García-Dessommes, Guillermo Juan; Ramírez-Lozano, Roque Gonzalo; Morales Rodríguez, Rocío; García-Díaz, Graciela
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under irrigation and fertilization
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RUMINAL DIGESTION AND CHEMICAL COMPOSITION OF NEW GENOTYPES OF BUFFELGRASS (Cenchrus ciliaris L.) UNDER IRRIGATION AND FERTILIZATION

Guillermo Juan García-Dessommes, Roque Gonzalo Ramírez-Lozano, Rocío Morales-Rodríguez and Graciela García-Díaz

SUMMARY

The study was conducted with the aim of evaluating and comparing the total dry matter production (TDMP), chemical composition and effective degradability of dry matter (EDDM), crude protein (EDCP), and neutral detergent fiber (EDNDF) of the Nueces hybrid and five new genotypes (PI 1, PI 2, PI 3, PI 4, PI 5) of buffelgrass. Grasses were irrigated and fertilized with 100kg·ha⁻¹ of urea-N, and hand harvested on June 5, 2001 at Nuevo León, Mexico. All grasses were established on a completely randomized design with three replicates. The TDMP was significantly different among genotypes. The crude protein content and cell wall components (cellulose, hemicellulose, and lignin) were significantly different among grasses. Moreover, EDDM, EDCP, and EDNDF were significantly different among genotypes. The P, Na, Cu, and Zn contents, in all grasses, were insufficient to meet growth requirements of beef cattle. Data of dry matter production and nutritional dynamics suggest that the new genotypes PI 3 and PI 4 could be considered good sources of nutrients for grazing ruminants in Northeastern Mexico.

RESUMEN

El estudio se llevó a cabo con el objetivo de evaluar y comparar el contenido nutritivo y degradabilidad efectiva de la materia seca (DEDM), proteína cruda (DEPC) y pared celular (DEFDN) del híbrido Nueces y cinco nuevas líneas (PI 1, PI 2, PI 3, PI 4, PI 5) de pasto buffalo en el noreste de México. Todos los pastos se establecieron usando un diseño completamente al azar con tres repeticiones. Fueron regados y fertilizados con 100kg·ha⁻¹ de urea-N y cosechados manualmente el 5 de junio de 2000 en Nuevo León, México. La producción de materia seca fue significativamente diferente entre los pastos. El contenido de proteína cruda, pared celular y sus componentes (celulosa, hemicelulosa y lignina) fueron significativamente diferentes entre los pastos. Los contenidos de P, Na, Cu y Zn no fueron suficientes para satisfacer los requerimientos del ganado de carne en crecimiento. Datos de producción de materia seca y dinámica nutricional sugieren que los nuevos genotipos PI 3 y PI 4 pueden ser considerados como buenas fuentes de nutrientes para el ganado en pastoreo en regiones del noreste de México.

Introduction

Common buffelgrass (Cenchrus ciliaris L.) is widely disseminated in semiarid regions of Texas and Northeastern Mexico; however, seasonality of rainfall and low temperatures are the major influences on its nutritional quality (Ramírez et al., 2003b). Previous studies carried out by García-Dessommes et al. (2003a, b) have reported that five new genotypes of buffelgrass, produced without irrigation, were less sensitive to environmental factors, yielding more dry matter and CP content than common buffelgrass and the Nueces hybrid.

Among forages, crude protein (CP) levels are well correlated with many desirable plant components like digestibility, vitamins, Ca and P. However, all these decline to deficient levels at about the same time, and CP serves as a reliable measure of overall nutritional quality (Ganskoop and Bohnert, 2001). Furthermore, CP values of a number of grasses showed lower mean values (11.5%) than legumes (17.0%) collected in different regions of the world (Minson, 1990), whereas tropical grasses have lower CP than temperate grasses (means= 10.0 and 12.9%, respectively; Minson, 1992). Several factors affect CP in grasses. One of the most important ones is the N content in soils, and it has been shown that N fertilization in temperate grasses increases CP (Whitehead, 2000). However, N fertilization did not affect dry matter or cell wall digestibility of beef cattle grazing temperate grasses (Puoli et al., 1991).

