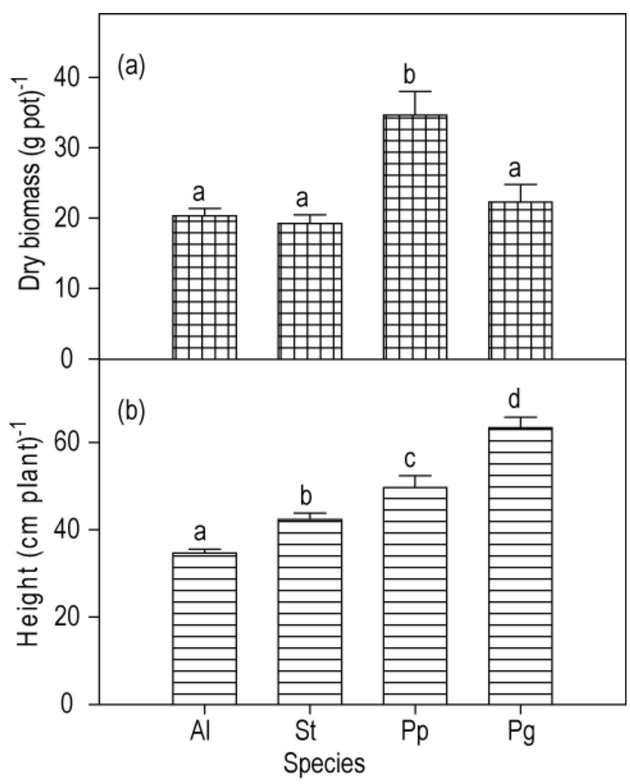

Fig. 1. Height (a) and dry biomass accumulation (b) among coastal (*Aeluropus lagopoides* = Al, *Sporobolus tremulus* = St) and inland (*Paspalum paspalodes* = Ps and *Paspalidium geminatum* = Pg) forage grasses. Bars represents means ± s.e. (n = 3). Similar letters show non-significant differences among species (Bonferoni test).

Table 1. Mean neutral detergent fiber (NDF), acid detergent fiber (ADF), acid digestible lignin (ADL), crude protein (CP), dry matter digestibility (DMD), metabolizable energy (ME) and ash among coastal (*Aeluropus lagopoides*, *Sporobolus tremulus*) and inland (*Paspalum paspalodes*, *Paspalidium geminatum*) forage grasses. Values are means (n = 3) on dry biomass basis. Similar letters show non-significant differences among species by one-way ANOVA.

Species	NDF (%)	ADF (%)	ADL (%)	CP (%)	DMD (%)	ME (Mcal/kg)	Ash (%)
A. lagopoides	69.03a	34.32a	10.00a	9.08a	59.11a	2.30a	5.51a
S. tremulus	62.46b	34.60a	5.39b	15.02b	61.38a	2.38a	5.91a
P. paspalodes	61.33b	24.33b	1.67c	5.38c	65.79b	2.53b	5.80a
P. geminatum	55.33c	32.67a	10.67a	8.19a	60.11a	2.33a	10.82b

Ash content: Significant ($F = 22.74$; $p<0.001$) differences occurred in ash content among test species with highest ash in *P. geminatum* (11%). In general, lower ash content was found among coastal grasses (Table 1).

Ca and Mg: A one way ANOVA showed significant differences ($F = 4.45$; $p<0.001$) in shoot Ca among all test species with higher values in coastal grasses *A. lagopoides* (0.91%) and *S. tremulus* (0.41%) in comparison with inland species *P. paspalodes* (0.20%) and *P. geminatum* (0.10%) (Fig. 2a). Shoot Mg varied significantly ($F = 13.04$; $p<0.001$) among all species. Higher Mg was found in coastal grasses *A. lagopoides* (0.40%) and *S. tremulus* (0.63%) in comparison with inland species *P. paspalodes* (0.19%) and *P. geminatum* (0.11%) (Fig. 2a).

