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Agronomic traits and nutritional value of forage sorghum genotypes

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ABSTRACT. This study aimed to evaluate the agronomic performance of 24 sorghum genotypes in four Brazilian regions and the chemical characteristics of genotypes grown in Sete Lagoas, state of Minas Gerais. Genotypes BRS655 and 12F37005 had higher average production of green matter (> 44 ton ha^{-1}) and dry matter (> 17 ton ha^{-1}), respectively. Genotypes 12F38019, 12F40019, 12F37005, 12F37043 and Volumax took more days to flower in three of the four municipalities (75-90 days). Genotypes 12F38006, 12F40006 and 12F37016 were taller (> 2 m). Values of dry matter, crude protein and neutral detergent fiber ranged from 37.15 to 50.13; 5.51 to 10.28 and 43.57 to 65.69%, respectively. The genotypes were not different regarding acid detergent fiber content, with mean value of 34.83%. Genotypes 12F38019, 12F37016, 12F39005, 12F39019, 12F37007, 12F37014, 12F39014 and BRS 655 showed the best values of dry matter digestibility (64.31 to 74.20%) and crude protein content (8.33 to 10.28%). Among them, 12F139014 exhibited the lowest lignin content (3.32%), suggesting less effect of this fraction on digestibility. Genotype 12F39014 is the most suitable for cultivation, as it presented the best nutritional value and good dry matter production in the four municipalities.

Keywords: chemical composition, hybrids, productivity.

Características agronômicas e valor nutritivo de genótipos de sorgo forrageiro

RESUMO. Objetivou-se avaliar o desempenho agronômico de 24 genótipos de sorgo em quatro regiões brasileiras e as características bromatológicas dos genótipos cultivados em Sete Lagoas-MG. O BRS655 apresentou média superior de produção de matéria verde (> 44 ton ha^{-1}) e o 12F37005 quanto à produção de matéria seca (> 17 ton ha^{-1}) nos quatro municípios. Os genótipos 12F38019, 12F40019, 12F37005, 12F37043 e Volumax floresceram em três das quatro cidades no prazo de 75 a 90 dias. Os genótipos 12F38006, 12F40006 e 12F37016 foram superiores quanto à altura (> 2 m). Quanto ao teor de matéria seca, proteína bruta e fibra em detergente neutro variaram de 37,15 a 50,13; 5,51 a 10,28 e 43,57 a 65,69%, respectivamente. Os genótipos não diferiram quanto aos teores de fibra em detergente ácido com média de 34,83%. Os genótipos 12F38019, 12F37016, 12F39005, 12F39019, 12F37007, 12F37014, 12F39014 e BRS 655 apresentaram os melhores valores de digestibilidade da matéria seca (64,31 a 74,20%) e teor de proteína bruta (8,33 a 10,28%). Dentre eles o 12F139014 apresentou o menor valor de lignina (3,32%), sugerindo menor efeito desta fração sobre a digestibilidade. O genótipo 12F39014 é mais indicado para cultivo, pois apresentou o melhor valor nutritivo e boa produção de matéria seca nos quatro municípios.

Palavras-chave: composição bromatológica, híbridos, produtividade.

Introduction

In Brazil, beef production on pasture is modulated by the occurrence of irregular rainfall, concentrated in a short rainy season, followed by a long period without rainfall events, affecting the productivity of forages and maintenance of animal production. The cultivation of plants more resistant to drought stress reduces the effects of the forage production seasonality and ensures the maintenance of animal production throughout the year.

Sorghum is a prominent crop in the Brazilian agricultural sector for being a high energy grass, with high digestibility, productivity and adaptation to dry and warm environments, where it is difficult to cultivate other species. The plant is used for silage or green cut feed, for grazing and grains can be used in animal feed and for human consumption (Buso, Morgado, Silva, & França, 2011). However, as the most diverse plant species, the development and productivity of sorghum are associated, in addition to genetics, with environmental factors such as rainfall, temperature and solar radiation.

As Brazil has a great diversity in terms of weather conditions, it is not expected a common behavior of sorghum hybrids in all regions. The identification of cultivars adapted to each region becomes essential as the crop expands to planting at different times and soil and weather conditions (Silva et al., 2013).

Thus, the present study evaluated the agronomic performance of 24 sorghum genotypes in four Brazilian regions and the qualitative characteristics of genotypes grown in Sete Lagoas, state of Minas Gerais.

