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Silage quality of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems

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ABSTRACT. Recently it has emerged a technique for silage production of intercropping systems of annual crop with forage through crop-livestock integration, aiming to reduce the deficit forage in the offseason. The study was conducted to evaluate the fermentation characteristics and nutritional value of silage of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems. The experiment was a randomized block design, with three replications, in a 3x2+4 factorial arrangement, with three cultivars of *Urochloa brizantha* (Marandu; Xaraes and Piata) intercropped with grain sorghum in two planting systems (row and between rows) and four monocrops (Sorghum, Marandu palisadegrass, Xaraes palisadegrass and Piatã palisadegrass). The planting system of intercropping systems did not interfere with fermentation characteristics and chemical composition of silages. The same was found for *Urochloa* cultivars. Silages from intercropping sorghum with *Urochloa brizantha* cultivars had lower pH values, buffering capacity, acetic and butyric acids and higher values of lactic acid, besides showed superior quality, as for the parameters dry matter, ether extract and total digestible nutrient than silages from grasses produced in monocropping system. Therefore, silages of intercropping systems ensure fermentation and nutritional quality, providing interesting supplementary bulky options to be used in the offseason for feeding animals.

Keywords: conservation, digestibility, fermentation, crop-livestock integration.

Qualidade de silagem de sorgo e cultivares de *Urochloa brizantha* em monocultivo e consorciado em diferentes sistemas de semeadura

RESUMO. Surgiu recentemente a técnica de produção de silagem de sistemas consorciados de cultura anual e forrageira tropical, na integração lavoura-pecuária, com intuito de minimizar déficit de forragens na entressafra. Sendo assim, objetivou-se avaliar as características fermentativas e valor nutritivo da silagem de sorgo e cultivares de *Urochloa brizantha* em monocultivo e consorciado em diferentes sistemas de semeadura. O delineamento experimental utilizado foi o de bloco ao acaso, com três repetições, em esquema fatorial 3x2+4, sendo três cultivares de *Urochloa brizantha* (Marandu, Xaraés e Piatã), consorciadas com sorgo granífero em dois sistemas de semeadura (linha e entrelinha) e quatro monocultivos (Sorgo, Marandu, Xaraés e Piatã). A forma de semeadura dos sistemas consorciados não interferiu nas características fermentativas e químico-bromatológicas das silagens. O mesmo foi obtido para cultivares de *Urochloa brizantha*. As silagens do consórcio do sorgo com cultivares de *Urochloa brizantha* apresentaram menores valores de pH, capacidade tampão, N-NH_3, ácido acético e butírico e maior ácido lático, além da qualidade superior, quanto aos parâmetros matéria seca, extrato etéreo e nutrientes digestíveis totais. Portanto, silagens dos sistemas consorciados garantem adequado processo fermentativo e qualidade nutricional, constituindo interessantes opções de volumosos suplementar para ser utilizado na entressafra na alimentação animal.

Palavra-chave: conservação, digestibilidade, fermentação, integração lavoura-pecuária.

Introduction

The seasonal production of forage plants, caused by low temperatures combined with insufficient humidity and light in part of the year, requires planning and implementing practices aimed at conservation of forage for the offseason. Conserving forage as silage is an option that has been widely used in ruminant feed.

Sorghum (*Sorghum bicolor)* is one of the species most commonly used for ensiling, due to the agronomic traits, besides satisfactory yield potential, efficient use of water, abundant and deep root system and high tolerance to diseases and pests (Ali, Abbas, Niaz, Zulkiffal, & Ali, 2009), in addition to succulent stems with high content of fermentable sugars along with high nutritional value (Almodares & Hadi, 2009).

Another option widely used as roughage is the silage produced from tropical forages, which has stood out because of the higher productivity under adverse conditions, in addition to be already planted in many properties, lowering the cost when compared to silage of conventional species, such as corn and sorghum (Chizzotti et al., 2005). In contrast, losses when ensiling tropical grasses are frequent, which suggests the use of technologies aimed at reducing these losses.