Grazing ruminants are dependent on an adequate supply of minerals for optimal rumen microbial activity. Under certain circumstances, grasses can provide adequate amounts of essential minerals for ruminants. However, grasses often have deficiencies in one or more minerals and, thus, supplementation is required for optimal animal performance and growth.

KEYWORDS / Buffelgrass / Chemical Composition / Nutrient Digestibility / Ruminal Digestion /

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Material and Methods

This study was carried out at the Experimental Station “General Terán”, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP) and the Universidad Autónoma de Nuevo León (UANL). General Terán, N.L., México, is at 25°18’N and 99°25’W, at an altitude of 332masl. The climate is typically semitropical and semiarid, with a warm summer. The main and most common type of vegetation is known as the Tamaulipan Thorn scrub or subtropical Thorn scrub woodlands. The dominant soils are deep, dark-gray, lime-clay Vertisols, which are the result of alluvial processes. These soils are characterized by high calcium carbonate (pH= 7.5-8.5) and relatively low organic matter content. Annual mean temperature is 22.4°C and the annual rainfall average is 784mm (INIFAP, 1991).

Five strains of buffelgrass PI-307622 (PI 1), PI-409252 (PI 2), PI-409375 (PI 3), PI-409443 (PI 4) and PI-409460 (PI 5), as well as the hybrid buffelgrass Nueces, which was considered as a reference grass with high nutritional quality, were established in an experiment under a completely randomized design with three replicates. The experimental plots consisted of rows 5m long with 0.8m between rows. In order to achieve a uniform grass growth, all grasses were cut prior to the experiment, on March 1, 2001. The grasses were irrigated four times during the experiment, on March 15, April 15, May 1, and May 15 to avoid any water stress in the plants. On March 15 the experimental plot was fertilized with the equivalent of 100 kg·ha⁻¹ de ureia-N and recolhidos manually in 5 de junho of 2000 in Nuevo León, México. A produção de matéria seca foi significativamente diferente entre os capins. O conteúdo de protein a crua, parede celular e seus componentes (celulosa, hemicelulose e lignina) foram significativamente diferentes entre os capins avaliados. Assim mesmo, DEMS, DEPC e DEFDN foram significativamente diferentes entre capins. Os conteúdos de P, Na, Cu e Zn não foram suficientes para satisfazer os requerimentos do gado de carne em crescimento. Dados de produção de matéria seca e dinâmica nutricional sugerem que os novos genótipos PI 3 e PI 4 podem ser considerados como boas fontes de nutrientes para o gado em pastoreio em regiões do noroeste do México.

Results and Discussion

Total dry matter production (TDMP) was significantly different among genotypes. PI 3 yielded more than other grasses (Table I), including Nueces, which has been recognized as a high producer of dry matter. As it would be expected, irrigation and fertilization led to a higher TDMP production than that of the same grasses (mean of 4.7ton·ha⁻¹ in two cuts) growing in the same area, but collected at different dates and without irrigation or fertil-
TABLE I