Material and methods

The experiment was conducted in four municipalities in November and December 2012, when occurred the first rainfall events in each of them: Sete Lagoas (November 22nd), Nova Porteirinha (December 06th), Passo Fundo (November 26th) and Goiânia (December 12nd). Sete Lagoas is located in the north central part of the state of Minas Gerais at 19°28' S and 44°15' W. Local climate is classified, according to Köeppen, as Cw, savannah with dry winter. Nova Porteirinha belongs to the northern region of the state of Minas Gerais, at latitude 15°45' S and longitude 43°17' W, typical climate is Aw, that is, savannah with dry winter. Passo Fundo is located in the state of Rio Grande do Sul, at 28°15' S and 52°24' W. The municipality is located in the fundamental temperate climate zone (C), with fundamental humid climate (f) and subtropical specific variety (Cfa). Goiania is the capital of the state of Goiás, situated at 16°40' S and 49°15' W. According to Köppen classification, climate is tropical rainy, savannah Aw, with sub-humid character and two well-defined seasons: a dry, lasting four to five months; and a rainy season, from late September to April (Ratke, Frazão, Calil, & Cedro, 2013). The climate date provide by the Agrometeorological Monitoring System, referring to the months in which the experiment was carried out,are Table 1.

We evaluated 24 sorghum genotypes, three forage genotypes (BRS610, BRS655 and Volumax) and 21 hybrids obtained from crosses between forage males and grain females (12F38019, 12F38006, 12F40006, 12F40005, 12F40019, 12F37016, 12F37005, 12F37043, 12F39006, 12F39005, 12F39019, 12F38005, 12F38007, 12F37007, 12F39007, 12F40007, 12F38014, 12F37014, 12F39014, 12F40014 and 12F38009).

Planting was made in three blocks, made up of 24 plots, each with six rows of six meters long and 70 cm spaced apart. The fertilization was performed according to soil analysis and requirements of the crop. The genotypes planted in the four municipalities were evaluated for their agronomic traits and materials sown in Sete Lagoas were analyzed for chemical characteristics. The dates of planting and harvesting in each municipality is shown in Table 2.

Table 1. Average temperature and rainfall (mm) during the experimental period per municipality.

Municipality	Average temperature (°C)	Rainfall (mm)
Sete Lagoas	24.8	389.9
Nova Porteirinha	26.9	485.9
Passo Fundo	21.6	730.7
Goiânia	25.2	1028.4

Source: Agritempo (2014).

Table 2. Dates of planting and harvesting and experimental period in days per municipality.

Municipality	Planting	Harvesting
Sete Lagoas	22/11/2012	19/03/2013
Nova Porteirinha	06/12/2012	15/04/2013
Passo Fundo	26/11/2012	18/04/2013
Goiânia	12/12/2012	26/03/2013

The two central rows of each plot were used to determine the age at flowering: days for the sorghum flower to emerge after planting; plant height: from ground level to the upper end of the plant, in 20% plants in each plot; production of green matter: from the weighing of all the plants of the useful area of the plot, determined after cutting 15 cm from the ground; and production of dry matter: calculated from the production of green matter and DM content of each genotype at the time of cutting.

Chemical characteristics of the genotypes were determined by evaluating the materials grown in Sete Lagoas, using the two central rows of each plot. After harvest, plants were minced, homogenized, weighed and pre-dried in a forced ventilation oven at 55°C for 72 hours to determine pre-dried matter. The pre-dried material was taken to the city of Janaúba, state of Minas Gerais, for chemical analysis at the Food Analysis Laboratory, State University of Montes Claros (Unimontes). Pre-dried samples were ground in a Wiley mill with a 1 millimeter sieve, and stored in polyethylene vials for further analysis. Dry matter content (DM) was determined in an oven at 105°C, ash and crude protein (CP); neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose, hemicellulose and lignin were determined according to Detmann et al. (2012). The *in vitro* dry matter digestibility was calculated according to procedure described by Tilley and Terry (1963), using the *in vitro* incubator Tecnal® (TE-150), with modification of the bag material used (7.5 x 7.5 cm), made using non-woven fabric (TNT - 100 g m^{-2}) in agreement with Casali et al. (2014).