In this context, intercropping annual crop with tropical forage through crop-livestock integration system aims to reduce costs for producing forage conserved for ruminants at the time of shortages. The system also provides agronomic benefits with increased yield of the crop and forage; and economic advantages with the rational use of inputs, machinery and hand-work. The use of intercropping systems of forages can optimize intake, thus improving the utilization of nutrients. However, there is a lack of information about the best planting system to provide high quality silage in intercropping systems.

This study evaluated the fermentation characteristics and quality of silage of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems, in the offseason.

Material and methods

The experiment was carried out under field conditions (17° 48' S; 50° 55' W; and 748 m asl) at the county of Rio Verde, state of Goiás, in the 2013 offseason, on Latossolo Vermelho distroférrico (Embrapa Solos, 2013). Soil samples were taken before planting to determine the physical and chemical characteristics of the experimental area, at 0-20 cm. The characterization was 510; 160; 330 g kg^{-1} of clay, silt and sand, respectively; $CaCl_2$ pH: 5.10; Ca: 2.88 $cmol_c$ dm^{-3}; Mg: 1.27 $cmol_c$ dm^{-3}; Al: 0.01 $cmol_c$ dm^{-3}; Al+H: 4.0 $cmol_c$ dm^{-3}; K: 0.39 $cmol_c$ dm^{-3}; CEC: 8.54 $cmol_c$ dm^{-3}; P: 6.72 mg dm^{-3}; Cu: 3.4 mg dm^{-3}; Zn: 1.5 mg dm^{-3}; Fe: 43.0 mg dm^{-3}; O.M.: 26.76 g kg^{-1}.

The area was prepared by removal of weeds with application of 3 L ha^{-1} glyphosate and 2,4-D. Thirty days after desiccation, a plowing was performed with disc harrow, followed by disking. A week before planting, another disking was made and sowing furrows were opened using a seeder.

The experiment was a randomized block design, with three replications, in a 3x2+4 factorial arrangement, with three cultivars of *Urochloa brizantha* (Marandu; Xaraes and Piata) intercropped with grain sorghum in two planting systems (row and between rows) and four monocrops (Sorghum, Marandu palisadegrass, Xaraes palisadegrass and Piata palisadegrass). The sorghum used was the hybrid Buster grain sorghum (short stature, early, tannin-free, reddish grains).

In all treatments, rows were spaced 50 cm apart. Monocropping and intercropping plots in the row were composed of eight rows with three meters long. For between-row intercropping, fifteen rows were used, eight with sorghum and seven with *Urochloa*, totaling 12 m^2. The working area was obtained considering only the four central rows, disregarding 0.5 m from each end.

Sowing was carried out in February 2013 with fertilization 150 kg ha^{-1} $P_2O_5$and 20 kg ha^{-1} FTE BR 12. At 20 and 40 days after seedling emergence (DAE), 50 kg ha^{-1} nitrogen and 40 kg ha^{-1} K_2O as urea and potassium chloride were broadcast, respectively.

In row intercropping, *Urochloa* cultivars were sown at 6 cm depth, along with fertilizer, and sorghum, at 2 cm. Between-row intercropping, both species were sown at 2 cm depth, as occurred in the sorghum monocrop.

Two weeks after seedling emergence, Buster sorghum was thinned according to population recommended for the cultivar in the region, leaving the equivalent of 240,000 plants ha^{-1}. For forage species, 5 kg viable pure seeds were used per hectare.

For ensiling, silages were harvested 90 days after planting (DAP), using backpack brush cutter, when the material was at the doughy-pasty stage. The material was chopped in a stationary forage ensiling machine, to 10-30 mm particles. Then, the material was stored in experimental PVC silos, 50 cm long and 10 cm diameter. The lid, also made of PVC, was provided with a Bunsen valve for removal of gases produced during fermentation. Then, the experimental silos were kept in a covered area, at room temperature.

After 60 days of fermentation, silos were opened; the material of the upper portion and the bottom of each was discarded. The central portion was homogenized and placed on plastic trays. Another silage samples were collected for pH and ammonia nitrogen determinations according to Bolsen, Lin, and Brent (1992). Silage pH was determined with a glass electrode after homogenization of 25 g of fresh silage with 100 mL of distilled water. Another 25 g of silage was mixed with 200 mL of H_2SO_4 solution

(0.2 N) and left undisturbed in a refrigerator for 48h. This mixture was passed through a quantitative filter paper and the filtrate was frozen for subsequent determination of NH_3-N content. Still was used part of fresh silage separated to be analyzed titratable acidity (TA) and buffering capacity (BC).