<table>
<thead>
<tr>
<th>Concept</th>
<th>Nueces</th>
<th>PI 1</th>
<th>PI 2</th>
<th>PI 3</th>
<th>PI 4</th>
<th>PI 5</th>
<th>Mean ±SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDMP, mg/kg</td>
<td>6.0 b</td>
<td>6.9 ab</td>
<td>7.3 ab</td>
<td>9.9 a</td>
<td>7.4 a</td>
<td>6.4 b</td>
<td>7.3 ±0.5</td>
</tr>
<tr>
<td>Organic matter</td>
<td>90.1 a</td>
<td>89.0 b</td>
<td>90.1 a</td>
<td>88.2 bc</td>
<td>88.1 c</td>
<td>90.4 a</td>
<td>89.3 ±0.3</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>8.8 c</td>
<td>8.0 c</td>
<td>8.5 d</td>
<td>9.1 b</td>
<td>8.1 e</td>
<td>9.6 a</td>
<td>8.7 ±0.1</td>
</tr>
<tr>
<td>NDF, %</td>
<td>72.1 abc</td>
<td>70.7 bcd</td>
<td>69.7 cd</td>
<td>68.7 d</td>
<td>72.7 ab</td>
<td>73.8 a</td>
<td>71.3 ±0.5</td>
</tr>
<tr>
<td>ADF, %</td>
<td>48.2 c</td>
<td>51.9 a</td>
<td>51.9 a</td>
<td>48.5 bc</td>
<td>49.8 b</td>
<td>49.3 bc</td>
<td>49.9 ±0.4</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>23.9 a</td>
<td>18.8 bc</td>
<td>17.8 c</td>
<td>20.2 b</td>
<td>22.6 a</td>
<td>23.7 a</td>
<td>21.2 ±0.6</td>
</tr>
<tr>
<td>Cellulose</td>
<td>39.7 b</td>
<td>43.2 a</td>
<td>40.3 b</td>
<td>39.6 b</td>
<td>40.4 b</td>
<td>36.7 c</td>
<td>40.0 ±0.5</td>
</tr>
<tr>
<td>ADL, %</td>
<td>3.3 d</td>
<td>3.9 c</td>
<td>5.4 b</td>
<td>4.1 c</td>
<td>3.4 d</td>
<td>6.0 a</td>
<td>4.3 ±0.4</td>
</tr>
<tr>
<td>INNDF, %</td>
<td>44.9 ab</td>
<td>41.6 bc</td>
<td>46.7 a</td>
<td>45.5 a</td>
<td>40.5 c</td>
<td>36.3 d</td>
<td>42.6 ±1.0</td>
</tr>
<tr>
<td>INADF, %</td>
<td>30.3 a</td>
<td>22.9 c</td>
<td>24.0 b</td>
<td>27.2 b</td>
<td>24.5 c</td>
<td>19.9 d</td>
<td>24.8 ±0.8</td>
</tr>
<tr>
<td>INNDF-INADF, %</td>
<td>14.6 c</td>
<td>18.7 b</td>
<td>22.7 a</td>
<td>18.3 d</td>
<td>16.0 bc</td>
<td>16.4 bc</td>
<td>17.8 ±0.8</td>
</tr>
</tbody>
</table>

The INNDF, INADF, and INNDF-INADF fractions were significantly different among grasses. The non-available N for ruminants estimated by the INADF fraction was higher (mean value of all grasses= 24.8%± 0.1%) higher than previous reports (3-15%; Van Soest, 1994) in temperate grasses. Buffelgrass PI 3 had the largest fully digestible portion of the NDF (100-INNDF= 31.3%) and PI 5 the lowest (26.2%). This fraction comes from true proteins, which in grasses constitute the enzymatic machinery that is rapidly degraded in the rumen and transformed in microbial protein (Van Soest, 1994).

The cell wall (NDF) content and its components (ADF, cellulose, and hemicellulose) were significantly different among grasses (Table I). PI 5 resulted with the highest NDF and PI 3 with the lowest. The irrigation and fertilization of buffelgrass plants with urea-N, evaluated in this study had about the same NDF content than that the same plants, but collected in summer and autumn 1999 and autumn 2000 (García-Dessommes et al., 2003a, b) and by Whitehead and Minson (2000). The irrigation and fertilization with urea-N lowered ADL (mean value of all grasses= 24.8%± 0.1%) compared with 5.5 and 7.0% obtained in previous studies carried out with the same grasses, but on different collection dates (García et al., 2003a, b; Morales-Rodríguez, 2003).

The fraction a (lost during the bag washing process) of the DM, CP, and NDF was significantly different among grasses (Table II). The fraction b (slowly degraded in the rumen of sheep) of the DM was not different (P>0.05).
TABLE III
MACRO AND TRACE MINERAL CONTENT IN THE FORAGE OF THE HYBRID NUECES AND FIVE NEW GENOTYPES OF BUFFERGRASS (Cenchrus ciliaris L)