After data collection, the agronomic traits were determined by individual analysis for all variables, once met the requirements necessary, as recommended by Banzatto and Kronka (1989), we ran a joint analysis to analyze the interactions between regions and sorghum hybrids. When the F-test was significant, hybrids and regions and the interaction between these factors were compared by Scott-Knott test at 5% level through Sisvar (Ferreira, 2011). Chemical data were tested by analysis of variance through Sisvar and when F-test showed significance for the main factors and the interaction between them, the mean of the factor genotype was compared by Scott-Knott test at 5%, according to the following statistical model a Equation 1:

$$Yik = \mu + Gi + Bk + eik \quad (1)$$

where:
Yik = Observation of genotype i, in repetition k;
μ = overall mean;
Gi = effect of genotype i, with i= 1, 2, 3... 24;
Bj = effect of block k, where k = 1, 2 and 3;
eik = experimental error associated with observed values (Yik) .

Results and discussion

The production of green matter (PMV) and dry matter (PMS) (Tables 3 and 4) were different in all evaluated municipalities ($p < 0.05$). In comparison between genotypes for PMV, the BRS655 presented higher mean value in all municipalities, and genotypes 12F37016, 12F37043, VOLUMAX and BRS610 in at least three municipalities. However, all these had the production influenced by the cultivation site, and the BRS610 was the most affected, with increased production in Nova Porteirinha.

For genotypes 12F40005, 12F39005, 12F38007, 12F37007, 12F39007, 12F38014, 12F39014, 12F38009 and 12F40014, there was no variation in PMV between municipalities ($p < 0.05$), demonstrating that these materials maintained the PMV at different sites (Table 3). For the other genotypes, production was influenced by location ($p > 0.05$). Passo Fundo was the municipality that had higher mean values of productivity for most genotypes, i.e., the municipality that presented the best growing conditions for most genotypes. The production of genotype BRS655 was influenced by the cultivation site, as mentioned earlier, and presented higher mean value in all evaluated municipalities. Although some materials have maintained the production levels, when analyzed the different cultivation sites, they had lower PMV than BRS655, in the comparison between genotypes in, at least, one of the municipalities.

Table 3. Mean values of green matter production (ton ha^{-1}) of 24 sorghum genotypes grown Sete Lagoas (MG), Nova Porteirinha (MG), Passo Fundo (RS) and Goiânia (GO).

Genotype	Sete Lagoas	Nova Porteirinha	Passo Fundo	Goiânia
12F38019	34.14 Bb	39.47 Bb	48.86 Aa	39.33 Ab
12F38006	46.43 Aa	38.71 Bb	43.14 Ba	37.90 Bb
12F40006	45.43 Aa	37.85 Bb	44.19 Ba	34.66 Bb
12F40005	33.14 Ba	33.43 Ba	36.28 Ca	34.24 Ba
12F40019	34.99 Bb	35.95 Bb	45.00 Ba	35.47 Bb
12F37016	41.57 Ab	48.76 Aa	54.19 Aa	36.99 Bb
12F37005	43.71 Ab	49.71 Aa	42.28 Bb	35.38 Bc
12F37043	37.14 Bb	44.90 Aa	49.91 Aa	39.24 Ab
12F39006	43.85 Aa	38.81 Bb	45.90 Ba	33.66 Bb
12F39005	42.43 Aa	41.90 Ba	41.90 Ba	35.57 Ba
12F39019	34.57 Bb	35.33 Bb	46.76 Ba	35.57 Bb
12F38005	38.14 Bb	42.09 Ba	44.57 Ba	32.76 Bb
12F38007	40.43 Aa	39.24 Ba	43.05 Ba	34.76 Ba
12F37007	35.57 Ba	40.95 Ba	43.86 Ba	40.43 Aa
12F39007	40.43 Aa	38.24 Ba	43.34 Ba	36.99 Ba
12F40007	37.28 Bb	33.38 Bb	44.19 Ba	36.24 Bb
12F38014	38.14 Ba	37.52 Ba	42.67 Ba	34.99 Ba
12F37014	39.71 Bb	39.09 Bb	47.81 Aa	39.52 Ab
12F39014	36.57 Ba	38.90 Ba	41.90 Ba	38.95 Aa
12F40014	39.43 Ba	38.43 Ba	34.67 Ca	36.57 Ba
12F38009	38.14 Ba	42.14 Ba	46.38 Ba	41.57 Aa
BRS 655	45.14 Ab	50.19 Aa	52.66 Aa	44.14 Ab
VOLUMAX	34.43 Bb	52.23 Aa	54.67 Aa	40.47 Ab
BRS610	43.14 Ab	51.95 Aa	45.71 Bb	43.66 Ab

Means followed by different upper case letters, in the same column, and different lower case letters, in the same row, are significantly different by Scott-Knott test ($p < 0.05$). Coefficient of variation: 9.66%.

