Nutritive value of hay from sorghum-sudangrass hybrids (*Sorghum sudanense* vs. *Sorghum bicolor*)

**Valor nutritivo do feno de híbridos de sorgo com capim-sudão (*Sorghum sudanense* vs. *Sorghum bicolor*)**

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ABSTRACT
This study aimed to evaluate the nutritive value of hay from ten sorghum-sudangrass hybrids. A randomized block design with ten treatments and three replicates was used. The chemical composition was analyzed 57 days after germination. Hay from hybrids BRS 810 and BRS 802 showed similar dry matter content, although it was lower compared to other genotypes (86.98; 86.47%). Ash content was highest for the hybrid BRS 810 (6.46%). The highest crude protein content was found in hybrids BRS 810, 1013020, and BRS 802 (14.01; 12.84 and 11.96%, respectively). The lowest neutral detergent fiber (NDF) concentrations were observed in hybrids 1134029 and BRS 810, ranging from 57.72 to 58.57%. The acid detergent fiber (ADF) concentration was least in hybrids BRS 810 and 1013029 (30.30 and 30.31%). The highest lignin content was found in hybrids 1013020 and 1134023 (5.82 and 5.41%, respectively). Values of dry matter digestibility were higher than 50%. Hay from all hybrids was of good quality, but hybrids 1013020, BRS 810, BRS 802 were better in terms of nutritive value.

Keyword: Cutting and grazing, Digestibility, Fodder, Genotype, Haymaking.
INTRODUCTION

The seasonality of forage production in Brazil is one of the reasons why most livestock systems become dependent on planning their feeding program based on conserved forages or species with improved drought resistance (AGUILAR et al., 2015).

The continuity of milk and meat production based on feeding high-quality forage as the main dietary component throughout the year has been a challenge in the tropical regions during the dry season. Then, feeding strategies have been proposed to minimize production costs and to overcome the lack of high-quality forage sources.

The grown and use of high-quality conserved forages is an alternative to fill the gap in forage production during the dry season, aiming at improving the low productivity of the herds, reducing the expenses with supplementation, and maintaining the profitability of the livestock enterprise (DANIEL et al., 2011; SANTIN et al., 2020).

Sorghum-sudangrass hybrids are a cross between *Sorghum bicolor* (L.) Moench and *Sorghum sudanense* (Piper) Stapf, also known as ‘sorghum grown for cutting and grazing’. These hybrids have been used as an alternative for maintaining the forage supply and, consequently, milk and meat production during the year. There are still few cultivars available in the Brazilian market, but they have been well-accepted by farmers as an available option to extend the period of use of green forage with high nutritive value (FERREIRA et al., 2015).

The use of sorghum-sudangrass hybrids has increased in livestock feeding due to their ease of cultivation, rapid establishment and growth. In addition to their ease of handling for cutting or grazing, these hybrids have good nutritive value and high forage production, making them a feasible option to supply green forage of high nutritional value (LIMA et al., 2017).

The nutritive value of sorghum grown for cutting and grazing does not vary considerably among genotypes in the market, but the productivity depends on adequate climatic conditions and soil fertility. Improvements in productivity are found when sorghum is harvested at more advanced phenological stages (SIMILI et al., 2011).

This study aimed to evaluate the nutritive value of hay from ten sorghum-sudangrass hybrids.

MATERIAL AND METHODS

The experiment was conducted at the State University of Southwest Bahia (UESB), in the municipality of Vitória da Conquista, in the state of Bahia, Brazil (15.95°S, 40.88°W and 839 meters above sea level). According to Köppen’s classification, the climate of the region is classified as humid subtropical climate (Cwa), with an average annual rainfall of 733.9 mm, mainly falling between November to March.
After the first rains from October to December 2016, ten sorghum-sudangrass hybrids for haymaking were sown: 1013020, 1013021, 1013026, 1013029, 1134023, 1134027, 1134029, 1013016, BRS 810, BRS 802. The seeds were provided by the National Center for Research on Corn and Sorghum (Embrapa).