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mineral</th>
<th>Nueces</th>
<th>PI 1</th>
<th>PI 2</th>
<th>PI 3</th>
<th>PI 4</th>
<th>PI 5</th>
<th>Mean±SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca *</td>
<td>8.9 a</td>
<td>8.3 a</td>
<td>8.3 ab</td>
<td>8.4 a</td>
<td>8.1 a</td>
<td>8.0 b</td>
<td>8.7±0.4</td>
</tr>
<tr>
<td></td>
<td>P *</td>
<td>1.7 ab</td>
<td>1.3 b</td>
<td>1.5 b</td>
<td>1.6 ab</td>
<td>1.5 b</td>
<td>1.1 c</td>
<td>1.6±0.07</td>
</tr>
<tr>
<td></td>
<td>Na *</td>
<td>1.2 a</td>
<td>1.1 a</td>
<td>1.2 a</td>
<td>1.1 a</td>
<td>1.2 a</td>
<td>1.2 a</td>
<td>1.2±0.1</td>
</tr>
<tr>
<td></td>
<td>K *</td>
<td>30.1 b</td>
<td>34.9 b</td>
<td>29.1 a</td>
<td>46.8 a</td>
<td>30.1 b</td>
<td>35.1 b</td>
<td>34.3±1.9</td>
</tr>
<tr>
<td></td>
<td>Mg *</td>
<td>2.6 a</td>
<td>1.7 b</td>
<td>2.0 b</td>
<td>2.3 ab</td>
<td>2.2 ab</td>
<td>1.9 b</td>
<td>2.1±1.0</td>
</tr>
<tr>
<td></td>
<td>Cu **</td>
<td>1.8 a</td>
<td>2.2 b</td>
<td>1.8 a</td>
<td>3.3 a</td>
<td>3.4 a</td>
<td>3.1 ab</td>
<td>2.4±0.2</td>
</tr>
<tr>
<td></td>
<td>Fe **</td>
<td>125.7 bc</td>
<td>148.3 bc</td>
<td>94.3 c</td>
<td>215.1 a</td>
<td>126.3 bc</td>
<td>151.9 b</td>
<td>143.6±11.5</td>
</tr>
<tr>
<td></td>
<td>Zn **</td>
<td>13.0 a</td>
<td>12.4 a</td>
<td>15.3 a</td>
<td>14.9 a</td>
<td>16.3 a</td>
<td>12.4 a</td>
<td>14.1±0.8</td>
</tr>
<tr>
<td></td>
<td>Mn **</td>
<td>37.7 ab</td>
<td>32.5 b</td>
<td>42.2 a</td>
<td>49.6 a</td>
<td>49.7 a</td>
<td>29.5 b</td>
<td>40.2±2.5</td>
</tr>
</tbody>
</table>

* g·kg⁻¹ and ** mg·kg⁻¹ dry matter basis.
Means in a row with different letter superscripts are different (P<0.05).

however, significant differences were obtained for CP and NDF. Degradation rate (c, %·h⁻¹) was significantly different only in DM and CP. The EDDM, EDNDF, and EDCP were significantly different among all grasses (Table II). The EDCP overall mean was estimated to be 47.3% and the potential available CP (100-INADF) was 75.2%. The difference between these two values (27.9%) corresponds to the value obtained by difference (INADF-INADF), which is slowly available to ruminant microbes, but could be fully digested in the abomasums (Van Soest, 1994). Digestion carried out in abomasums and the small intestine is also a vital process for the ruminant (Merchen and Bourquin, 1995).

In this study, all grasses resulted with lower EDCP than the same grasses collected at different dates and without irrigation or fertilization (García-Dessommes et al., 2003a, b). Moreover, in a study conducted by Puoli et al. (1991) it was found that the addition of 75kg·ha⁻¹ of urea-N increased dry matter intake of beef cattle grazing Bermuda grass; however, they did not obtain increments in digestibility of CP and cell wall. In this study, EDNDF values resulted lower than the same genotypes collected in different dates without irrigation or fertilization (García-Dessommes et al., 2003a, b). It is possible that lignification of the cell wall was related to low degradability of nutrients contained in the genotypes evaluated in this study. This effect was also found by Akin and Chesson (1990), who found that high levels of ADL in grass resulted in lower ruminal DM digestion and volatile fatty acid production.