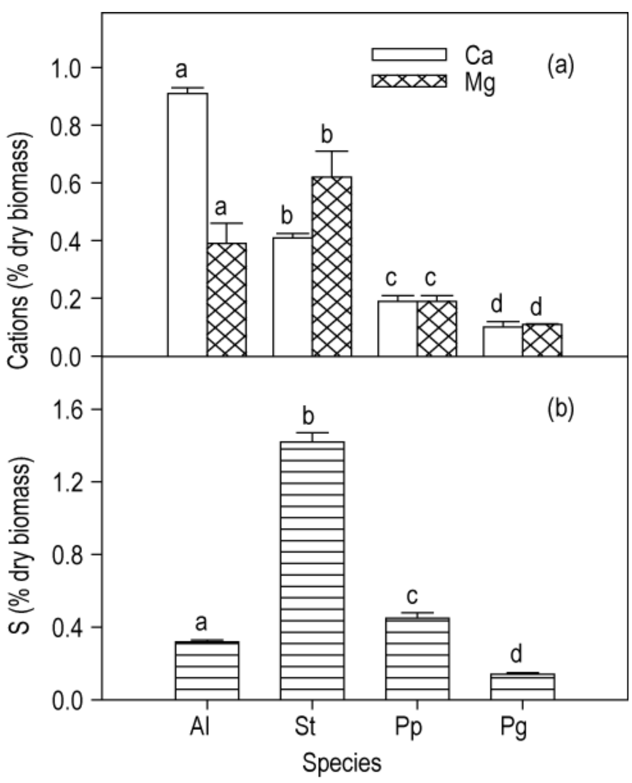

Fig. 2. Comparison of (a) calcium, magnesium and (b) sulfur accumulation among coastal (*Aeluropus lagopoides* = Al, *Sporobolus tremulus* = St) and inland (*Paspalum paspalodes* = Ps and *Paspalidium geminatum* = Pg) forage grasses. Bars represents mean ± s.e. (n = 3) on dry biomass basis. Similar letters show non-significant differences among species (Bonferoni test).

Sulphur: Sulfur also varied significantly ($F = 408$; $p<0.001$) among all test species with highest values in *S. tremulus* (1.4%), followed by *P. paspalodes* (0.45%), *A. lagopoides* (0.32%) and lowest values in *P. geminatum* (0.14%) (Fig. 2b).

Discussion

Growth: Considerable variation in biomass accumulation has been reported in salt tolerant forage grasses in controlled laboratory experiments and this variation could be species specific or an adaptive response to habitat conditions (Arzani *et al*., 2006; Masters *et al*., 2007; Yayneshet *et al*., 2009). Species which thrive in saline conditions have a competitive advantage over others in their natural habitats. In the present study the inland species were collected from soils having an $ECe_{1:5}$ up to 10 dS/m and coastal species up to 25 dS/m. The evaluation of these dominant grasses with specific adaptations in morphological, physiological and biochemical mechanisms would be helpful in selecting the right plant for a particular environment for instance decreased leaf surface area to maintain high water use efficiency (Larcher, 2003; Munns & Tester, 2008). This study compares inland and coastal grasses for their growth and nutritive potential under non-saline conditions. Inland species showed better growth in comparison with the coastal species with highest dry biomass accumulation in *Paspalum paspalodes* than the other three test species although *P. geminatum* was the tallest.

Fiber: Inland species had higher (> 60%) DMD values in comparison with the coastal species, much higher than the recommended level for animal maintenance (Arzani *et al*., 2006). A strong negative correlation was found between DMD and ADF and between DMD and ADL. Similar results were reported for forage grasses of Himalayan (Sultan *et al*., 2008) and Zagros (Arzani *et al.,* 2006) mountain rangelands. However, Van Soest (1994) found inconsistent association between ADL and DMD. Lignin is considered to be a major cell wall constituent (Abd El-Rehman, 2008) that may limit nutrient availability for ruminants (Casler & Jung, 2006). Similarly higher ME values (> 9–MJ/Kg ≈ 2 Mcal/Kg) in coastal grasses as well as *P. geminatum* appeared to be sufficient for maintenance of beef and cattle (Anon., 1996) while ME values > 10 MJ/Kg (2.53 Kcal/Kg) in *Paspalum paspalodes* were comparable to various cultivars of *P. vaginatum* (Robinson *et al*., 2004; Suyama *et al*., 2007) which could be suitable for dairy cattle.

Crude protein: Generally about 6-8 % CP is required for weight maintenance in various types of ruminants (Esmaeli & Ebrahimi, 2003; El-Shatnawi & Mohawesh, 2000; White, 1983). In the present study, *S. tremulus* had the highest CP values while those of other three species were within acceptable limits as part of maintenance diet for livestock.

Ash and mineral content: Ash levels were low among all four test species which would be expected for other grasses such as *Sporobolus* sp. and *Distichlis* sp. (Dakheel *et al.*, 2008; Alhadrami *et al.*, 2010) a favorable trait for forage crops. Mineral contents were also within the acceptable upper limits for K (2%), Ca (1.5%) and Mg (0.6%) (Anon., 2005) with higher Ca and Mg in coastal species.

Sulphur: High (> 0.4%) S could lead to loss of appetite and increased sulphide production by ruminant microorganism (Bird, 1972; Kandylis, 1984) leading to cerebro-cortical necrosis (Gould *et al.*, 2002). Sulphur may also interact with Mo in rumen to reduce Cu availability (Suttle, 1991) causing anemia, fragile bones and reproductive disorders. In the present study only *Sporobolus tremulus* had undesirably high S levels.

Conclusions

Paspalum paspalodes proved to be the best forage candidate for biomass production, DMD, ME, and low S, NDF, ADF and ADL. *Aeluropus lagopoides* had somewhat higher NDF and ADL, while *Paspalidium geminatum* had high ash, Ca and ADL but within acceptable limits recommended for livestock. *Sporobolus tremulus* showed promising results for crude protein, DMD and ME but with contained high S. In general, inland grasses appeared to have better biomass and nutritive value, however with careful rationing all four species could be used as fodder.

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