After this procedure, a silage sample was taken and divided into two parts. The first was stored in plastic bags and frozen. For determination of the ammonia nitrogen (NH_3-N/NT), the samples were thawed for juice extraction. The organic acids were determined in a high performance liquid chromatograph (HPLC), Shimadzu, SPD-10A VP, coupled with ultraviolet (UV) detector, at 210 nm wavelength, according to the method described by Kung Jr. and Shaver (2001).

The other portion of silage with approximately 1 kg was weighed and taken to a forced ventilation oven at 55°C for 72 hours and then ground in a Wiley knife mill, with 1 mm sieve, and stored in plastic containers.

Chemical analyses were performed to determine for (DM) dry matter (Method 934.01); (MM) ash (Method 924.05); (CP) crude protein obtained by determining total N, using the micro-Kjeldahl technique (Method 920.87) and fixed conversion factor (6.25); (EE) ether extract content, determined gravimetrically after extraction with petroleum ether in a Goldfish device (Method 920.85) according to AOAC. The (NDF) neutral detergent fiber according to Mertens (2002); (ADF) acid detergent fiber (Method 973.18; Association of Analytical Communities [AOAC], 1990); and lignin in 13.51 M sulfuric acid (Van Soest, Robertson, & Lewis, 1991). The total digestible nutrient (TDN) was obtained using the equation (% TDN = 105.2-0.68 (% NDF)), proposed by Chandler (1990). For in *vitro* dry matter digestibility (IVDMD), we adopted the technique described by Tilley and Terry (1963) adapted to the artificial rumen, developed by ANKON® using the "Daisy incubator" of Ankom Technology.

Before ensiling, chemical analysis of forage was carried out, according to the methods described above (Table 1).

The results were subjected to individual analysis of variance of the intercropping (*B. brizantha* cultivars and planting systems) and subsequently combined analysis between the intercropping and monocropping systems. It was applied the Tukey test at 5% probability, when found significance for the sources of variation tested in both cropping systems. It was also used the Dunnett's test at 5% to compare the means of the intercropping with sorghum in monocropped. Analyses were run using the ASSISTAT version 7.6 beta.

Results and discussion

Values of pH, buffering capacity and N-NH_3 were not different ($p > 0.05$) neither intercropping systems nor the different planting systems (Table 2). On the other hand, when comparing monocropped sorghum with the other treatments, it was found that *B. brizantha* cultivars had higher mean values for the variables mentioned above, which suggests inferiority in the quality of silages obtained.

Considering the pH, the lowest values were in sorghum in monocropping and in intercropping systems, demonstrating the importance of crop-livestock integration system, in order to contribute to reduce the pH value in silages. Possibly this is due to high content of soluble sugars in sorghum, readily available for fermentation of lactic acid-producing bacteria.

The mean pH in silage of *Urochloa brizantha* cultivars in monocropping was 4.35. This result may be related to the fact that the fermentation of tropical forage has some difficulties, such as low DM content and a high buffering capacity, which promote stabilization of silage at high pH.

Table 1. Chemical composition of sorghum and cultivars of *Urochloa brizantha* in monocropping and intercropping systems, before ensiling (g kg^{-1} DM).

Forage system	DM	CP	NDF	ADF	EE	IVDMD
SMR	261.4	97.5	700.8	376.7	29.5	572.2
SMBR	300.5	93.4	705.3	358.5	28.4	548.9
SXR	270.3	91.3	682.5	378.6	30.6	572.5
SXBR	269.5	92.4	673.9	375.3	29.8	565.9
SPR	284.1	98.7	668.5	378.9	30.5	582.5
SPBR	295.9	100.5	689.3	323.5	29.3	580.2
Sorghum	337.5	83.6	631.6	340.6	41.5	653.5
Marandu palisadegrass	229.8	92.5	737.2	400.5	17.8	510.1
Xaraes palisadegrass	238.2	97.2	713.8	402.8	16.5	560.3
Piata palisadegrass	241.8	98.5	705.7	398.7	15.9	571.0

SMR: Sorghum x Marandu palisadegrass in the row; SMBR: Sorghum x Marandu palisadegrass in the between rows; SXR: Sorghum x Xaraes palisadegrass in the row; SXBR: Sorghum x Xaraes palisadegrass in the between rows; SPR: Sorghum x Piata palisadegrass in the row; SPBR: Sorghum x Piata palisadegrass in the between rows. DM: Dry matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; EE: Ether extract; IVDMD: *in vitro* dry matter digestibility.

