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Productivity and nutritional value of tropical grasses in monoculture and intercropping with interseason corn

Produtividade e valor nutritivo de gramíneas tropicais em monocultivo e em consórcio com milho na segunda safra

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Abstract

This study aimed to assess productivity and nutritional value of the tropical grasses *Brachiaria brizantha* cv. Piatã, Xaraés, and Marandu, *Panicum maximum* cv. Mombaça, and *B. ruziziensis* cv. Kennedy in the interseason of an integrated crop-livestock (ICL) system since alternatives are needed for forage production for animal grazing in Autumn and Winter. The experimental design was a randomized block design in a split-split plot scheme with four replications. The treatments of plots consisted of five grasses, subplots consisted of three cropping systems (monoculture, intercropping with corn and unsuppressed grass, and intercropped with corn and suppressed grass), and sub-subplots consisted of four cutting intervals of grasses (50, 90, 125, and 195 days after emergence - DAE). The experiment was carried out from February to September 2014. Dry matter (DM) productivity, obtained at 195 DAE for the three cropping systems (monoculture grass, unsuppressed and suppressed grass in intercropping), were 18.45, 7.15, and 3.05 t ha^{-1}, respectively, and average crude protein contents of leaf blades of grasses decreased linearly between the cutting intervals of 50 to 195 DAE from 19.95 to 9.70%, respectively. Under integrated systems, the studied grasses showed better yields and nutritional quality when compared to traditional grazing systems. *Panicum maximum* cv. Mombaça and *Brachiaria brizantha* cv. Xaraés and Piatã had the highest leaf and crude protein yields when compared to *Brachiaria ruziziensis* cv. Kennedy and *Brachiaria brizantha* cv. Marandu. In terms of nutritional value, *Brachiaria ruziziensis* cv. Kennedy was superior to Mombaça and Xaraés grasses but had lower total dry matter yield. Finally, Xaraés, Piatã and Mombaça grasses are recommended choices ICL systems when fodder grass production is the goal.
Keywords: *Brachiaria*. Forages. Integrated crop-livestock. Interseason corn. *Panicum*.

Resumo

Objetivou-se com este estudo avaliar a produtividade e o valor nutritivo das gramíneas forrageiras tropicais: *Brachiaria brizantha* cvs. Piatã, Xaraés e Marandu, *Panicum maximum* cv. Mombaça e *B. ruziziensis* cv. Kennedy, em sistema de integração lavoura-pecuária (ILP), na segunda safra, buscando novas alternativas de produção de forragem para alimentação animal no outono-inverno. Utilizou-se delineamento experimental de blocos ao acaso em esquema de parcelas subsubdivididas, com quatro repetições. Os tratamentos das parcelas corresponderam às cinco forrageiras, às subparcelas corrresponderam a três sistemas de cultivo (monocultivo, consórcio com milho sem supressão e consórcio com milho com supressão), e às sub-subparcelas, quatro intervalos de corte das forrageiras

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(50, 90, 125 e 195 dias após a emergência, DAE). O experimento foi conduzido no período de fevereiro a setembro de 2014. As produtividades de matéria seca, obtidas aos 195 DAE, referentes aos três sistemas de cultivo (monocultivo, consórcio sem supressão e com supressão), foram de 18,45; 7,15 e 3,05 t ha^{-1}, respectivamente, e os teores de proteína bruta da lâmina foliar das forrageiras decresceram linearmente entre os intervalos de corte, de 50 a 195 DAE, de 19,95 % para 9,70%. O cultivo de forrageiras tropicais em sistemas integrados na segunda safra produz forragem de alta qualidade e quantidade para o outono-inverno. As gramíneas tropicais *Panicum maximum* cv. Mombaça e *Brachiaria brizantha* cvs. Xaraés e Piatã apresentaram maior produtividade de folhas e proteína bruta, em comparação às demais forrageiras em estudo. Em termos de valor nutritivo, *Brachiaria ruziziensis* cv. Kennedy foi superior aos capins Mombaça e Xaraés, porém apresentou menores produtividades de matéria seca total, folha e proteína bruta. De maneira geral, os capins Xaraés, Piatã e Mombaça são os mais indicados para o cultivo na segunda safra em sistema de ILP visando a produção de forragem para alimentação animal.
Palavras-chave: *Brachiaria*. Gramíneas forrageiras. Integração lavoura-pecuária. *Panicum*. Segunda safra.

Introduction

Beef cattle is an activity of great social and economic importance in Brazil, accounting for 167.5 billion dollars a year in the production chain (ABIEC, 2014).

