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Agronomic characteristics of sorghum genotypes and nutritional values of silage

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ABSTRACT. The objective was to assess agronomic characteristics of sorghum genotypes and nutritional values of produced silage. A total of 15 sorghum genotypes were used. Planting was carried out through a randomized-block design with three replications per genotype, totaling forty-five (45) plots. Agronomic and nutritional characteristics, besides the quality of the silage, were assessed. There were differences between genotypes for all characteristics analyzed, with the exception of levels of acid detergent unavailable nitrogen (ADUN), acid detergent unavailable protein (ADUP) and water activity (aw). The assessment of the parameters, except for genotypes 1016013, 1016025, 1016037, 1016039, Volumax and BRS 610, which presented protein level below 7%, showed that the other genotypes can be used for silage production, since they have a good profile of fermentation and in vitro dry matter digestibility; however, genotype SF15 is the most favorable one for silage production due to its little participation in the neutral detergent fiber fraction.

Keywords: digestibility, production, quality.

Características agronômicas de genótipos de sorgo e valores nutricionais das silagens

RESUMO. Objetivou-se avaliar as características agronômicas de genótipos de sorgo e o valor nutricional das silagens produzidas. Foram utilizados 15 genótipos de sorgo. O plantio foi realizado em blocos casualizados com três repetições por genótipo num total de 45 (quarenta e cinco) parcelas. Avaliaram-se as características agronômicas, nutricionais e qualidade da silagem. Houve diferença entre os genótipos para todas as características analisadas, com exceção dos teores de nitrogênio indisponível em detergente ácido (NIDA), proteína indisponível em detergente ácido (PIDA) e atividade de água (aw). Avaliando os parâmetros, com exceção dos genótipos 1016013, 1016025, 1016037, 1016039, Volumax, BRS 610, que apresentaram teor proteico abaixo de 7 %, os demais estão aptos a serem utilizados para a ensilagem, pois possuem um bom perfil de fermentação e digestibilidade *in vitro* da matéria seca; no entanto, o genótipo SF 15 é o mais favorável para a produção de silagem, devido à sua menor participação na fração de fibra em detergente neutro.

Palavras-chave: digestibilidade, produção, qualidade.

Introduction

The Brazilian animal husbandry - beef cattle and dairy farming - has been undergoing a process of intense modernization, but much of the production systems is still based on extensive breeding in pastures. To Santos et al. (2013), the pasture-based animal husbandry system is challenging due to the seasonality of forage production mainly during dry periods. An alternative to improve the animal production system has been the cultivation of sorghum, which is a tropical plant adapted to the most diverse conditions, including climate and soil fertility, thus being a more resistant plant in comparison with maize in situations of high temperatures and water stress; for this reason, this plant is grown in several regions that present high temperatures and dry spells (Andrade Neto, Miranda, Duda, Góes, & Lima, 2010). Thus, sorghum silage is gaining a prominent role, especially in arid and semi-arid regions where this crop stands out for its greater strength, proving a potential alternative for feeding ruminants.

The nutritional value of the silage is related to the cultivar used, the maturity stage the plant is at the time of cutting and the nature of the fermentation process, which will directly reflect on its chemical composition and, consequently, on animal performance. For this reason, more precise studies related to new genetic materials entering the market need to be evaluated and validated by research institutions so that technicians and cattlemen choose the adequate material for producing silage as well as its ideal point of harvest. (Antunes et al., 2007). Considering the above, this study aimed to assess agronomic characteristics of fifteen sorghum genotypes and nutritional values of produced silage as well as digestibility.

Material and methods

The experiment was conducted at the facilities of the *Centro Nacional de Pesquisa de Milho e Sorgo* [National Center for Maize and Sorghum Research] of Embrapa, in the municipality of Sete Lagoas, Minas Gerais State, located at Km 65 of MG 424 highway, in the central region of the state, between the coordinates 19º 28' south latitude, and 44º 15' west longitude from Greenwich. A total of 15 sorghum genotypes were assessed: 1016009, 1016011, 1016013, 1016017, 1016023, 1016025, 1016029, 1016033, 1016035, 1016037, 1016039, BRS655, Volumax, BRS610 and SF15. The experiment was implemented in December 21, 2010, when the first rains fell in the region. For sowing, the direct planting system was adopted, with 13 seeds per linear meter in each plot. The genotypes were planted in three randomized blocks, each plot being composed of six rows of six meters in length and 70 cm of spacing between rows; each genotype was a treatment.

