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Protein fraction and digestibility of marandu, xaraes and campo grande grasses in monocropping and intercropping systems under different sowing methods

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ABSTRACT. A study was carried out to evaluate the protein fraction and *in vitro* dry matter digestibility of marandu, xaraes grasses and campo grande in monocropping and intercropping systems under different planting methods, for a period of two years. The experimental design was a complete randomized block with four replications. The treatments consisted of the following crop systems: campo grande in monocropping; xaraés grass in monocropping; marandu grass in monocropping; xaraés intercropped with campo grande in rows; xaraés intercropped with campo grande, broadcast; marandu grass intercropped with campo grande in rows; and marandu intercropped with campo grand, broadcast. The evaluations were conducted for two years, consisting of seasonal evaluations (autumn, winter, spring and summer) in the same plots, with repeated measurements over time. The results showed that xaraes and marandu grasses were similar between crop systems, indicating that both can be intercropped with campo grande. The intercropping of campo grande with *Brachiaria brizantha* cultivars improved the protein fraction and digestibility. The row method of planting provided better protein fractions and *in vitro* dry matter digestibility.

Keywords: *Brachiaria brizantha*, persistence, *Stylosanthes* spp., nutritional value.

Fracionamento de proteínas e digestibilidade dos capins marandu, xaraés e campo grande em cultivo solteiro e consorciado em diferentes métodos de plantio

RESUMO. Desenvolveu-se esse estudo com o objetivo de avaliar o fracionamento das proteínas e digestibilidade *in vitro* da matéria seca dos capins marandu, xaraés e campo grande em cultivo solteiro e consorciado em diferentes métodos de plantio, por um período de dois anos. O delineamento experimental utilizado foi de blocos completos ao acaso, com quatro repetições. Os tratamentos foram constituídos dos seguintes sistemas forrageiros: capim-xaraés solteiro; capim-marandu solteiro; campo grande solteiro; capim-xaraés consorciado com campo grande em linha; capim-xaraés consorciado com campo grande a lanço; capim-marandu consorciado com campo grande em linha e capim-marandu consorciada com campo grande a lanço. As avaliações foram realizadas durante dois anos, consistindo em avaliações por estações do ano (outono, inverno, primavera e verão) nas mesmas parcelas, com medidas repetidas no tempo. Os resultados demonstraram que os capins xaraés e marandu mostraram semelhanças entre os sistemas de consórcio, indicando que ambos podem ser consorciados com o campo grande. O consórcio do campo grande com os cultivares de *Brachiaria brizantha* traz melhoria no fracionamento das proteínas e digestibilidade. O método de plantio em linha proporcionou melhores frações proteicas e digestibilidade *n vitro* da matéria seca.

Palavras-chave: *Brachiaria brizantha*, persistência, *Stylosanthes* spp., valor nutritivo.

Introduction

The introduction of legumes in pasture increases animal production, in terms of quality and quantity of offered forage. This results not only in the participation of these legumes in animal diets, but also in the indirect effects related to biological nitrogen fixation and its transfer to the ecosystem grazing, capable of producing good yields and quality of forage and, consequently, good animal performance (RIBEIRO et al., 2008).

It is important to evaluate that the nutritional needs of ruminants depend mainly on the energy and protein contents of the diet. Therefore, new systems and methodologies for assessing ruminant feeds are being used to maximize nutrient use by animals. The Cornell Net Carbohydrate and Protein System (CNCPS) is a system that considers the ruminal fermentation dynamics and the potential loss of nitrogen as ammonia in feed evaluation and aims to adjust the ruminal digestion of carbohydrates and proteins in order to maximize microbial synthesis, reduce losses of nitrogen by the animals and estimate the ruminal escape of nutrients (SNIFFEN et al., 1992).

Knowledge of nutrient utilization by animals is also of fundamental importance, and is obtained through digestibility and ruminal degradability studies. Among the techniques employed to evaluate ruminal degradability, the *in vitro* method should be able to represent the process of digestion that occurs in the rumen, abomasum or intestine to quantitatively estimate the rate and extent of digestion, similarly to what happens *in vivo* (BERCHIELLI et al., 2006).

The aim of this study was to evaluate the protein fractions and *in vitro* dry matter digestibility of marandu, xaraes and campo grande grasses in monocropping and intercropping systems under different planting methods, over a period of two years.