Table 4. Mean values of dry matter production (ton ha^{-1}) of 24 sorghum genotypes grown in Sete Lagoas (MG), Nova Porteirinha (MG), Passo Fundo (RS) and Goiânia (GO).

Genotype	Sete Lagoas	Nova Porteirinha	Passo Fundo	Goiânia
12F38019	13.02 Cb	15.06 Db	18.64 Aa	15.00 Bb
12F38006	17.96 Aa	17.30 Ca	19.29 Aa	16.95 Aa
12F40006	17.30 Aa	14.67 Cb	17.11 Ba	13.42 Bb
12F40005	15.44 Ba	13.21 Ca	14.33 Ca	13.52 Ba
12F40019	12.72 Cb	13.69 Cb	17.14 Ba	13.51 Bb
12F37016	16.44 Bb	19.98 Ba	22.20 Aa	15.16 Bb
12F37005	18.88 Ab	23.15 Aa	19.71 Ab	16.48 Ac
12F37043	15.07 Bb	17.34 Ca	19.26 Aa	15.15 Bb
12F39006	18.26 Aa	14.10 Db	16.69 Ba	12.23 Bb
12F39005	18.47 Ab	21.00 Ba	21.00 Aa	17.83 Ab
12F39019	13.92 Cb	13.97 Db	18.49 Aa	14.06 Bb
12F38005	14.83 Bb	19.56 Ba	20.72 Aa	15.23 Bb
12F38007	15.97 Ba	16.95 Ca	18.59 Aa	15.01 Ba
12F37007	15.89 Ba	17.44 Ca	18.67 Aa	17.21 Aa
12F39007	15.97 Ba	15.52 Da	17.56 Ba	14.99 Ba
12F40007	15.28 Bb	14.28 Db	18.90 Aa	15.49 Bb
12F38014	14.72 Bb	15.63 Db	17.76 Ba	14.58 Bb
12F37014	19.90 Aa	16.45 Cb	20.12 Aa	16.63 Ab
12F39014	16.99 Aa	16.94 Ca	18.25 Aa	16.96 Aa
12F40014	16.79 Aa	15.12 Da	13.64 Ca	14.39 Ba
12F38009	16.31 Ba	16.97 Ca	18.67 Aa	16.74 Aa
BRS 655	17.76 Ab	19.51 Ba	20.48 Aa	17.16 Ab
VOLUMAX	13.16 Cb	19.41 Ba	20.31 Aa	15.04 Bb
BRS610	16.03 Bb	20.52 Ba	18.06 Bb	17.25 Ab

Means followed by different upper case letters, in the same column, and different lower case letters, in the same row, are significantly different by Scott-Knott test ($p < 0.05$). Coefficient of variation: 9.74%.

As the sorghum plant is susceptible to photoperiod, its productivity is related to climatic conditions of each region, which leads to the need for trials with genotypes in different regions to investigate the interaction genotype x environment.

There were differences in PMS between genotypes for all cultivation sites ($p < 0.05$) (Table 4), ranging from 12.23 to 23.15 ton ha^{-1} for genotypes 12F39006 and 12F37005, Goiânia and Nova Porteirinha, respectively.

Comparing the genotypes within each municipality, 12F37005 exhibited higher mean value in all municipalities and genotypes 12F37014, 12F39014 and BRS 655 in at least three municipalities. Between municipalities, for most genotypes, there was variation in PMS ($p < 0.05$). Genotypes 12F38006, 12F40005, 12F38007, 12F37007, 22 12F39007, 12F39014, 12F40014 and 12F38009 kept the DM production in the different municipalities. When assessed production within each municipality, genotype 12F37005 presented higher mean value in all municipalities, despite the influence of cultivation site on production. As well for PMV, Passo Fundo showed higher mean values for PMS for most of genotypes. It is noteworthy that the rainfall in this municipality is greater than in the others (larger volume and better distribution), corroborating the results for production.