Fertilization was performed according to the soil analysis and crop demands, using 350 kg ha^{-1} of the formula 08-28-16 (N-P-K) + 0.5% of zinc in the planting and 150 kg ha^{-1} of urea in the coverage 25 days after emergence. Agronomic assessments were carried out in four lines of each plot, in the two central rows, of which the number of plants per hectare was assessed (No. plants ha^{-1}) - number obtained by counting the number of plants in the useful plot and estimated by multiplying the conversion factor 2.8571 [10/(1 line * 6 meters long * 0.70 meters of spacing between lines)]; plant height (PLHT) was measured from soil level to the top end of the plant, in 20% of the plants of each plot; green matter production was obtained from the weighing of all the plants of the useful area of the plot, carried out after cutting at 15 cm from the soil, and dry matter production (DMP) was calculated from the green matter production and DM content of each genotype at the moment of cutting. The samples were weighed and pre-dried in forced ventilation oven at 55°C for 72 hours.

For the ensiling process the two middle rows of each plot were used, being cut upon presenting dry matter content of 30 to 35%. Laboratory silos made of PVC pipes measuring 100 mm wide and 500 mm long were used; forage was chopped in a stationary chopper and pressed in a wooden mortar, with average density being 600 kg m^3. The silos were sealed at the time of ensiling with PVC caps fitted with Bunsen-type valves sealed with masking tape. Three replications per treatment and two replications per plot were done, totaling 90 (ninety) silos, which were opened after 56 days.

Nutritional assessment of the silage was performed at the Food Analysis Laboratory of the State University of Montes Claros (UNIMONTES) – Campus Janaúba, Minas Gerais State. Upon the opening of the silos, the material was homogenized; 200 ml of juice was extracted from the silage with the aid of a hydraulic press for determination of pH values; 25 g of silage were extracted from the silo mass for ammoniacal nitrogen, and 20 g for determination of water activity, and placed in plastic mini-trays.

Part of the ensiled material was placed in paper bags, weighed and then pre-dried in forced ventilation oven at 55°C for 72 hours or until reaching constant weight. The pre-dried samples were ground in a bench grinder with a 1 mm mesh sieve and then placed in glass containers with caps identified for food chemical composition analysis: dry matter (DM), ashes (ASH), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (LIG). All above mentioned analyses were performed according to methodology described by Detmann et al. (2012). The neutral detergent fiber analysis (NDF) and acid detergent fiber analysis (ADF) were done in autoclave and treated with thermostable alpha-amylase without the use of sodium sulfite, and corrected for nitrogen and residual ash.

For silage quality analyses, pH, ammoniacal nitrogen and water activity were assessed using the juice and the finished silage. For determination of pH values, a calibrated pH meter was employed. N-NH3/TN analysis was carried out with the sampling of approximately 25 g of the silage of each genotype. Subsequently, the silage was treated with 200 ml of sulfuric acid solution, 0.2N, inserted into containers with caps and kept at rest for 48 hours under refrigeration for N-NH3 solubilization and subjected to distillation, as suggested by Bolsen et al. (1992).

The water activity of the silage was measured using the AquaLab 4TE DUO equipment. *In vitro* digestibility (IVDMD) was assessed with the pre-dried samples and then ground with a 1 mm mesh sieve. The IVDMD was determined according to methodology described by Tilley and Terry (1963) with the aid of a Tecnal® *in vitro* incubator (TE-150), with modification in the sachet material used (7.5 x 7.5 cm), manufactured with nonwoven fabric (TNT – 100 g m^{-2}), in accordance with Casali et al. (2008).

