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), 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 (< 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 C4 grasses with high nutritive value (Khan et al., 2009; El-Shaar, 2010). About 68 halophytic grasses occur in Pakistan with 18 species along the coast (Khan & Qaiser, 2010). About 68 halophytic grasses occur in Pakistan with 18 species along the coast (Khan & Qaiser, 2010). Coastal species with similar values in other test species. Sporobolus tremulus had the highest sulphur (1.42%) while the other three species had considerably lower values (< 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.

Materials and Methods

Ramets of the inland grasses Paspalum paspalodes and Paspalidium geminatum were collected from Korangi industrial area (24°51'03.2 N; 67°05'60.4 E) and Malir River Karachi (24°49'41.1N; 67°05'54 E) respectively, and of the coastal grasses Aeluropus lagopoides and Sporobolus tremulus from Sandspit (24°49'06. 70° N; 66 ° 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**
  \[
  \text{CP} = \text{Total nitrogen (N)} \times 6.25 \quad \text{[Newman et al., 2003]}
  \]

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

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

- **Metabolizable energy (ME) was calculated as:**
  \[
  \text{ME (Mcal / kg)} = 0.821 \times \text{DE (Mcal / kg)} \quad \text{[Khalil et al., 1986]}
  \]

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 (61%) followed by *S. tremulus* (59%) 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 (Bonferroni test).](image)
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.

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

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).

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 ECe1:5 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-Shataawi & Mohawesh, 2000; White, 1983). In the present study, Sporobolas 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 Sporobolas sp. and Distichlis sp. (Dakheel et al., 2000; 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 Sporobolas 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 ADF, while Paspalum geminatum had high ash, Ca and ADL but within acceptable limits recommended for livestock. Sporobolas 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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References


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