Material and methods

The experiment was carried out at the University of Rio Verde, located at Fontes do Saber Farm. The total area of the experiment was approximately 500 m^2, and each plot was 4 m long and 4 m wide, with a total of 16 m^2.

The experimental design was a complete randomized block with four replications. The treatments consisted of the following crop systems: campo grande in monocropping; xaraés grass in monocropping; marandu grass in monocropping; xaraés intercropped with campo grande in rows; xaraés intercropped with campo grande, broadcast; marandu grass intercropped with campo grande in rows; and marandu intercropped with campo grand, broadcast. The evaluations were conducted for two years, consisting of seasonal evaluations (autumn, winter, spring and summer) in the same plots, with repeated measurements over time.

The soil was classified as distroferric Red Latosol (Oxisol), (EMBRAPA, 2006); its chemical and physical characteristics in the 0-20 cm layer are shown in Table 1.

Table 1. Physical and chemical characteristics of soil from forage systems in the years 2008 and 2009.

Characteristics	2008	2009	Characteristics	2008	2009
pH ($CaCl_2$)	4.4	5.1	V (%)	32.0	46.0
Al^{3+} ($cmol_c$ dm^{-3})	0.45	0.1	Cu (mg dm^{-3})	3.4	2.7
H+Al ($cmol_c$ dm^{-3})	4.8	4.1	Zn (mg dm^{-3})	1.5	1.9
Ca^{2+} ($cmol_c$ dm^{-3})	1.36	2.19	Fe (mg dm^{-3})	43.0	30.0
Mg^{2+} ($cmol_c$ dm^{-3})	0.73	0.98	Mn (mg dm^{-3})	38.4	41.0
K^+ ($cmol_c$ dm^{-3})	0.17	0.33	M.O. (g dm^{-3})	18.6	21.7
CTC ($cmol_c$ dm^{-3})	7.05	7.6	Clay (g kg^{-1})	600	600
P-Mehlich-1 (mg dm^{-3})	2.07	4.3	Silt (g kg^{-1})	350	350
SO_4^{-2} (mg dm^{-3})	9.6	10.9	Sand (g kg^{-1})	50	50

The area was prepared by eliminating invasive plants, with application of glyphosate at a dosage of 1,500 g ha^{-1}. Twenty days after desiccation 900 kg ha^{-1} of lime (100% PRNT) were applied, followed by harrowing and followed by leveling.

During planting, 100 kg ha^{-1} P_2O_5, 60 kg ha^{-1} of K_2O and 20 kg ha^{-1} of FTE BR-12 were applied, using single super phosphate, potassium chloride and fritted trace elements as sources, respectively. In the second year, maintenance fertilization was done using 80 kg ha^{-1} of P_2O_5 and 60 kg ha^{-1} of K_2O, from the simple super phosphate and potassium chloride sources, respectively. In the monocropping grasses, 90 kg ha^{-1} of nitrogen per year were applied, parceled in three applications, in the ammonium sulfate source.

For forage seeding, 5 and 9 kg of viable seeds were applied per hectare of campo grande and marandu and xaraes grasses, for each forage system, respectively. Intercropped seeding in rows consisted of eight rows with 4.0 m each, totaling four rows of grass and four rows of legumes, with 50 cm spacing. After germination the plants were cut, maintaining the same number of grass and legume plants.

The forage systems were evaluated in the rainy and dry seasons, by collecting two 1-m^2 samples per plot, directing the square in each row of useful fodder in the area, so that grasses and legumes were sampled. For the broadcasting method of seeding, the square was placed randomly within each plot. Fourteen cuts were made or evaluation, over two years, with the following periods: autumn (March and May 2008/2009), winter (July and September 2008/2009), spring (October and December 2008/2009), and summer (January 2009/2010). After each evaluation, cuts were made to standardize the entire experimental area, and residues were removed.

The material collected in the field was placed in plastic bags and sent to the lab, where a representative sample was collected for each plot, (approximately 500 g) and placed in a forced-air oven at a temperature of 65°C for 72 hours for pre-drying. Subsequently, the samples were milled and stored in plastic bags for analysis.

The methodologies adopted for determining nitrogen fractions were from Krishnamoorthy et al. (1982) and Licitra et al. (1996). Protein fractions were calculated following the methodology adopted by the Cornell (CNCPS) program (SNIFFEN et al., 1992), and *in vitro* digestibility was determined by the procedure of Tilley and Terry (1963), with two 48-hour incubation stages.