The rumen fluid needed for the assessment was collected from two castrated adult steers fitted with rumen cannula, with approximately 400 kg of live weight. The animals were housed in a pen, fed roughage (sorghum silage) and concentrates, mineral salt and water *ad libitum* during the 15 days prior to collection. Data was subjected to analysis of variance by means of the software SISVAR (analysis of variance system), and means were compared through the Scott-Knot test at significance level of 5%.

Statistical model: $Y_{ik} = \mu + G_i + B_k + e_{ik}$,

where:
Y_{ik} = value observed for genotype i, subject to block k;
μ = overall mean;
G_i= effect of genotype i, with i = 1, 2 ... 14 and 15;
B_k = effect of block k, with k = 1, 2 and 3;
e_{ik}= experimental error associated with the observed values (Y_{ik}).

Results and discussion

Data referring to the average number of plants per hectare (No. PL ha^{-1}), height (m), green mass production (ton ha^{-1}) and dry mass production (ton ha^{-1}) are displayed in Table 1.

Table 1. Average number of plants per hectare (No. Pl ha^{-1}), mean values of plant height (PLHT) in meters, green matter weight (GMW) in tons per hectare, and dry matter weight (DMW) of fifteen sorghum genotypes grown for silage production.

Genotype	N° Pl ha^{-1}	PLHT (m)	GMW (ton ha^{-1})	DMW (ton ha^{-1})
1016009	135.67 B	2.38 B	32.80 C	11.97 A
1016011	159.33 A	2.26 B	37.13 C	12.66 A
1016013	163.33 A	2.53 B	37.47 C	12.94 A
1016017	142.00 B	2.07 C	30.60 C	10.94 B
1016025	150.33 B	2.32 B	30.80 C	9.36 B
1016029	129.00 B	2.05 C	30.00 C	11.15 B
1016031	161.00 A	2.15 C	29.00 C	12.29 A
1016033	163.33 A	2.10 C	26.40 C	10.02 B
1016035	152.33 A	2.03 C	26.60 C	9.81 B
1016037	138.00 B	2.50 B	35.87 C	11.92 A
1016039	161.33 A	2.40 B	31.40 C	9.46 B
BRS 655	147.00 B	2.15 C	33.53 C	11.13 B
Volumax	146.00 B	2.32 B	48.00 A	12.73 A
BRS 610	161.00 A	2.26 B	41.87 B	10.87 B
SF 15	170.67 A	3.30 A	52.07 A	15.41 A
(CV)	8.72	5.02	34.90	11.51

Means followed by different letters in the column differ by Scott-Knott test at 5% probability.
Fonte: Search result

For No. Pl ha^{-1}, a difference between hybrids was observed ($p < 0.05$), ranging from 129.00 to 170.67; genotypes 1016011, 1016013, 1016031, 1016033, 1016035, 1016037, 1016039, BRS610, SF15 showed larger final number of plants compared to the other ones. The larger number of plants per area means higher productivity, but high densities may favor the lodging of plants due to smaller stem diameter, especially in later maturity stages when the panicle has greater amount of starch and, consequently, is heavier, thus causing the plant to topple.

There was difference ($p < 0.05$) between hybrids for the height variable; genotype SF15 stood out when compared to the other ones, being the highest (3.30 m), while the other genotypes varied from 2.03 (1016013) to 2.53 (1016035) m. All hybrids assessed were taller than 2.00 m, a characteristic of forage sorghum, which is taller when compared to grain cultivars, has many leaves, open panicles, few seeds, great forage production and is adapted to regions with low rainfall. The superiority of hybrid SF15 is correlated with an intrinsic characteristic of the genotype, as it is a hybrid obtained by the crossing of saccharine and dry stems varieties, with high adaptability to regions of harsh climate, which allows it to reach an average height of 2.50 to 3.00m, with high productive potential, while the medium-size or dual-purpose sorghum presents smaller production per hectare, which can be observed in the data presented.