Table 2. Hydrogen ion potential (pH), buffering capacity (BC), titratable acidity (TA) and ammonia nitrogen in relation to total nitrogen (NH_3-N NT^{-1}) of silage of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems.

Forage system	Planting system: Row	Between row	Mean	Planting system: Row	Between row	Mean
	pH			Buffering capacity (eq.mg HCl 100 g^{-1} DM)		
SM	3.94 ab	3.81 b	3.88 A	5.72 b	5.55 b	5.63 A
SX	3.93 b	3.89 b	3.91 A	6.45 b	5.66 b	6.06 A
SP	3.88 b	3.86 b	3.87 A	5.94 b	5.03 b	5.49 A
Sorghum	3.73 b			4.69 b		
Marandu palisadegrass	4.35 a			10.28 a		
Xaraes palisadegrass	4.29 a			10.05 a		
Piata palisadegrass	4.42 a			9.56 a		
Mean[1]	3.92 A	3.85 A		6.04 A	5.41A	
CV (%)	3.21			17.24		
	Titratable Acidity (g^{-1} 100 mL)			NH_3-N/NT (%)		
SM	2.51 a	2.53 a	2.52 A	3.93 b	4.57 b	4.25 A
SX	2.46 a	2.29 a	2.38 A	3.61 b	3.59 b	3.60 A
SP	2.52 a	2.74 a	2.63 A	2.61 b	3.92 b	3.27 A
Sorghum	3.68 a			5.25 b		
Marandu palisadegrass	1.62 a			8.84 a		
Xaraes palisadegrass	1.77 a			8.56 a		
Piata palisadegrass	1.97 a			6.52 ab		
Mean[1]	2.50 A	2.52 A		3.38 A	4.03 A	
CV (%)	21.70			30.39		

SM: Sorghum x Marandu palisadegrass; SX: Sorghum x Xaraes palisadegrass; SP: Sorghum x Piata palisadegrass; Mean[1]: means followed by different uppercase letters in the same row of the intercropping system in two planting systems are significantly different by Tukey's test at 5% probability; Means followed by different uppercase letters are significantly different by Tukey's test at 5% probability; Means followed by different lowercase letters are significantly different from sorghum monocrop by Dunnett's test at 5% probability.

However, pH cannot per se be considered as a safe criterion to evaluate silage. Attention should be paid to the speed at which pH declines, since there is a rapid initial acidification, which is the key to control the growth of enterobacteria and *Clostridium*, which may grow to an inhibitory concentration of non-dissociated acids (Pahlow, Muck, & Driehuis, 2003) and or maintain the pH within the optimal range, which is 3.8 to 4.2 (Tomich et al., 2004). In this sense, silages of *Urochloa brizantha* cultivars in monocropping system did not show pH within the optimal range.

According to Ribeiro et al. (2009), hydrolysis of peptide bonds, started from the forage harvesting, is restricted when the ensiled material has a high DM content or low pH value, since the proteolytic clostridia are not osmotolerant and the activity is controlled at low pH. Therefore, the restriction of proteolysis, confirmed by low NH_3-N content of silages (Table 2), indicates rapid decline in pH.

Similarly to pH, values of buffering capacity were reduced in intercropping systems, with values ranging from 5.03 to 6.45 eq.mg HCl 100 g^{-1} DM. In general, the buffering capacity values found in the forages did not represent an obstacle for the rapid pH decline, and the ideal values are below 20 eq.mg HCl 100 g^{-1} DM (Ferrari Junior & Lavezzo, 2001).