During the experiment, temperature and precipitation data were monitored (Figure 1).

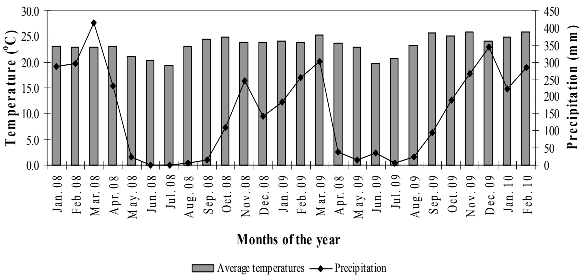

Figure 1. Average temperatures (°C) and precipitation (mm) observed during the period of January 2008 to February 2010 in Rio Verde, Goiás State.

The data were subjected to analysis of variance, and means were compared by Tukey's test, with a significance level of 5% probability. Analyses were performed by the split-plot model in time, as the adequacy of linear Gaussian Markov models using the software SISVAR (FERREIRA, 2000).

Results and discussion

Analyzing the forage systems within each season, it is observed in Table 2 that in the autumn and spring, the A fraction differed from the other systems only for monocropping grasses, which had smaller fractions. In winter, intercropping systems with xaraes grass rows and broadcast, as well as marandu grass rows, had larger fractions. In summer campo grande in monocropping and intercropped with grasses in rows differed from all other systems, with higher A fractions. According to Russell et al. (1992), sources of non-protein nitrogen (NPN) are essential for proper rumen functioning because ruminal microorganisms, which ferment structural carbohydrates, use ammonia as a nitrogen source.

Table 2. A, B1, B2, B3 and C fraction of forage systems, measured in different seasons (average of two years).

Forage Systems	Seasons			
	Autumn	Winter	Spring	Summer
	A Fraction			
Campo grande	63.27 Aa	40.38 Bc	56.68 Ab	62.46 Aa
Xaraes	56.16 Ba	39.64 Bc	48.07 Cb	53.61 Ca
Marandu	57.10 Ba	39.98 Bc	47.69 Cb	54.00 Ca
Xaraes x campo grande rows	62.43 Aa	45.26 Ac	57.79 Ab	61.40 Aa
Xaraes x campo grande broadcast	59.04 Aa	44.58 Ab	56.70 Aa	56.60 Ba
Marandu x campo grande rows	62.07 Aa	45.32 Ab	56.69 Aa	59.00 Aa
Marandu x campo grande broadcast	58.20 Ba	40.61 Bc	55.92 Ab	55.28 Bb
CV (%)	3.59			
	B1 Fraction			
Campo grande	10.59 Aa	10.67Aa	11.14 Aa	10.90 Aa
Xaraes	8.49 Ba	8.55 Bb	7.31 Cb	9.39 Ba
Marandu	8.70 Ba	8.44 Bb	7.99 Cb	9.59 Ba
Xaraes x campo grande rows	9.78 Aa	9.55 Aa	10.55 ABa	10.33 Aa
Xaraes x campo grande broadcast	9.19 Aa	8.00 Bb	8.98 Cb	7.72 Bb
Marandu x campo grande rows	9.16 Aa	9.64 Aa	9.87 Ba	9.37 Ba
Marandu x campo grande broadcast	9.15 Ba	10.56 Aa	8.93 Ca	8.11 Ba
CV (%)	20.66			
	B2 Fraction			
Campo grande	10.56 Aa	9.79 Ab	10.14 Ba	10.05 Aa
Xaraes	9.49 Ab	8.17 Bb	12.38 Aa	8.13 Bb
Marandu	8.10 Bb	8.52 Bb	12.13 Aa	8.87 Bb
Xaraes x campo grande rows	10.46 Aa	9.93 Ab	10.31 Ba	11.27 Aa
Xaraes x campo grande broadcast	10.00 Aa	8.20 Bb	10.96 Ba	11.34 Aa
Marandu x campo grande rows	9.53 Aa	9.70 Ab	10.79 Ba	11.40 Aa
Marandu x campo grande broadcast	10.88 Aa	8.89 Ab	10.63 Ba	10.21 Aa
CV (%)	18.61			
	B3 Fraction			
Campo grande	6.86 Cb	9.78 Ba	8.57 Bb	8.95 Bb
Xaraes	10.46 Aa	12.50 Aa	11.58 Aa	10.90 Aa
Marandu	10.03 Aa	12.03 Aa	10.34 Aa	10.10 Aa
Xaraes x campo grande rows	7.79 BCb	8.54 Ba	8.05 Ba	7.60 Bb
Xaraes x campo grande broadcast	8.38 Ba	9.87 Ba	8.23 Ba	9.22 Aa
Marandu x campo grande rows	7.43 BCb	8.76 Ba	9.83 Bb	8.23 Bb
Marandu x campo grande broadcast	8.71 Ba	9.97 Ba	8.40 Bb	9.42 Aa
CV (%)	25.25			
	C Fraction			
Campo grande	8.71 Cc	29.38 Aa	13.38 Bb	7.56 Cc
Xaraes	15.39 Ac	31.14 Aa	20.66 Ab	18.00 Ac
Marandu	16.06 Ac	31.03 Aa	21.85 Ab	17.44 Ac
Xaraes x campo grande rows	9.54 Cc	26.77 Ba	13.30 Bb	9.40 Bc
Xaraes x campo grande broadcast	13.39 Bc	29.35 Aa	15.13 Bb	15.12 Ab
Marandu x campo grande rows	11.81 Bb	26.49 Ba	12.82 Bb	12.00 Bb
Marandu x campo grande broadcast	13.06 Bb	29.97 Aa	16.12 Bb	16.98 Ab
CV (%)	10.16			