Von Pinho, Vasconcelos, Borges and Rezende (2006), analyzing the characteristics of sorghum genotypes AG1018 (grain), DKB860 (grain), AG2005E (dual purpose), MASSA3 (dual purpose), Volumax (forage) and BRS610 (forage), observed that the height of the plants ranged from 1.46 m for grain sorghum, 1.79 m for dual-purpose sorghum, and 2.66 m for forage sorghum. This characteristic correlates with the genetic composition of the material and the environment where it was grown. This suggests that studies should go deeper so as to obtain sorghum genotypes that aggregate quality characteristic of silage with high dry matter production.

Analyzing green matter production (GMP) and dry matter production (DMP) among the genotypes, the latter differed from each other ($p < 0.05$). The mean values of green matter production (GMP) presented in Table 1 show that only genotypes Volumax, BRS 610 and SF15 were superior, with production of 48.00, 41.86 and 52.06 (ton ha^{-1}), while the others did not differ statistically ($p > 005$), with production inferior to 40 ton ha^{-1}. High-quality forage sorghum, known as dual-purpose sorghum (grain and forage), produce silage comparable to that of maize. They are medium-sized genotypes, with plants ranging from 2.00 to 2.30 meters high. Green mass production is high, varying between 40 to 55 ton ha^{-1}, which has not been observed; the low productivity can be explained by temperature conditions and unfavorable soil humidity during the development of the plants. Santos et al. (2013) found a GMP of 89.4 and 55.3 ton ha^{-1} with cultivars BRS 506 and BRS 610, respectively.

As for dry matter production (DMP), there was variation between genotypes ($p < 0.05$). The greatest production was observed for genotypes 1016009, 1016011, 1016013, 1016031, 1016037, Volumax, SF15, ranging from 11.92 to 15.41. The dry matter production of forage sorghum is generally correlated with plant height, that is, the dry matter production potential increases with height. It is the most important part, since it allows the conversion of the elements contained in it to nutrients. Von Pinho et al. (2006) observed variations in dry matter production of 9 t. ha^{-1} for grain sorghum, 10.8 ton ha^{-1} for dual-purpose sorghum, and 14.4 ton ha^{-1} for forage sorghum.

When considering the quality of the silage, Table 2 shows a significant difference ($p < 0.05$) between genotypes for pH and N-NH3/TN.

Table 2. Mean values for pH, ammoniacal nitrogen in relation to total nitrogen (NH3-N /TN) and water activity (Aw) of the silage of fifteen sorghum genotypes grown for silage production.

Genotype	pH	N-NH3/TN	AW
1016009	4.00 B	2.28 C	0.97
1016011	4.31 A	1.79 C	0.96
1016013	3.63 B	2.38 C	0.97
1016017	3.85 B	1.27 C	0.97
1016025	3.95 B	5.90 A	0.97
1016029	3.78 B	4.05 B	0.97
1016031	3.89 B	5.00 A	0.97
1016033	3.82 B	2.31 C	0.96
1016035	3.88 B	3.69 B	0.96
1016037	3.76 B	1.85 C	0.97
1016039	3.74 B	1.47 C	0.97
BRS 655	3.91 B	2.31 C	0.97
Volumax	3.67 B	1.82 C	0.98
BRS 610	3.63 B	1.53 C	0.98
SF 15	3.76 B	2.28 C	0.96
(CV)	3.61	29.59	0.65

Means followed by different letters in the column differ by Scott-Knott test at 5% probability.
Fonte: Search result

Genotype 1016011 was superior to the others for pH, with a mean of 4.31; the other ones varied from 3.63 to 4.00 and were similar to each other ($p > 0.05$). Despite the difference, the ensiled materials showed pH values that enable a good preservation of the ensiled material, being within the range of 3.8 to 4.2 to keep the silage well preserved. Ribeiro et al. (2007), while determining the fermentation pattern of the silage of five sorghum genotypes, found pH values varying between the 3.69 and 4.58. As for NH3/TN, which expresses the amount of protein degraded during the fermentation phase, the ideal NH3/TN value should be lower than 10%. This research found lower values ranging from 1.53 to 5.90. According to Gonçalves, Borges and Ferreira (2009), the level of ammoniacal nitrogen in sorghum silage varies from 0.5 to 7.8% of the total nitrogen. Thus, the levels found in this study corroborate with the results obtained by the authors. Consequently, the silage of this experiment is considered of good quality.