At sowing, 20 kg ha\(^{-1}\) of N as urea + 70 kg ha\(^{-1}\) of P\(_2\)O\(_5\) as single superphosphate were used. For top dressing, 75 kg ha\(^{-1}\) of K\(_2\)O as potassium chloride + 90 kg ha\(^{-1}\) of N as urea (divided into three applications) were used.

Three replicates (blocks) were set for each treatment (hybrid), constituted by four rows of five-meter long spaced 0.5 m apart (total area of 10m\(^2\)), totaling ten treatments with 30 experimental plots in a randomized block design. Cutting was carried out at 57 days after germination. The two central rows (useful plot) were considered for analyzes, disregarding the two outer rows of the plots.

Sorghum-sudangrass hybrids were harvested manually using sickle and scattered over the floor of a shed for drying. The material was turned over every two hours for standardization of dehydration. After drying, the sampled hay was placed into nylon bags and stored in a ventilated area. Hay samples were chopped, homogenized and placed in identified paper bags.

Samples were immediately transported to the Laboratory of Animal Nutrition of the State University of Southwest Bahia (UESB) - Campus Vitória da Conquista, Bahia. The samples were weighed and dried in a forced ventilation oven at 65\(^\circ\)C for 24 hours. After drying, the material was left at room temperature for 1 hour to constant weight and weighed to determine the dry matter (DM) content. The dried samples were ground using a Wiley mill to pass a 1-mm sieve and stored in polyethylene flasks for further analysis.

Whole-plant hay samples were used to evaluate the following nutritional parameters: dry matter content (DM), crude protein (CP), ether extract (EE), ash, cellulose, hemicellulose, lignin, ash and protein-free neutral detergent fiber (aNDF), acid detergent fiber (ADF), according to Detmann \textit{et al.} (2012). Hemicellulose was determined by the difference between the concentrations of NDF and ADF.

The \textit{in vitro} DM digestibility (IVDMD) was determined on the Daisy\textsuperscript{II} digestion apparatus (ANKOM\textsuperscript{®} Technology Corp., Fairport, NY). Ruminal fluid was collected from crossbred cannulated Holstein x Zebu cows with a mean body weight of 550 kg. Cows were fed a diet comprising commercial concentrate and sorghum hay, which started 15 days before the sampling to ensure gradual adaptation of the ruminal microbiota to the diet.

The \textit{in vitro} DM digestibility was determined using the ANKOM\textsuperscript{®} methodology (ANKOM TECHNOLOGY, 2010), after incubation in an artificial rumen (TE-150, TECNAL). A total of 0.5 g of dried sample was placed into filter bags (F-57 ANKOM\textsuperscript{®}), which were subsequently heat-
sealed. The filter bags with 30 samples corresponding to each treatment and their replicates were placed in an incubation digestion jar for 48 hours.

The buffer solution was prepared in preheated (39°C) flasks. Solution A (g/liter) was composed of 10.0 g \( \text{KH}_2\text{PO}_4 \); 0.5 g \( \text{MgSO}_4\cdot7\text{H}_2\text{O} \); 0.5 g \( \text{NaCl} \); 0.1 g \( \text{CaC}_2\cdot2\text{H}_2\text{O} \) and 0.5 g urea; and solution B (g/100 mL) was composed of 15.0 g \( \text{Na}_2\text{CO}_3 \); 1.0 g \( \text{Na}_2\text{S}_9\cdot\text{H}_2\text{O} \). The solutions were mixed by adding 266 mL of solution B to 1330 mL of solution A (ratio 1:5), at a final pH of 6.8 and a temperature of 39°C. Approximately 1600 mL of the combined mixture was added to each digestion jar, then 400 mL of ruminal liquid was added to each incubation digestion jar containing the ANKOM F57 filter bags. After incubation, filter bags were washed and treated with neutral detergent (NDF) solution following the procedures described by Detmann et al. (2012).

The digestible dry matter production of hay (DDMH) was obtained by multiplying hay production (kg) by its dry matter content and digestibility.

Data were submitted to analysis of variance, and the means were compared by the Scott-Knott’s test at 5% significance using the ASSISTAT v.7.7 Beta software (SILVA and AZEVEDO, 2016).