In the four municipalities, there were differences between genotypes as for days to flowering ($p < 0.01$), and for all genotypes, there were differences between the municipalities for this trait ($p < 0.01$) (Table 5).

Table 5. Mean values of flowering period (days) of 24 sorghum genotypes grown in Sete Lagoas (MG), Nova Porteirinha (MG), Passo Fundo (RS) and Goiânia (GO).

Genotype	Sete Lagoas	Nova Porteirinha	Passo Fundo	Goiânia
12F38019	82 Bb	87 Aa	81 Ab	76 Ac
12F38006	80 Ba	79 Ca	82 Aa	72 Bb
12F40006	78 Cb	83 Ba	77 Bb	74 Ac
12F40005	79 Cb	86 Aa	78 Bb	75 Ab
12F40019	81 Bb	86 Aa	79 Ab	75 Ac
12F37016	81 Ba	83 Ba	82 Aa	74 Ab
12F37005	82 Bb	87 Aa	80 Ac	76 Ad
12F37043	83 Ba	85 Aa	80 Ab	75 Ac
12F39006	78 Ca	79 Ca	78 Ba	73 Bb
12F39005	79 Ba	81 Ba	76 Bb	74 Ab
12F39019	80 Ba	81 Ba	78 Bb	75 Ab
12F38005	80 Bb	87 Aa	76 Bc	74 Ac
12F38007	80 Ba	77 Ca	77 Ba	72 Bb
12F37007	80 Ba	81 Ba	78 Ba	71 Bb
12F39007	77 Ca	75 Da	76 Ba	71 Bb
12F40007	78 Ca	77 Ca	76 Ba	70 Bb
12F38014	76 Ca	76 Da	76 Ba	70 Bb
12F37014	76 Ca	79 Ca	76 Ba	71 Bb
12F39014	76 Ca	76 Da	74 Ba	71 Bb
12F40014	75 Da	76 Da	74 Ba	71 Bb
12F38009	82 Ba	82 Ba	78 Bb	72 Bc
BRS 655	74 Db	74 Db	79 Aa	72 Bb
VOLUMAX	90 Aa	84 Bb	82 Ab	77 Ac
BRS610	75 Db	74 Db	78 Ba	71 Bc

Means followed by different upper case letters, in the same column, and different lower case letters, in the same row, are significantly different by Scott-Knott test ($p < 0.05$). Coefficient of variation: 2.63%.

Genotype 12F37005 is among the later genotypes, because except for Sete Lagoas, where Volumax had the highest mean value among all genotypes, the 12F37005 genotype showed higher mean values in the other municipalities (Table 5). This may explain the superiority of this material for PMS, once, according Almeida Filho et al. (2014), genotypes presenting later cycle tend to be more productive because they have a longer vegetative stage.

In relation to plant height (Table 6), genotypes 12F38006, 12F40006 and 12F37016 showed higher mean values in the four municipalities investigated and both were influenced by the cultivation site.

Table 6. Mean values of plant height (m) of 24 sorghum genotypes grown in Sete Lagoas (MG), Nova Porteirinha (MG), Passo Fundo (RS) and Goiânia (GO).

Genotype	Sete Lagoas	Nova Porteirinha	Passo Fundo	Goiânia
12F38019	2.47 Ba	1.88 Bc	1.83 Bc	2.04 Ab
12F38006	2.65 Aa	2.06 Ab	2.04 Ab	2.15 Ab
12F40006	2.63 Aa	2.05 Ab	2.19 Ab	2.11 Ab
12F40005	2.38 Ca	1.83 Bb	1.83 Bb	1.96 Bb
12F40019	2.28 Ca	1.72 Cc	1.93 Ab	1.91 Bb
12F37016	2.68 Aa	2.18 Ab	2.19 Ab	2.23 Ab
12F37005	2.83 Aa	1.97 Bb	1.92 Bb	1.83 Bb
12F37043	2.47 Ba	1.88 Bb	1.99 Bb	2.06 Ab
12F39006	2.52 Ba	2.10 Ab	2.23 Ab	2.21 Ab
12F39005	2.47 Ba	1.95 Bb	1.87 Bb	1.83 Bb
12F39019	2.32 Ca	1.72 Cc	1.82 Bc	1.99 Bb
12F38005	2.38 Ca	1.80 Cb	1.88 Bb	2.02 Ab
12F38007	2.52 Ba	1.87 Bb	1.82 Bb	1.88 Bb
12F37007	2.57 Ba	1.80 Cc	1.82 Bc	2.01 Ab
12F39007	2.47 Ba	1.95 Bb	1.97 Bb	2.06 Ab
12F40007	2.33 Ca	1.68 Cc	1.84 Bb	1.99 Bb
12F38014	2.35 Ca	1.90 Bb	1.86 Bb	1.96 Bb
12F37014	2.40 Ca	1.92 Bb	1.83 Bb	1.95 Bb
12F39014	2.18 Da	1.90 Bb	1.95 Bb	2.05 Aa
12F40014	2.22 Da	1.87 Bb	1.85 Bb	1.86 Bb
12F38009	2.33 Ca	1.97 Bb	1.99 Bb	2.04 Ab
BRS 655	2.45 Ba	2.23 Ab	1.86 Bc	1.88 Bc
VOLUMAX	2.45 Ba	2.13 Aa	1.94 Ba	2.00 Ba
BRS610	2.45 Ba	2.12 Ab	1.86 Bc	1.94 Bc