For water activity, there was no difference between the silages of the different hybrids assessed, with a mean of 0.97 ($p > 0.05$). Aw refers to the measuring of the concentration of solutes in water and their effects on the chemical activity of the water. Microorganisms in general are fundamental in silage fermentation process and have their activity largely affected by Aw; the growth of most bacteria and fungi is restricted to Aw values over 0.90. In this work, most genotypes reached 0.97 on average; in this way, this amount of water contributed to the decrease in pH and improved the quality and fermentation of the silage.

The genotypes differed from each other as to DM, CP and EE levels ($p < 0.05$) (Table 3).

Table 3. Mean levels of dry matter (DM), crude protein (CP) and ether extract (EE) of fifteen sorghum genotypes grown for silage production (data expressed in dry matter).

Genotype	DM (%)	CP (%)[1]	EE (%)[1]
1016009	36.53 B	9.04 A	2.44 B
1016011	34.14 C	8.62 A	4.17 A
1016013	34.51 C	5.88 B	1.64 B
1016017	35.74 B	8.06 A	4.01 A
1016025	30.28 C	6.95 B	2.78 B
1016029	37.13 B	9.00 A	2.97 A
1016031	42.33 A	9.03 A	3.46 A
1016033	37.94 B	9.07 A	3.12 A
1016035	36.82 B	8.69 A	3.69 A
1016037	33.24 C	6.12 B	2.19 B
1016039	30.14 D	4.58 C	2.25 B
BRS 655	33.24 C	8.84 A	2.45 B
Volumax	26.37 E	5.36 C	3.66 A
BRS 610	25.89 E	6.03 B	1.75 B
SF 15	29.68 D	8.03 A	1.80 B
(CV)	33.60	8.17	17.06

Means followed by different letters in the column differ by Scott-Knott test at 5% probability.
Fonte: Search result

There is a great variation in DM values between the genotypes studied (25.89 to 42.33 g kg^{-1} of DM). The dry matter content of the forage at the time of ensiling is one of the main determinants of the fermentation process and, consequently, of the quality of the silage produced. The dry matter content of the silage can be explained by the hybrids being dual purpose, with succulent stems, and the greater participation of leaves and panicles in the structure of the plant, contributing to the high dry matter content.

Mean CP values differed between the genotypes assessed ($p < 0.05$), ranging from 4.58 to 9.03%. Analyzing these values, it can be observed that, with the exception of genotypes 1016039, 1016013, 1016025, 1016037, 1016039, Volumax and BRS 610, the values for CP observed in the present study were higher than the values found in that research. These materials did not present CP levels ideal to meet the nitrogen requirements of the rumen flora and to allow the proper functioning of the rumen, which is at least 7% (Van Soest, 1965). CP levels of sorghum depend on the association of several factors, including the agronomic behavior of the genotype, maturity stage, and soil and climatic conditions of the farming area.

Taller genotypes, which have greater stem ratio, may show lower protein level; dual-purpose genotypes, in turn, which are shorter, tend to present more acceptable protein levels due to the greater leaf and grain ratio that corroborates with this characteristic. Besides these factors, the age of harvesting and fertilization must be considered as well. Von Pinho et al. (2006), when studying nutritional characteristics of the silage of sorghum genotypes AG2005E (dual purpose), MASSA3 (dual purpose), Volumax (forage) and BRS610 (forage), found higher crude protein values in comparison with those of this experiment. The values found by the authors were 8.0 and 9.2% for forage sorghum and dual- purpose sorghum, respectively. As for ether extract levels (EE), there was difference between genotypes ($p < 0.05$), with highlight to 1016011, 1016017, 1016029, 1016031, 1016033, 1016035 and Volumax, with values of 4.17, 4.01, 2.97, 3.46, 3.12, 3.69 and 3.66%, respectively. Although the ether extract levels of the sorghum are low overall, the values reported in the study constitute a good source of food. Chieza et al. (2008), while working with sorghum hybrids, found 3.89% of EE in hybrid AG 2005E.