Means followed by different capital letters in columns (forage systems) and lowercase in rows (seasons) differ by Tukey's test ($p < 0.05$).In all studied seasons, the smallest fractions were obtained in monocropping systems. This result is due to lower levels of crude protein in grasses compared with legumes. When intercropped with campo grande, there is an improvement in the A fraction because of the presence of legumes in the system. Barcellos et al. (2008) reported that biological nitrogen fixation from the air, through the symbiotic association of their roots with bacteria of the Rhizobium genus, becomes available to grasses in intercropping, improving the nutritional quality of forage and diet quality for animal. This result is important because the A fraction represents the soluble fraction, with rapid ruminal degradation.

Comparing the seasons within each forage system, it can be noted that the A fraction of campo grande remained similar during autumn, spring and summer, differing only in winter. However, the highest fractions for monocropped and intercropped grasses were obtained in autumn and summer, due to improved weather conditions during that period (Figure 1). During those seasons, the A fraction was considered high, indicating rapid ruminal degradation. Therefore, the higher, the increase in A fraction values there is an increase in the supply of carbohydrate of rapid degradation, for appropriate synchronism of carbohydrates and protein fermentation in rumen.

The A fraction was not affected ($p < 0.05$) when comparing the evaluated years for monocropping and intercropping systems in rows (Figure 2a). However, for the broadcasting seeding system, there was a decrease in the A fraction of 7.2% and 7.8% during the second year for the intercropping of xaraes and marandu grasses, respectively. This result is due to the lower persistence of the legume to survive along with grasses in the broadcasting intercropping system due to increased competition among the forages.

On the other hand, when the intercropping seeding was done in rows, the A fraction was similar between the studied years, showing that this seeding system increases legume persistence, with greater chance of persisting longer in the system, because of plant spacing is 50 cm, which avoids competition for water and nutrients between legume and grass, which is more aggressive (AROEIRA et al., 2005).

Analyzing the B1 fraction of forage systems within each season, it is observed in Table 2 that for all seasons, the smaller B1 fractions were found in the monocropping grasses and the highest in the intercropped grasses in rows and monocropped campo grande.

Sniffen et al. (1992) reported that the B1 fraction is the soluble fraction that is rapidly degraded in the rumen. Therefore, it is important to note that the participation of legume intercropped systems in rows increased the B1 fraction, favoring better ruminal degradation, because it can ensure better synchronization between carbohydrate and protein fermentation in the rumen and consequently promote better microbial growth, resulting in better utilization of nutrients.

Regarding the seasons within each forage system, it is observed that the monocropped campo grande and intercropped with xaraes and marandu in rows and marandu broadcast maintained imilar B1 fraction values, in all seasons, with better results. As for monocropped grasses, the largest fractions were obtained in autumn and summer, which differed from winter and spring. This can be explained by the improved climate conditions during these periods (Figure 1), as there was water stress during winter and early spring, causing accumulation of dead material. For xaraes broadcast intercropped system, only autumn differed from the other seasons, with higher B1 fraction values.