With the exception of Na and Zn all minerals studied were different (P<0.05) among grasses (Table III). Ca, K, Mg, Fe and Mn contents were higher in irrigated and fertilized grasses than the same grasses without irrigation or fertilization, and collected at different days (García-Dessommes et al., 2003a, b). In this study, all grasses had sufficient Ca to meet growing beef cattle requirements (4.5g·kg⁻¹ DM; McDowell, 2003), but the amount of P in all cases was insufficient for growing beef cattle needs (3.0g·kg⁻¹ DM; McDowell, 2003). García-Dessommes et al. (2003a, b) and Morales-Rodríguez (2003) also found low P content in new genotypes of buffelgrass growing in the same area. Thus, cattle grazing these grasses must be supplemented with P. Growing beef cattle needs about 1.0g·kg⁻¹ DM of Mg (McDowell, 2003). In this study, all genotypes had sufficient Mg content to satisfy the requirements of this nutrient, as was that of K, which met the requirements for growing beef cattle (6.0g·kg⁻¹ DM; McDowell, 2003). Growing beef cattle requires 0.6g·kg⁻¹ DM of Na in their diets (McDowell, 2003); in this study all grasses had insufficient Na and can be considered as Na non-accumulators because they contain less than 2g·kg⁻¹ DM of Na (Youssef, 1988). Furthermore, high K content in the evaluated grasses could reduce Na absorption of cattle feeding on them, because it has been reported that an elevated dietary K may decrease ruminal concentration and absorption of Na in steers (Spears, 1994). However, Na deficiencies can be alleviated by supplementing common salt.

Cattle consuming the evaluated grasses must be supplemented with Cu, as the latter contained insufficient amounts to meet growing beef cattle requirements (10mg·kg⁻¹; McDowell, 2003). Low Cu concentrations were also reported in cultivated grasses growing in semiarid regions of North‐eastern Mexico (Ramírez et al., 2002a, b, 2005). A low Cu in the evaluated grasses may be caused by the high pH (7.5-8.5) in the soils (Spears, 1994) in these regions. Growing beef cattle requires about 50mg·kg⁻¹ of Fe in the DM of their diets (McDowell, 2003). In this study, all grasses had adequate Fe amounts to meet such requirements. Similar findings were reported in previous studies (Ramírez et al., 2002a, b, 2003a, b, 2005) carried out in the same region. Iron deficiency seldom occurs in grazing ruminants due to generally adequate forage concentrations and contaminants of plants by soil (McDowell, 2003). All the grasses studied had sufficient amounts of Mn to meet requirements of growing beef cattle (20g·kg⁻¹ DM; McDowell, 2003). Although Mn deficiency for ruminants under grazing conditions has been reported in USA and other countries (McDowell, 1985), with effects on skeletal development and reproductive performance, doubt has been expressed whether this deficiency arises under field conditions in Mexico. In the report by McDowell (1985), contrary to our findings the Zn content was significantly different among all grasses within different seasons; in the present study, Zn content was marginally deficient to meet growing beef cattle requirements (30g·kg⁻¹ DM; McDowell, 2003). Similar findings were reported by García-Dessommes and coworkers (2003a, b), who evaluated the Zn content of the same grasses collected at different dates, but without irrigation or fertilization. High levels of Ca, found in this study, may increase the dietary Zn requirements (Underwood and Suttle, 1999) and therefore, supplemental Zn is required.

Conclusions

The grasses evaluated in the present study yielded more dry matter than they did when collected without irrigation or fertilization and at different dates. The same pattern was observed in CP, EDDM, Ca, K, Mg, Na, Fe and Mn. However, NDF, ADF, cellulose, hemicellulose, INNDF, INADF, P, Cu and Zn remained the same. Lower values were obtained in lignin, EDCP and EDNDF. Concentrations of P, Na, Cu, and Zn in all grasses were insufficient to meet growing beef cattle requirements. The genotype PI 4 resulted in higher dry matter production, CP and EDCP. In general, all genotypes had nutritional qualities comparable to the hybrid buffelgrass Nueces, which in this study...
Cattle grazing these grasses must be supplemented with P, Na, Cu, and Zn.

REFERENCES