### 3 RESULTS AND DISCUSSION

Sorghum-sudangrass hybrids were different for dry matter content, ash and crude protein concentration \( (P<0.05) \) (Table 1). The highest dry matter contents were found in hay from hybrids 1013016, 1134027, 1134023, 1013021, 1013029, 1013026, 1013020, which did not differ from each other \( (P<0.05) \). The hybrids BRS 810 and BRS 802 showed similar dry matter content, although it was lower compared to other genotypes (86.98 and 86.47%, respectively).

| Hybrids   | DM   | Ash¹ | CP¹  | EE¹ |
|-----------|------|------|------|-----|
| 1013020   | 88.31a | 5.27b | 12.84a | 2.01a |
| 1013021   | 88.60a | 5.21b | 11.26b | 1.53a |
| BRS 810   | 86.89b | 6.46a | 14.01a | 2.24a |
| 1013026   | 88.52a | 4.90b | 9.88b | 2.11a |
| 1013029   | 88.53a | 4.57b | 10.06b | 2.05a |
| 1134023   | 88.71a | 4.95b | 10.17b | 2.29a |
| 1134027   | 89.23a | 5.26b | 9.53b | 1.98a |
| 1134029   | 88.75a | 5.10b | 10.33b | 2.07a |
| 1013016   | 89.38a | 4.63b | 11.18b | 1.86a |
| BRS 802   | 86.47b | 5.22b | 11.96a | 1.84a |
| Mean      | 88.34 | 5.15 | 11.13 | 2.00 |
| CV (%)    | 0.65  | 10.90| 11.01 | 9.54 |

Means followed by similar lowercase letters within rows are not significantly different at \( P<0.05 \) (Scott-Knott’s test); CV = coefficient of variation; ¹Dry matter basis.

Data source: Authors.
According to Neres and Ames (2015), hay with a maximum moisture content of 15% can be stored over a long period without fermenting, mold growing or even spontaneous combustion. Therefore, dry matter losses are reduced.

The results found in the present study were lower than that found by Athayde et al. (2012) evaluating the chemical composition of hay from coastcross grass at different stages of growth. The authors obtained values of 96.65; 96.81; 92.46; 92.63% DM for cuttings at 20, 40, 60 and 80 days.

Ash content was highest for the hybrid BRS 810, averaging 6.46%. For other hybrids, the values ranged from 4.57 to 5.27%, which did not differ from each other \((P>0.05)\).

The highest crude protein content was found in hybrids BRS 810, 1013020, BRS 802, reaching 14.01, 12.84 and 11.96%, respectively, although they did not differ from each other. For other hybrids, the values ranged from 9.53 to 11.26% CP. In a study conducted to evaluate the hay from nineteen hybrids of sorghum-sudangrass, Lima et al. (2017) reported crude protein levels ranging from 11.84 to 15.57%, averaging 12.98%.

Several factors can alter the protein content of hybrids of sorghum-sudangrass, including harvest frequency, plant spacing and nitrogen fertilization (PENNA et al., 2010). According to Edward Junior et al. (1971), the main factors are plant cutting height and cutting age. As plant progresses through several growth stages, its constitution is markedly changed, with greater fiber accumulation and a higher proportion of stem, which reduce the protein content.

Crude protein levels in hay from the ten hybrids were above the minimum of 7% nitrogen required by the rumen flora to ensure adequate ruminal fermentation (SAMPAIO et al., 2009). For the ether extract, there was no difference between hybrids \((P>0.05)\). Hybrids 1134023, BRS 810, 1013026, 1134029, 1013029, 1013020, 1134027, 1013016, BRS 802, 1013021 had 2.29; 2.24; 2.11; 2.07; 2.05; 2.01; 1.98; 1.86; 1.84 and 1.53% EE, respectively, with an average value of 2.0% (Table 1).

When analyzing the hay from Tifton-85 grass, Ataíde Junior et al. (2000) reported values below than that observed in the present study (1.17 and 1.48% EE, respectively). As recommended by the NRC (2001), in most situations, total lipids in ruminant diets should not exceed 6 to 7% of the total dry matter because it may cause reductions in ruminal fermentation, fiber digestibility and passage rate.