Means followed by different upper case letters, in the same column, and different lower case letters, in the same row, are significantly different by Scott-Knott test ($p < 0.05$). Coefficient of variation: 5.48%.

In Passo Fundo, despite the good rainfall regime, there were lower thermal indices, which may have contributed to the lower height compared to Sete Lagoas. In the municipality of Nova Porteirinha, despite good light and good thermal indices for the growth of plants like sorghum, rainfall was lower than in other municipalities.

The agronomic differences between Goiânia and Sete Lagoas, which have good soil and climatic conditions, may be because planting has not been done on the same day, which may have influenced the availability of light for plants.

There was a large variation in DM content between genotypes (with a coefficient of variation of 0.88), which may be related to different types of sorghum, with different cycles, which were planted and harvested on the same date, and showed remarkable differences in the DM content, ranging from 37.15 to 50.13% for genotypes Volumax and 12F39005, respectively (Table 7).

Table 7. Chemical composition and dry matter digestibility of 24 sorghum genotypes grown in Sete Lagoas, state of Minas Gerais.

Genotype	DM	CP	NDF	ADF	Lignin	DIVMS
12F38019	38.16 J	8.72 A	44.27 B	30.77 A	5.37 B	74.20 A
12F38006	44.69 C	7.91 B	58.63 A	43.33 A	6.61 A	68.44 A
12F40006	38.73 I	9.36 A	60.47 A	35.93 A	7.79 A	61.39 B
12F40005	39.51 H	6.84 B	46.77 B	34.40 A	7.13 A	58.95 B
12F40019	38.09 J	7.53 B	43.57 B	26.31 A	8.17 A	56.03 B
12F37016	40.98 G	8.53 A	61.50 A	42.35 A	5.41 B	65.38 A
12F37005	46.59 B	7.99 B	55.92 A	33.93 A	7.22 A	60.56 B
12F37043	38.61 I	8.84 A	57.89 A	35.17 A	8.18 A	56.70 B
12F39006	36.35 L	7.89 B	50.96 B	32.54 A	5.03 B	66.19 A
12F39005	50.13 A	9.07 A	43.65 B	29.99 A	5.11 B	63.31 A
12F39019	39.55 H	8.33 A	56.49 A	35.57 A	5.96 B	64.87 A
12F38005	46.47 B	8.45 A	55.06 A	35.56 A	8.23 A	59.61 B
12F38007	43.19 D	10.28 A	57.09 A	33.73 A	7.64 A	55.17 B
12F37007	42.58 E	8.71 A	59.50 A	41.79 A	5.27 B	64.31 A
12F39007	40.56 G	7.77 B	54.00 A	40.40 A	5.23 B	62.79 A
12F40007	42.77 E	7.33 B	43.96 B	29.82 A	6.06 B	60.86 B
12F38014	41.63 F	7.49 B	52.96 A	34.97 A	6.82 A	67.22 A
12F37014	42.09 E	9.27 A	65.69 A	41.21 A	7.02 A	68.76 A
12F39014	43.54 D	8.98 A	60.97 A	26.11 A	3.32 C	67.83 A
12F40014	39.35 H	6.78 B	61.32 A	39.39 A	2.14 C	66.80 A
12F38009	40.27 G	5.51 B	58.18 A	35.44 A	5.65 B	61.00 B
BRS 655	38.88 I	9.82 A	57.28 A	37.29 A	5.51 B	67.94 A
VOLUMAX	37.15 K	7.70 B	44.17 B	26.17 A	6.51 A	50.41 B
BRS610	39.49 H	7.70 B	58.84 A	35.15 A	6.57 A	66.01 A
Média	41.26	8.2	54.54	34.83	6.16	63.11
CV (%)	0.88	12.55	8.61	17.98	24.06	8.78