Regarding NH_3-N, higher values were found in the silages of marandu and Xaraes palisadegrass in monocrop. Considering the proposal of Ferrari Junior and Lavezzo (2001) all silages can be classified as desirable, if NH_3-N value is less than 10% total nitrogen. In addition, sorghum intercropped with *Urochloa brizantha* cultivars contributed to reduce ammonia nitrogen of silages, possibly due to the high content of soluble carbohydrates of sorghum, readily available for fermentation of lactic acid-producing bacteria.

The concentration of lactic acid was higher ($p < 0.05$) in silage of sorghum in monocropping, followed by the silages of intercropping systems (Table 3). It is noteworthy that the silages in intercropping systems produced about three times more lactic acid when compared to silages of *Urochloa brizantha* cultivars in monocrop. These results demonstrate the relevance of intercropping sorghum with *Urochloa brizantha* cultivars in the production of lactic acid, which plays a key role in the conservation of forage, for presenting a higher dissociation constant, being responsible for the pH drop to values below 4.2 (Moisio & Heikonem, 1994).

Higher pH values verified in silages of *Urochloa brizantha* cultivars in monocrop can be indicative of increased production of acetic and butyric acids ($p < 0.05$), as registered herein, with a mean value of 48.4 and 1.5 g kg^{-1} DM.

Moreover, silage of sorghum in monocropping showed lower values of the acetic acid content, possibly this is because it is an early hybrid harvested at the ideal time, allowing a good lactic fermentation and a possible reduction of heterofermentative bacteria (Pires et al., 2013).

From this perspective, silage of intercropping systems becomes an interesting tool to improve the fermentation profile, based on values of pH, NH_3-N, lactic, acetic and butyric acids, thus preserving most the nutrients from the silage.

Higher values of DM content were observed in silages of sorghum in monocropping ($p < 0.05$), differing from other treatments (Table 4). This result is related to the greater DM content of sorghum at the time of harvest (Table 1). In relation to *Urochloa brizantha* cultivars in monocrop, there was high moisture, which possibly led to a dilution of acids produced by heterofermentative bacteria, hindering reduction of pH of silages (Table 2) and delaying the start of the stability phase (Jobim, Nussio, Reis, & Schmidt, 2007).

A suitable fermentation in the silo is desired when the forage ensiled has 280-340 g kg^{-1} DM, and, in these conditions, even soluble carbohydrate contents of 60-80 g kg^{-1} DM would be enough to trigger lactic fermentation, provided that the buffering capacity is not high. Therefore, in this study, it was found that sorghum monocropped and intercropped with Marandu palisadegrass and Piata palisadegrass, between rows, propitiated minimum DM content required in the forage to be ensiled in order to obtain quality silages (Table 1).

The ash content in silages of *Urochloa cultivars* was higher than in other silages ($p < 0.05$). This result is in line with Mehmet (2006) because the increase in the ash content of silages is probably associated with the loss of organic matter, due to the fermentation and oxidation processes.

Table 3. Concentration of organic acids of silage of sorghum and *Urochloa brizantha* cultivars monocropping or intercropping systems in different planting systems.

	Planting system			Planting system		
Forage system	Row	Between row	Mean	Row	Betweenrow	Mean
	Lactic (%)			Acetic (%)		
SM	56.3 b	58.1 b	57.2 A	19.9 b	14.9 b	17.4 A
SX	58.3 b	52.9 b	55.6 A	23.6 b	18.3 b	20.9 A
SP	60.4 b	55.7 b	58.1 A	27.6 b	25.7 b	26.6 A
Sorgo	88.5 a			14.5 b		
Marandu palisadegrass	20.7 c			50.7 a		
Xaraes palisadegrass	16.8 c			50.5 a		
Piata palisadegrass	17.1 c			43.9 a		
Means[1]	58.3 A	55.6 A		23.7 A	19.6 A	
CV (%)	.... 23.33			.... 32.71		
	Propionic (%)			Butyric (%)		
SM	0.9 b	0.8 b	0.8 A	0.5 b	0.6 b	0.5 A
SX	1.0 b	1.2 b	1.1 A	0.7 b	0.7 b	0.7 A
SP	0.8 b	1.0 b	0.9 A	0.8 ab	0.7 b	0.7 A
Sorgo	0.9 b			0.4 b		
Marandu palisadegrass	6.8 a			1.5 a		
Xaraes palisadegrass	6.3 a			1.4 a		
Piata palisadegrass	7.5 a			1.6 a		
Mean[1]	0.9 A	1.0 A		0.6 A	0.6 A	
CV (%)	.... 43.32			.... 25.95		