Some authors reported a deficiency of the B1 fraction in protein of tropical forages (RUSSELL et al. 1992; SNIFFEN et al., 1992), but this was not observed in this study for monocropped grasses, which had values between 7.31 and 9.39% of B1 fraction, in the seasons.

When comparing the B1 fraction of the evaluated years in different forage systems, it is observed in Figure 2b that only intercropped xaraes in rows was not influenced by the studied years. However, for all other systems there was a significant effect ($p < 0.05$) between years, where the largest B1 fractions were obtained in the first year of implementation, with a decrease of the fraction in the second year.

The B2 fraction is considered the fraction of intermediate degradation (SNIFFEN et al., 1992). When looking at B2 Fraction of forage systems within each season, it is observed in Table 2 that for autumn, spring and summer, only monocropped grasses differed from other systems. However, for winter, the B2 fraction values were similar between the monocropped and intercropped broadcast grass systems.

With respect to the seasons within each forage system (Table 2), for monocropped campo grande and intercropped with grasses in rows and broadcast, the B2 fraction values were similar between the autumn, spring and summer seasons, differing only from winter, which had smaller fractions. For monocropped grasses, meanwhile, the B2 fraction was different from other seasons only in the spring, with higher values.

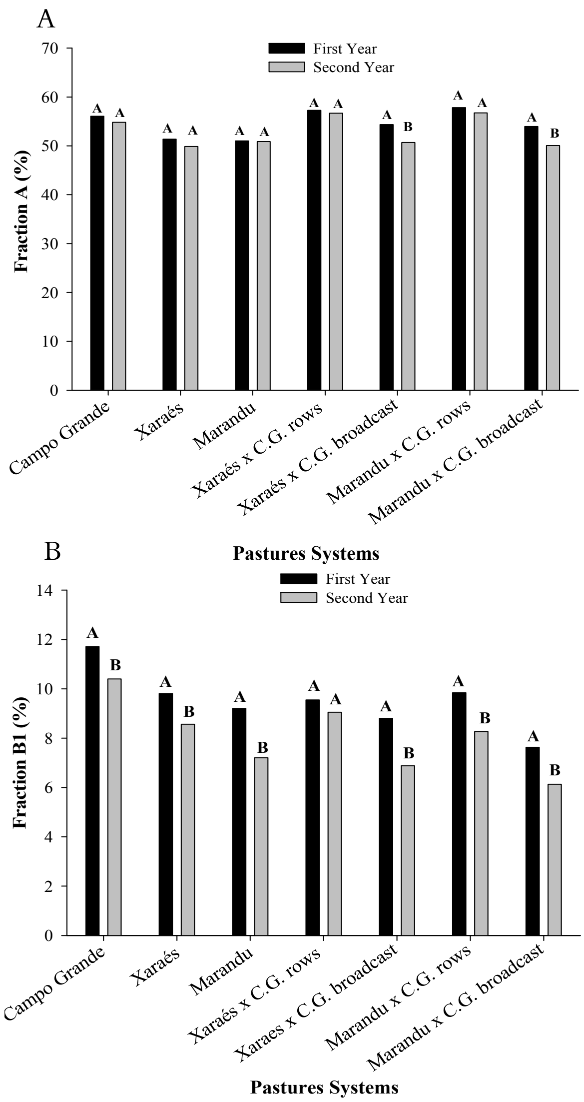

Figure 2. A (a) and B1 (b) fractions of forage systems evaluated in the first and second years.

For the studied seasons, with the exception of spring, campo grande monocropped and intercropped with grasses in rows and broadcast showed the highest values of fraction B2. These results demonstrate the benefit the legume can have in improving the quality of tropical grasses.

According to Sniffen et al. (1992), the B1 + B2 fraction, due to its rapid rate of ruminal degradation compared to the B3 fraction, tends to be extensively degraded in the rumen, helping to meet the nitrogen requirements of rumen microorganisms, but the rapid proteolysis in rumen of these fractions can lead to peptide accumulation and allow their escape into the intestines, since the use of peptides is considered limiting to protein degradation.

Sá et al. (2010), B1 + B2 fraction values of 53.8, 45.3 and 39.4% were found for marandu grass at cutting ages of 28, 35 and 54 days, respectively. These values were higher than those obtained in this study for monocropped grasses.