There was variation between genotypes as to NDF, ADF and IVDMD levels ($p > 0.05$), as shown in Table 4.

Genotypes 1016035, 1016039, BRS 610, SF 15 showed lower NDF level compared to other genotypes, with values standing at 49.40; 57.43; 55.85; 44.64 respectively. NDF levels should fall between 50 and 60%; higher values can compromise consumption due to greater participation of fibrous carbohydrates that slowly pass through the digestive tract of ruminants, taking up space longer and limiting the rate of consumption. The superiority of this fraction can be correlated with increased length of stay of the plants in the field and their age at the moment of cutting. Data obtained herein is overall above the indicated, and these values may reduce the consumption of this food by the animals. Rodrigues Filho et al. (2006), assessing the chemical composition of certain sorghum hybrids, found for genotype BRS 610, a NDF of 50.28%, value similar to that of this work. Sorghum genotypes 1016011, 1016013, 1016017, 1016025, 1016029, 1016035, 1016039, Volumax and SF15 showed values greater than 50% for ADF levels.

Table 4. Mean levels of neutral detergent fiber (NDF), acid detergent fiber (ADF) and *in vitro* dry matter digestibility (IVDMD) of the silage of fifteen sorghum genotypes grown for silage production.

Genotype	NDF (%)[1]	ADF (%)[1]	IVDMD
1016009	69.32 A	40.98 B	46.16 A
1016011	67.27 A	52.28 A	36.57 B
1016013	69.97 A	52.42 A	33.82 B
1016017	65.28 A	52.95 A	42.98 A
1016025	62.99 A	54.46 A	39.98 B
1016029	72.12 A	54.69 A	39.53 B
1016031	68.14 A	44.61 B	43.58 A
1016033	64.33 A	38.92 B	50.24 A
1016035	49.40 B	53.24 A	46.63 A
1016037	69.13 A	47.21 B	52.39 A
1016039	57.43 B	56.33 A	43.95 A
BRS 655	66.34 A	44.85 B	40.46 B
Volumax	61.05 A	51.50 A	37.28 B
BRS 610	55.85 B	43.70 B	40.50 B
SF 15	44.64 B	53.03 A	37.80 B
(CV)	11.33	13.90	12.9

Means followed by different letters in the column differ by Scott-Knott test at 5% probability. [1]Data expressed in dry matter.

Fonte: Search result

Consumption can be estimated based on the chemical composition of the forage. Forage with ADF value around 30% or lower is consumed at high levels, unlike those with levels over 40% (Van Soest, 1994). It is possible to observe that in the present study ADF levels are above the limits recommended by the literature, which compromises the enzymatic attack of microorganisms on the fiber due to the presence of lignin, which works as a barrier.

The higher values for fibrous fractions are consistent with the higher levels of DM. These higher values can be a result of the maturity of the plants, which were harvested at a later stage, with increase in lignin level and in the cell wall of plant tissues, mainly due to decreased leaf/stem ratio. The biggest changes that occur in the chemical composition of forage plants are those that accompany their maturation.

Regarding in vitro dry matter digestibility (IVDMD), there was variation between sorghum genotypes ($p < 0.05$), and the highest digestibility values were found in genotypes 1016039, 1016037, 1016033, 1016031, 1016017, 1016009. Digestibility is the ability that food has to allow the animal to use its nutrients to a greater or lesser extent (Oliveira et al.,2010). Several factors can interfere with food digestibility coefficients, especially the maturity of the plant, when it comes to forage, exerting a negative effect on digestibility. With the assessment of dry matter production per hectare and ADF and IVDMD levels, it is observed that genotypes 1016009, 1016031 and 1016037 had greater productivity per area, smaller ADF value and better IVDMD, results that complement each other and show the better performance of these materials, since these characteristics should be considered in the choice of a forage species, as they are associated with the productivity of plants and their consumption by animals. Araújo et al. (2007), when determining the quality of the silage of three sorghum genotypes, found IVDMD values ranging from 44.63 to 51.38%, that is, similar to those of this experiment.