SM: Sorghum x Marandu palisadegrass; SX: Sorghum x Xaraes palisadegrass; SP: Sorghum x Piata palisadegrass; Mean[1]: means followed by different uppercase letters in the same row of the intercropping system in two planting systems are significantly different by Tukey's test at 5% probability; Means followed by different uppercase letters in column are significantly different by Tukey's test at 5% probability; Means followed by different lowercase letters are significantly different from sorghum monocrop by Dunnett's test at 5% probability.

Table 4. Dry matter (DM), ash, crude protein (CP) and ether extract (EE) of silage of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems.

	Planting system			Planting system		
Forage system	Row	Between row	Mean	Row	Between row	Mean
	DM (g kg^{-1})			Ash (g kg^{-1})		
SM	257.2 b	290.9 b	274.1 A	46.3 c	39.0 c	42.6 B
SX	264.1 b	267.6 b	265.8 A	56.8 b	49.0 bc	52.9 A
SP	271.0 b	283.5 b	277.2 A	55.1 b	45.1 c	50.1 A
Sorgo	331.8 a			36.8 d		
Marandu palisadegrass	226.4 b			71.0 a		
Xaraes palisadegrass	235.9 b			70.7 a		
Piata palisadegrass	239.6 b			72.7 a		
Means[1]	264.1 B	280.7 A		52.7 B	44.4 A	
CV (%)	.... 10.25			.... 8.93		
	CP (g kg^{-1})			EE (g kg^{-1})		
SM	92.8 a	90.6 a	91.7 A	30.5 b	27.5 b	29.0 A
SX	89.0 a	89.0 a	89.0 A	29.7 b	29.2 b	29.4 A
SP	93.8 a	96.1 a	95.0 A	29.1 b	27.0 b	28.1 A
Sorgo	81.9 b			39.9 a		
Marandu palisadegrass	98.2 a			16.7 c		
Xaraes palisadegrass	95.0 a			16.7 c		
Piata palisadegrass	96.3 a			13.7 c		
Mean[1]	91.9 A	91.9 A		29.7 A	27.9 A	
CV (%)	.... 16.53			.... 9.46		

SM: Sorghum x Marandu palisadegrass; SX: Sorghum x Xaraes palisadegrass; SP: Sorghum x Piata palisadegrass; Mean[1]: means followed by different uppercase letters in the same of the intercropping system in two planting systems are significantly different by Tukey's test at 5% probability; Means followed by different uppercase letters in the same column are significantly different by Tukey's test at 5% probability; Means followed by different lowercase letters are significantly different from sorghum monocrop by Dunnett's test at 5% probability.

Table 5. Neutral detergent fiber (NDF), acid detergent fiber (ADF), in vitro dry matter digestibility (IVDMD) and total digestible nutrients (TDN) of silage of sorghum and *Urochloa brizantha* cultivars monocropped or intercropped in different planting systems.

Forage system	Planting system			Planting system		
	Row	Between row	Mean	Row	Between row	Mean
	NDF (g kg^{-1})			ADF (g kg^{-1})		
SM	703.6	723.4	713.5 A	365.4 a	364.4 a	364.9 AB
SX	689.4	675.3	682.3 A	383.5 a	381.7 a	382.6 A
SP	665.5	691.2	678.35 A	384.1 a	326.5 b	355.3 B
Sorgo	624.8			343.5 a		
Marandu palisadegrass	730.1			406.6 a		
Xaraes palisadegrass	701.1			401.4 a		
Piata palisadegrass	711.0			402.4a		
Mean[1]	686.2 A	696.6 A		377.6 A	357.6 B	
CV (%)	.... 6.46			.... 6.51		
	IVDMD (g kg^{-1})			TDN (g kg^{-1})		
SM	546.6	535.7	511.2 A	630.3 b	633.7 b	632.0 A
SX	561.6	540.6	551.1 A	639.0 b	639.7 b	639.3 A
SP	571.1	570.4	570.8 A	621.7 b	635.3 b	628.5 A
Sorgo	649.0 a			700.0 a		
Marandu palisadegrass	486.0 b			520.0 c		
Xaraes palisadegrass	551.9 b			509.7 c		
Piata palisadegrass	557.2 b			499.0 c		
Mean[1]	561.9 A	548.9 A		630.3 A	636.2 A	
CV (%)	.... 17.33			.... 23.71		