The B2 fraction remained stable over the years in forage systems, as it does not show any difference between the first and second years of evaluation for the campo grande system, either monocropped or intercropped with grasses in rows and broadcast. Only fractions of monocropped grasses were influenced by the evaluated year, with an increase of 9.0% and 9.5% in the B2 Fraction from the first to second year for xaraes and marandu grasses, respectively (Figure 3a).

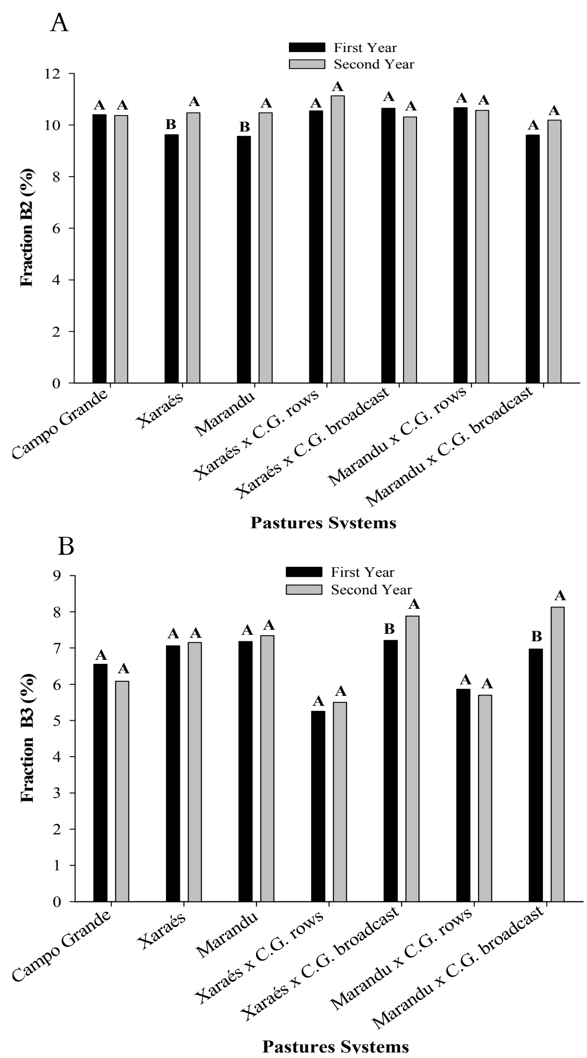

Figure 3. B2 (a) and B3 (b) fractions of forage systems evaluated in the first and second years.

The B3 fraction shows a very slow rate of degradation, as it is associated with plant cell walls. This fraction is represented by extensive proteins bound to the cell wall, thus showing slow degradation rate, which is primarily digested in the intestines (SNIFFEN et al., 1992). When analyzing the forage systems within each season, it is observed in Table 2 that the B3 fraction of monocropped and intercropped campo grande in rows and broadcast were similar for all seasons, differing only from monocropped grasses. The seeding method did not affect the values for that fraction, showing similar results. However, the largest B3 fractions were obtained in monocropped grass systems, ranging from 10.10 to 11.54%, showing that these grasses have very slow degradation when compared to other systems. These results are attributed to lower levels of crude protein in grasses compared to campo grande, hence larger B3 fractions are obtained in these forages, with slower degradation.

Regarding the season within each forage system, it is observed that the B3 fraction of monocropped grasses and marandu grass intercropped in rows were similar between the studied seasons (Table 2). As for campo grande, only the winter fraction differed from the other seasons. For xaraes grass intercropped in rows, the smallest fractions were obtained in autumn and summer, and autumn and spring for intercropped broadcast xaraes and marandu.

Higher values for the B3 fraction were obtained in the study by Velásquez et al. (2010), who while evaluating the protein fractions of tropical forages cut at different ages, observed the B3 fraction ranging from 23.77 to 33.40%.

When comparing the B3 fraction of years in different forage systems, it is observed in Figure 3b that the B3 fractions were similar between the evaluated years in monocropped campo grande, monocropped grasses in rows and intercropped. However, for the broadcast intercropped grasses there was an increase of 9.3 and 16.5% in the B3 fraction when comparing the first and second years for xaraes and marandu intercropping, respectively. This increase is correlated to the lowest participation of campo grande in the second year of the system, due to lower persistence of the legume to survive along with grass when seeding by broadcasting.