Regarding NDUN and ADUN levels, there was significant difference ($p < 0.05$) between the genotypes analyzed for NDUN, while for ADUN no difference between the materials was observed ($p > 0.05$), with a mean of 0.78%, as shown in Table 5. The highest values were observed for genotypes 1016025, 1016035, BRS 610 and SF15. The assessment of the potential availability of nitrogenous compounds in foods has been receiving special attention in tropical conditions due to their high association with the organic matrix of the cell wall. Such association compromises the accessibility to these compounds by ruminal microorganisms (HenriqueS et al., 2007).

Table 5. Level of neutral detergent unavailable nitrogen (NDUN), acid detergent unavailable nitrogen (ADUN), neutral detergent insoluble protein (NDIP) and acid detergent insoluble protein (ADIP) of the silage of fifteen sorghum genotypes grown for silage production.

Genotype	NDUN (%)[1]	ADUN (%)[1]	NDIP (%)[1]	ADIP (%)[1]
1016009	0.97 A	0.74 A	6.04 A	4.63 A
1016011	0.93 A	0.71 A	5.82 A	4.46 A
1016013	0.87 A	0.85 A	5.43 A	5.29 A
1016017	1.02 A	0.99 A	6.39 A	6.24 A
1016025	0.68 B	0.82 A	4.27 B	5.13 A
1016029	0.96 A	0.92 A	6.04 A	5.78 A
1016031	1.09 A	0.94 A	6.79 A	5.91 A
1016033	0.83 A	0.61 A	5.19 A	3.84 A
1016035	0.62 B	0.80 A	3.91 B	4.99 A
1016037	1.13 A	0.60 A	7.04 A	3.74 A
1016039	0.91 A	0.76 A	5.72 A	4.77 A
BRS 655	1.00 A	0.78 A	6.28 A	4.91 A
Volumax	0.83 A	0.83 A	5.43 A	5.16 A
BRS 610	0.59 B	0.47 A	3.68 B	2.92 A
SF 15	0.52 B	0.74 A	3.24 B	4.64 A
(CV)	25.80	19.21	5.40	4.83

Means followed by different letters in the column differ by Scott-Knott test at 5% probability. [1]Data expressed in dry matter.
Fonte: Search result

When considering the ADIP and NDIP levels present in the sorghum silage and displayed in Table 5, it can be observed that there was interaction between the genotypes for NDIP ($p < 0.05$), and that there was no statistical difference ($p > 0.05$) between the genotypes for the ADIP variable, with a mean of 19.19. Concerning the NDIP variable, there was significant difference between genotypes ($p < 0.05$). Genotypes 1016025, 1016031, 1016035, BRS 610, SF15 were superior. The forms of unavailable nitrogen (NC fraction) and unavailable protein (C fraction) are determined based on the levels of acid detergent insoluble nitrogen and protein, fractions which are composed by the form of nitrogen and associated with lignin, tannin-protein complexes and compounds resulting from the Maillard reaction. The components of these fractions are highly resistant to microbial and enzymatic attack; for this reason, they are completely insoluble and/or indigestible in the gastrointestinal tract. The highest NDIP levels can be explained by the height of the plant; the dual-purpose genotype is shorter, that is, it is completing the vegetative cycle. As a result, there is greater lignification of the fractions of the plant, mainly the stem.

Conclusion

With the exception of genotypes 1016013, 1016025, 1016037, 1016039, Volumax and BRS 610, which showed protein level below 7%, the other ones can be used for ensiling since they have a good profile of fermentation and *in vitro* dry matter digestibility; however, genotype SF15 is the most favorable one for silage production due to its little participation in the neutral detergent fiber fraction.

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