Means followed by different upper case letters, in the same column, and different lower case letters, in the same row, are significantly different by Scott-Knott test ($p < 0.05$).

For Volumax, values between 31.9 and 21% DM are reported by Ribeiro et al. (2007) and Von Pinho, Vasconcelos, Borges, and Resende (2007), respectively, both lower than the values observed in this study for the same material. In turn, Machado et al. (2014) evaluated the chemical composition of the silages of sorghum hybrids BRS 610, BR 700 and BRS 655 at milky, pasty and dough maturity stages and reported DM content of silages ranging from 22.86 to 41.27%, with 26.75% for BRS610 and 27.17% for BRS655. These values are lower than those reported here for the same genotypes.

Genotypes 12F40005, 12F40014 and 12F38009 showed optimal levels to meet the nitrogen requirements for ruminal flora and for a good functioning of the rumen, which is at least 7% (Table 7). CP content of sorghum depends on the combination of several factors, including the agronomic behavior of genotype, maturity stage and soil and climatic conditions of the planting area. The greater proportion of leaf and grain contributes to higher protein content and these proportions are affected by height, age of harvesting and fertilization. Rodrigues et al. (2012) reported for BRS610 and BRS655, CP content of 6.00 and 6.52% respectively, both lower than those reported in this study for the same genotypes.

There was variation between genotypes for NDF ($p > 0.05$). The values ranged from 43.57 to 65.69% in materials 12F39005 and 12F37014, respectively (Table 7).

According to Van Soest (1994), the NDF content should be in the range of 50-60%. And although some materials present NDF higher than 60%, the same materials did not differ from others with values within the suggested range. NDF values observed in this study suggest that the consumption of materials would not be impaired; however, the high values of ADF content could negatively affect the digestibility, which did not occur. Thus, more important than evaluating separately the content of NDF and/or ADF is to evaluate the composition of the fiber fractions.

In addition to the NDF and ADF content, the determination of lignin levels is important for understanding the use of forages by the animal, with consequent increase or decrease in DIVMS, depending on the concentration of this phenolic compound.

In this study, lignin values ranged from 2.14 to 8.23% for genotypes 12F40014 and 12F38005 (Table 6). Lower values of lignin content were obtained in genotypes 12F40014 and 12F39014, values of 2.14 and 3.32, respectively. The lower the lignin content in the forage, the more efficient the food degradation process in the rumen. Skonieski et al. (2010) determined production and nutritional value of sorghum silages and reported values of 5.22 and 4.83% lignin for forage and dual purpose materials, respectively.

Most genotypes with lower lignin content showed higher values of DIVMS. All genotypes showed DIVMS values above 50%, suggesting good potential for rumen degradability and digestibility. In this condition, sorghum genotypes evaluated can be better used by animals, because the greater the digestibility, the greater the absorption of nutrients.

Genotypes 12F38019, 12F37016, 12F39005, 12F39019, 12F37007, 12F37014, 12F39014 and BRS 655 presented the best DIVMS values and the higher values of CP content. Among them, 12F139014, besides the high protein content, showed the lowest content of lignin, suggesting less effect of this fraction on digestibility. Despite the high NDF of this material, there was no impairment of DIVMS, strengthening the importance of evaluating the fiber quality of foods. Pires et al. (2013), evaluating characteristics of silages of five sorghum genotypes grown in winter, and found mean values of DIVMS for Volumax at 52.22% and for BRS610 at 56.38%, which is lower than the value for Volumax and higher for BR610, in this study.

Conclusion

In relation to the agronomic traits, genotype 12F37005 showed higher mean values of dry matter production in all evaluated municipalities, demonstrating its adaptation to different cultivation sites. However, genotype 12F39014 is the most suitable for cultivation due to good nutritional value and good dry matter production.