There was a difference between hybrids \((P<0.05)\) for neutral detergent fiber, acid detergent fiber, and lignin concentrations. Sorghum hybrids were similar \((P>0.05)\) for hemicellulose and cellulose (Table 2).
Table 2. Mean values of neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEM), cellulose (CEL), and lignin (LIG) of hay from ten hybrids of sorghum-sudangrass.

| Hybrids     | NDF¹ | ADF¹ | HEM¹ | CEL¹ | LIG¹ |
|-------------|------|------|------|------|------|
| 1013020     | 63.59a | 36.38a | 27.20a | 30.22a | 5.82a |
| 1013021     | 61.81a | 34.50a | 32.18a | 26.77a | 3.87b |
| BRS 810     | 58.57b | 30.30b | 28.27a | 26.81a | 3.18b |
| 1013026     | 61.52a | 34.86a | 26.66a | 30.10a | 4.61b |
| 1013029     | 57.63b | 30.31b | 27.33a | 26.35a | 3.66b |
| 1134023     | 62.80a | 36.12a | 26.67a | 30.52a | 5.41a |
| 1134027     | 62.58a | 35.86a | 26.72a | 31.33a | 4.37b |
| 1134029     | 57.72b | 33.11a | 24.60a | 29.50a | 4.07b |
| 1013016     | 63.48a | 32.44b | 31.04a | 27.75a | 4.47b |
| BRS 802     | 61.80a | 32.47b | 29.33a | 28.56a | 4.10b |
| Mean        | 61.15 | 33.63 | 28.00 | 28.77 | 4.35 |
| CV (%)      | 3.80 | 7.51 | 10.39 | 7.35 | 16.90 |

Means followed by similar lowercase letters within rows are not significantly different at P<0.05 (Scott-Knott’s test); CV = coefficient of variation; tDry matter basis.

Data source: Authors.

Hybrids were different for NDF concentration, with higher values (P<0.05) for hybrids 1013026, BRS 802, 1013021, 1134027, 1134023, 1013016, 1013020, ranging from 61.52 to 63.59%. The lowest NDF concentrations were observed in hybrids 1134029, 1134023 and BRS 810 (57.63, 57.72 and 58.57%, respectively), which did not differ between from each other. The mean NDF concentration was 61.15%.

The mean NDF concentration of 59.30% reported by Lima et al. (2017) when evaluating hay from sorghum hybrids grown for cutting and grazing was similar to that found in the present study (61.15%). The NDF values observed in hybrids in the present study and the study of Lima et al. (2017) are associated with early haymaking (57 days and 52 days), respectively.

Determining the fibrous fractions is essential for the characterization of the nutritive value of forage since these components are associated with the regulation of intake, digestibility, passage rate, and chewing activity of ruminants. In a high-fiber diet, the energy density tends to be low, with intake limited by rumen fill; then, animal performance may be compromised. On the other hand, low fiber contents increase the risk of metabolic disorders (LIMA et al., 2017).

The NDF concentration is directly associated with factors such as cultivar cycle, night temperature, soluble carbohydrate content, among others (OLIVEIRA et al., 2010).

Regarding the ADF concentration, there was a significant difference (P<0.05) between hybrids. Hybrids BRS 810, 1013029, 1013016, and BRS 802 had the lowest ADF levels, reaching 30.30; 30.31; 32.44 and 32.47%, respectively, although did not differ between from each other.

Regarding hemicellulose, sorghum hybrids grown for cutting and grazing were not significantly different (P>0.05). The values ranged from 24.60 to 32.18%, with an average value of 27.43%. For cellulose, sorghum hybrids were also similar (P>0.05), and the values ranged from 26.35 to 31.33%, averaging 26.93%.
As reported by Van Soest et al. (1991), cellulose corresponds to the most important component of the cell wall structure. The nutritional availability of cellulose varies from total indigestibility to complete digestibility depending on the degree of lignification.

In this study, the mean hemicellulose content was 28.00%, which is similar to the mean cellulose content (28.77%). Hemicellulose content should be higher or similar to that of cellulose since NDF fraction consists predominantly of hemicellulose. This cell wall component is calculated by the difference between NDF and ADF, with higher digestion rate than cellulose.