The C fraction corresponds to unavailable nitrogen, and consists of protein and nitrogen compounds associated with lignin (SNIFFEN et al., 1992). Analyzing the C fraction of forage systems within each season, it is observed in Table 2 that in autumn the lowest C fractions were obtained for monocropped campo grande and intercropped xaraes grass in rows, while the highest values were found in monocropped grasses. These higher fractions in monocropped grasses may be explained due to lower CP levels and higher NDF, ADF and lignin values in the cell walls in grasses compared to legumes.

In winter, only grasses intercropped in rows differed from the other systems, with smaller C fractions. During this period, campo grande had a high C fraction due to the low resistance of that legume in the dry season, in natural reseeding occurs starting in May, since their plants are mostly annual and biennial.

In the spring, the major fractions were obtained in monocropped grasses, which differed from other production systems. In summer, the smallest fractions were observed in monocropped campo grande, followed by the rows intercropped with grasses. In the broadcast intercropped system, the C fractions were similar to monocropped grasses, showing that in the seasons, there was a significant decrease in the percentage of legume in the broadcast intercropping system due to increased competition for water, light and nutrients, and also between plants of *Brachiaria brizantha*, as they are plants with higher photosynthetic efficiency (C4 cycle) under tropical conditions, competing better than legumes, which belong to the C3 cycle (AROEIRA et al., 2005). This shows that the best method of sowing in the experimental conditions to favor the persistence of the legume in the seasons and years would be the rows planting by maintaining a more balanced proportion of forage.

When comparing the C fraction of the seasons within each forage system (Table 2), it is observed that in autumn and summer, in campo grande, monocropped grasses and xaraes grass intercropped rows showed similar fractions. In the broadcast intercropped xaraés the smallest C fraction was obtained in the autumn. Moreover, it can be observed that during the autumn, spring and summer the C fraction of marandu grass intercropped rows and broadcast was similar, differing only from winter.

Velásquez et al. (2010), evaluating protein fractions in tropical forages cut at different ages, found C fraction values from 19.66 to 27.04%. These values were similar to those obtained in this study, which ranged from 15.38 to 29.13% among the studied seasons.

In all seasons, the highest C fractions were obtained in winter. This can be explained by the fact that the conditions of temperature and precipitation (Figure 1) limited development, jeopardizing growth and formation of new tillers in all forage systems.

Fraction C was influenced ($p < 0.05$) when comparing the evaluated years of forage systems, with the exception of the of xaraes grass intercropped rows, which showed similar fraction values in both years (Figure 4a). As for the other systems, the major fractions were obtained in the second year. For broadcast intercropped systems, these larger fractions may correlate to the smaller number of campo grande plants in the second year of the intercropping with grasses, due to the low persistence of the legume when submitted to this form of planting because it competes directly with more aggressive grasses.

Analyzing the *in vitro* digestibility of dry matter forage systems within each season, is observed in Table 3 that the lowest digestibility in autumn was obtained in monocropped campo grande, followed by CG intercropped with grasses in rows and broadcast. In winter, the monocropped and intercropped campo grande in rows showed similar digestibility levels, differing from monocropped and broadcast intercropped systems, which had lower digestibility. In the spring, intercropping systems showed similar digestibility compared to monocropped campo grande. In summer, the digestibility was similar in intercropped and monocropped broadcast grasses, evidencing low persistence of the legume in the seasons in this planting form, influencing the digestibility of food by animals, because it contains lower levels of CP in these systems.

It is important to highlight that the intercropping of grass and legumes brings considerable benefits in forage quality. In this sense, it is observed that when the grasses were intercropped with campo grande, there was a significant increase in digestibility, especially in row sowing systems.

When comparing the digestibility in the seasons within each forage system (Table 3), it appears that for the monocropped campo grande and grass the digestibility remained stable between the seasons of autumn, spring and summer, differing only in winter, with low levels. However, for the rows and intercropped broadcast grasses the highest digestibility were obtained in spring, followed by autumn and summer, which showed similar levels. Alencar et al. (2009), evaluating N doses and seasons in the digestibility of marandu grass under grazing, found that in the spring and summer, marandu grass had higher digestibility.

Among the studied seasons, the lowest digestibility for all forage systems were observed in winter due to unfavorable weather conditions during that season (Figure 1), compromising forage quality.