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References

Agritempo. (2014). Sistema de monitoramento agrometeorológico. Retrieved on July 20, 2014 from http://www.agritempo.gov.br/agritempo/index.jsp

Almeida Filho, J. E., Tardin, F. D., Daher, R. F., Silva, K. J., Xavier Neto, J. B., Bastos, E., ... Menezes, C. B. (2014). Avaliação agronômica de híbridos de sorgo granífero em diferentes regiões produtoras do Brasil. *Revista Brasileira de Milho e Sorgo, 13*(1), 82-95.

Banzatto, D. A., & Kronka, S. N. (1989). *Experimentação agrícola*. Jaboticabal, SP: Funep.

Buso, W. H. D., Morgado, H. S., Silva, L. B., & França, A. F. S. (2011). Utilização do sorgo forrageiro na alimentação animal. *Pubvet, 5*(23), 1-26.

Casali, A. O., Detmann, E., Valadares Filho, S. C., Pereira, C., Henriques, L. T., Freitas, S. G., & Paulino, M. F. (2014). Influência do tempo de incubação e do tamanho de partículas sobre os teores de compostos indigestíveis em alimentos e fezes bovinas obtidos por procedimentos *in situ*. *Revista Brasileira de Zootecnia, 37*(2), 335-342.

Detmann, E., Souza, M. A., Valadares Filho, S. C., Queiroz, A. C., Berchielli, T. T., Saliba, E. O. S., & Azevedo, J. A. G. (2012). *Métodos para análise de alimentos*. Visconde do Rio Branco, MG: Suprema.

Ferreira, D. F. (2011). Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia, 35*(6), 1039-1042.

Machado, F. S., Rodriguez, N. M., Gonçalves, L. C., Rodrigues, J. A. S., Ribas, M. N., Lobato, F. C. L., ... Pereira, L. G. R. (2014). Valor nutricional de híbridos de sorgo em diferentes estádios de maturação. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 66*(1), 244-252.

Pires, D. A. A., Rocha Junior, V. R., Sales, E. C. J., Reis, S. T., Jayme, D. G., Cruz, S. S., ... Esteves, B. L. C. (2013). Características das silagens de cinco genótipos de sorgo cultivados no inverno. *Revista Brasileira de Milho e Sorgo, 12*(1), 68-77.

Ratke, R. F., Frazão, J. J., Calil, P. M., & Cedro, D. A. B. (2013). Caracterização ambiental da microbacia do córrego Samambaia, Goiânia-GO, utilizando SIG. *Global Science Technology, 6*(1), 1-11.

Ribeiro, C. G. M., Gonçalves, L. C., Rodrigues, J. A. S., Rodriguez, N. M., Borges, I., Borges, A. L. C. C., ... Ribeiro Junior, G. O. (2007). Padrão de fermentação da silagem de cinco genótipos de sorgo. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 59*(6), 1531-1537.

Rodrigues, J. A. S., Machado, F. S., Rodríguez, N. M., Ribas, M. N., Teixeira, A. M., Ribeiro Júnior, G. O., ... Pereira, L. G. R. (2012). Qualidade da silagem de híbridos de sorgo em diferentes estádios de maturação. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 64*(1), 711-720.

Silva, K. J., Menezes, C. B., Tardin, F. D., Emygdio, B. M., Souza, V. F., Carvalho, G. A., & Silva, M. J. (2013). Seleção de híbridos de sorgo granífero cultivados no verão em três localidades. *Revista Brasileira de Milho e Sorgo, 12*(1), 44-53.

Skonieski, F. R., Nornberg, J. L., Azevedo, E. B., David, D. B., Kessier, J. D., & Menegas, A. L. (2010). Produção, caracterização nutricional e fermentativa de silagens de sorgo forrageiro e sorgo duplo propósito. *Acta Scientiarum. Animal Sciences, 32*(1), 27-32.

Tilley, J. M., & Terry, R. A. (1963). A two stage technique for the *in vitro* digestion of forage crops. *Journal of the British Grassland Society, 18*(2), 104-111.

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant* (2nd ed.). Ithaca, NY: Cornell University Press.

Von Pinho, R. G., Vasconcelos, R. C., Borges, I. D., & Resende, A. V. (2007). Produtividade e qualidade da silagem de milho e sorgo em função da época de semeadura. *Bragantia, 66*(2), 235-245.

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