Hybrids 1134023 and 1013020 had the highest lignin levels (5.41 and 5.82%, respectively). The other hybrids had lower, but similar values for lignin, ranging from 3.18 to 4.61%, which correspond to that found in hybrids BRS 810 and 1013026. The mean lignin concentration was 4.35%.

The low values found in hybrids BRS 810 and BRS 802 is associated with the fact that they were developed to have a lower lignin content, resulting in lower fiber content and higher digestibility.

The lignin concentration of tropical grasses has been reported by Leonel et al. (2009) as the depreciative fraction of feedstuffs. Consequently, lower lignin contents result in better use of fiber by ruminal microorganisms.

Hybrids were significantly different ($P<0.05$) for ash and protein-free neutral detergent fiber and in vitro dry matter digestibility (Table 2).

The highest ANDF levels were observed in hybrids 1013016, 1134027, 1013020, 1013021, 1013026, 1134023, 1134029, and BRS 802 (61.37, 60.49, 59.88, 59.06, 59.02, 58.49, 57.93, 57.88%, respectively). The lowest ANDF values were reported in hybrids 1013029, and BRS 810 (54.45 and 56.06%, respectively).

The hybrids BRS 810, 1013029, 1013021, BRS 802, and 1013020 had the highest IVDMD values, which did not differ between from each other.

The high digestibility of the BRS 810 and BRS 802 hybrids is directly associated with their low amount of fiber and lignin (3.18 and 4.10% of lignin, respectively). These two hybrids are mutant plants characterized by a brown midrib in the leaves, resulting in low lignin content and better digestibility rates. Consequently, it can lead to higher feed intake and animal performance (LEDGERWOOD et al., 2009; ASTIGARRAGA et al., 2014; SANTIN et al., 2020).
Table 3. Mean values of ash and protein-free neutral detergent fiber (aNDF), *in vitro* dry matter digestibility (IVDMD) and digestible dry matter production of hay (DDMH) of hay from ten hybrids of sorghum-sudangrass.

| Hybrids   | aNDF¹ | IVDMD¹ | DDMH² |
|-----------|-------|--------|-------|
| 1013020   | 59.88a| 65.66a | 3.22a |
| 1013021   | 59.06a| 66.79a | 1.96a |
| BRS 810   | 56.06b| 72.00a | 1.97a |
| 1013026   | 59.02a| 64.21b | 1.83a |
| 1013029   | 54.45b| 68.73a | 2.43a |
| 1134023   | 58.49a| 61.75b | 2.45a |
| 1134027   | 60.49a| 62.24b | 2.01a |
| 1134029   | 57.93a| 62.93b | 2.14a |
| 1013016   | 61.37a| 58.91b | 2.21a |
| BRS 802   | 57.88a| 65.91a | 1.99a |
| Mean      | 58.46 | 64.91  | 2.22  |
| CV (%)    | 2.98  | 4.83   | 20.50 |

Means followed by similar lowercase letters within rows are not significantly different at *P*<0.05 (Scott-Knott’s test); CV = coefficient of variation; ¹Dry matter basis. ²(t ha⁻¹).

Data source: Authors.

The stage of development in plants has a strong relationship with the chemical composition and forage digestibility. With the advancement of physiological maturity, there is an increase in the contents of structural carbohydrates and lignin, and a decrease in the cellular content, reducing the digestibility. The digestibility of the hybrids can be associated with the early cutting age (57 days after germination).

Regarding the digestible dry matter production of hay, no statistical difference (*P*>0.05) was observed between hybrids. The values ranged from 1.96 to 3.22 t ha⁻¹, with an average value of 2.22 t ha⁻¹ of DDMH. Penna *et al.* (2010), evaluating six sorghum-sudangrass hybrids under three cuttings and two sowing seasons, reported mean digestible dry matter yields of 2.67 t ha⁻¹ and 3.64 t ha⁻¹ for the first and second season, respectively. These values are higher than those found in the present study, but the authors performed three cuttings per season.

4 CONCLUSION

Hay from all hybrids was of good quality, with dry matter digestibility higher than 50%. However, hybrids 1013020, BRS 810, BRS 802 were better in terms of nutritive value.

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