Comparing the digestibility between the years, it is observed in Figure 4b that the digestibility differed among the studied years only in the intercropped broadcast system. The lowest levels were obtained in the second year, with a reduction of 7.12 and 6.2% for the intercropping of xaraes and marandu grasses, respectively. This decrease in digestibility can be associated with lower persistence of campo grande under this form of seeding. On the other hand, when the intercropping was sown in rows, the digestibility was stable between years and did not impair forage quality. This was due to the management adopted in this system, using 50 cm row spacing, which resulted in less competition between grasses and campo grande, showing advantage in this form of sowing.

Table 3. *In vitro* dry matter digestibility (%) of forage systems, evaluated in different seasons of the year (average of two years).

Forage Systems	Seasons			
	Autumn	Winter	Spring	Summer
Campo grande	76.78 Aa	59.23 Ab	74.66 Aa	75.86 Aa
Xaraes	66.13 Ca	52.93 Bb	64.30 Ba	64.36 Ca
Marandu	65.43 Ca	53.73 Bb	64.56 Ba	64.26 Ca
Xaraes x campo grande rows	70.56 Bb	57.50 Ac	74.08 Aa	72.91 Bb
Xaraes x campo grande broadcast	68.23 Bb	54.76 Bc	72.83 Aa	66.56 Cb
Marandu x campo grande rows	70.33 Bb	57.66 Ac	75.66 Aa	70.53 Bb
Marandu x campo grande broadcast	69.63 Bb	53.96 Bc	72.46 Aa	64.96 Cb
CV (%)		1.95		

Means followed by different capital letters in columns (forage systems) and lowercase in rows (seasons) differ by Tukey's test ($p < 0.05$).

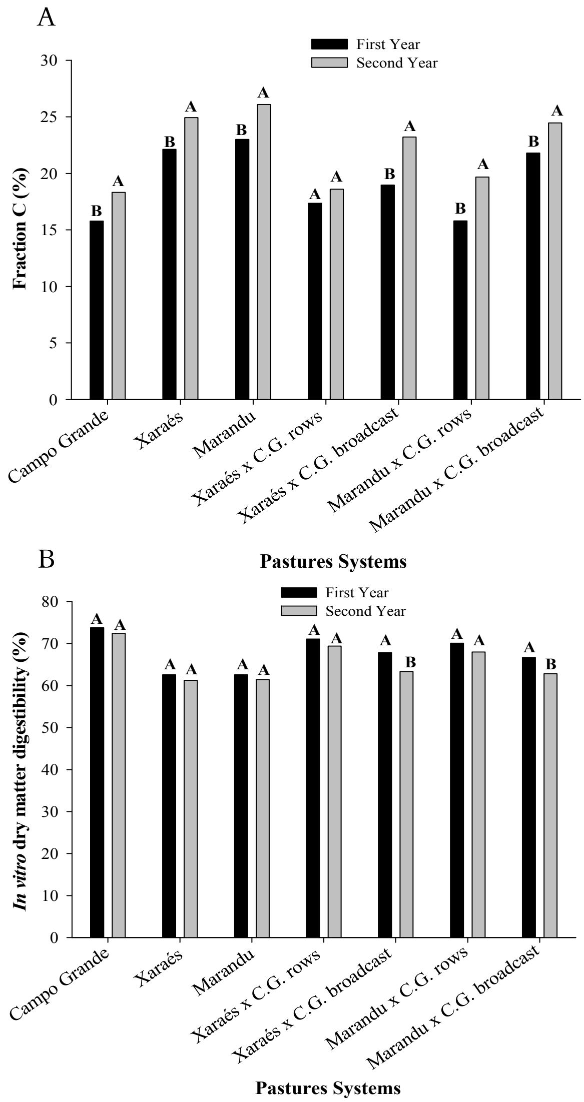

Figure 4. C fraction (a) and *in vitro* DM digestibility (b) of different forage systems, evaluated in the first and second years.

Barcellos et al. (2008) reported that *Brachiaria brizantha* cv. Marandu has proved to be the most aggressive grass, jeopardizing the stability of pasture intercropped with herbaceous or low stature legumes

Conclusion

The xaraes and marandu grasses proved to be similar among the intercropped systems, indicating that both can be intercropped with campo grande.

The intercropping of campo grande with *Brachiaria brizantha* cultivars improved protein fractions and digestibility. The row seeding method provides the best protein fractions and *in vitro* digestibility of dry matter.

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