SM: Sorghum x Marandu palisadegrass; SX: Sorghum x Xaraes palisadegrass; SP: Sorghum x Piata palisadegrass; Mean[1]: means followed by different uppercase letters in the same row of the intercropping system in two planting systems are significantly different by Tukey's test at 5% probability; Means followed by different uppercase letters in the same column are significantly different by Tukey's test at 5% probability; Means followed by different lowercase letters are significantly different from sorghum monocrop by Dunnett's test at 5% probability.

With respect to CP, it is observed in Table 4 the lower value was obtained sorghum silage if different ($p < 0.05$) from other silages, and these values were higher than those found by Machado et al. (2012), which was 5.92 at the dough stage, probably related to the greater proportion of panicles in the DM, once the hybrid used was the grain hybrid. It is noteworthy that in all forage systems, silages showed CP levels above 70 g kg^{-1} DM, the minimum for no impairment of ruminal microbial growth and consequently to occur efficient use of the fiber of silages (Lazzarini et al., 2009).

The mean EE content of silages of *Urochloa brizantha* cultivars in monocrop was lower ($p < 0.05$) than those of other systems (Table 4). This is due to the lower EE content in plants of the *Urochloa* genus compared to sorghum, reflecting directly in the TDN content.

As for the NDF, values were not different between the silages, with mean values of 686.4; 684.8 and 714.1 g kg^{-1} DM, for intercropping systems and monocrops of sorghum and *Urochloa brizantha* cultivars, respectively (Table 5). The NDF of silage of sorghum in monocrop was close to that reported by Nascimento et al. (2008), 659.2 g kg^{-1} DM, in the study of the nutritional value of corn and sorghum silages.

There was a significant effect ($p < 0.05$) on ADF content of silages (Table 5). The lowest value was obtained in the silage intercropped with Piata palisadegrass between rows. This is possibly because the Piata palisadegrass has high leaf: stem ratio, thin stems and, consequently, can be considered as grass with high production potential and good nutritional value for ensiling (Epifanio et al., 2014; Perim et al., 2014).

Sampaio et al. (2009) emphasizes that the reduction in ADF of diets containing high proportion of roughage may contribute to increase the IVDMD, resulting in increased energy density of feed for ruminants.

For the IVDMD, the values were not similar ($p > 0.05$) between the intercropping systems in the two planting systems. However, when comparing forage systems, sorghum silage in monocrop showed higher IVDMD compared to monocrops of the cultivars of *Urochloa brizantha*. This result may be due to the presence of grains in the sorghum crop.

Values of TDN content were higher ($p < 0.05$) in sorghum silage (Table 5), followed by silage of intercropping systems. The highest value observed in sorghum silage may be because sorghum contains higher concentration of non-fiber carbohydrates and ether extract. TDN content is important, since energy and protein are often the most limiting factors to ruminant production (Oliveira et al., 2010). Based on these results, it can be suggested that the presence of sorghum in intercropping systems raised the TDN. A similar finding was observed by Leonel et al. (2009), who reported that the average TDN content of silages in intercropping systems was higher than those achieved in the silages of grasses in monocrop.

Therefore, it is worth mentioning the importance of the crop-livestock integration system aimed at increasing the efficiency of the energy content for silage and the importance in the determination for balancing and optimizing diets.

Conclusion

The planting system of intercropping systems did not interfere with the fermentation characteristics and chemical composition of silages. The same was found for *Urochloa* cultivars.

Silages from intercropping sorghum with *Urochloa brizantha* cultivars had lower values of pH, buffering capacity, NH_3-N, acetic and butyric acids and higher values of lactic acid, besides showed superior quality, as for the parameters DM, EE and TDN than silages of grasses produced in monocropping system.

Therefore, silages of intercropping systems ensure proper fermentation and nutritional quality, providing interesting supplementary bulky options to be used in the offseason for feeding animals.

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