Pasture degradation is one of the major problems of Brazilian livestock farming, directly affecting the sustainability of the production system and leading to a low productivity and forage quality, which directly affects productivity per animal and per area, resulting in late livestock with low zootechnical indices and profitability, besides contributing to soil and environment degradation (KICHEL et al., 2011).

According to Kichel et al. (2014b), pasture recovery in an integrated crop-livestock (ICL) system by means of the cultivation of grasses in monoculture or intercropped with grain crops provide great benefits for livestock due to the supply of food in a higher quantity and quality, with a lower production cost. Among the food options are the pasture formation, grain production, silage and hay production, as well as the use of agricultural residues, which increase productivity and quality of meat and milk, especially in the interseason.

Considering only the growth and fattening of animals, the average productivity of degraded pastures is about 30 kg of beef ha^{-1} year^{-1}, while in recovered, well-managed pastures under integrated crop-livestock systems, it can reach up to 450 kg ha^{-1} year^{-1} (KICHEL et al., 2014a).

The use of ICL systems, in addition to making livestock more precocious, increasing the profitability and competitiveness of the meat and milk chains in the domestic and international markets, reduces the pressure for opening new areas in the so-called land-saving effect (MARTHA JUNIOR et al., 2012).

The benefits obtained by integrated production systems are related to the synergism between activities, being the pasture benefited by soil chemical conditioning through the correction and residual fertilization of the crop, which is benefited by the improvement of soil physical and biological conditions provided by the pasture. In this context, the soil, as the basis of agroecosystems, is understood as the focal point of interrelations of the system components (crop and livestock) and the maintenance of their properties, becoming the key to a sustainable production and having as positive effects to the production system a higher efficiency in the use of resources (natural resources, inputs, labor, and energy), reduction of environmental impacts, higher economic efficiency, and flexibility related to biological, climatic, and market risks (ALMEIDA et al., 2015).

The cultivation of corn-associated tropical grasses can provide increases in the total forage production without appreciable reductions in grain productivity of the crop, provided that an adequate crop management is applied, preventing the forage from over competition with corn in the early growth stages. Ceccon et al. (2010) recommended the application of sub-doses of the herbicide nicosulfuron (6 to 8 g a.i. ha^{-1}) together with herbicides for weed control.

Kichel et al. (2014a) studied a simultaneous cultivation of corn and Piatã grass in the interseason corn harvest with different levels of grass suppression by herbicide and observed that corn grain productivity was reduced in the simultaneous cultivation, but grass suppression through herbicide use maintained corn productivity and reduced forage productivity.

The aim of this study was to assess the productivity and nutritional value of different tropical grasses intercropped or not with corn cultivated in the interseason corn harvest, seeking for new alternatives of forage production for animal feed in the in autumn and winter.

Material and Methods

The experiment was carried out from February to September 2014 in the Embrapa Beef Cattle, located in Campo Grande, MS, at the geographical coordinates 20°27′ S and 54°37′ W, with 530 m of altitude. The soil was characterized as a very clayey Oxisol (EMBRAPA, 1999).

According to Köppen, the regional climatic pattern is within the tropical humid transition range between Cfa and Aw. The average annual precipitation is 1,500 mm, with a dry period from May to September (30% of the annual rainfall).

The meteorological data for 2014 (maximum, minimum, and mean temperature, relative air humidity, and rainfall index) were recorded by the INMET – A702 weather station, located about 500 m from the experimental area (Table 1).

Table 1. Meteorological data (maximum, minimum, and mean temperature, relative air humidity, and rainfall index) recorded by the INMET - A702 weather station. Embrapa Beef Cattle, Campo Grande, MS, 2014.

Month	Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Relative air humidity (%)	Rainfall index (mm)
January	31.1	20.4	24.6	75	162
February	30.6	21.2	25.1	81	112
March	30.3	20.6	24.3	84	163
April	30.0	20.3	24.1	80	53
May	26.6	16.8	20.6	81	166
June	27.0	16.9	20.7	79	51
July	26.7	15.8	20.1	73	115
August	30.9	17.6	23.0	58	18
September	32.3	20.3	25.5	64	66
October	34.3	21.3	27.0	58	20
November	30.8	19.9	24.7	79	218
December	30.4	21.1	24.9	87	359

Soil chemical analysis of the experimental area was performed at depths of 0–10, 10–20, and 20–40 cm in January 2014 (Table 2). Based on this soil analysis, the experimental area was corrected with the application of 1 Mg ha^{-1} of dolomitic limestone (85% RPTN) and 1 Mg ha^{-1} of agricultural gypsum, with a subsequent incorporation to the soil.

The experimental area was cultivated with soybean in the 2013/2014 season and the experiment started after soybean harvest by installing the treatments on February 21, 2014.

Table 2. Chemical analysis of soil samples from the experimental area at depths of 0−10, 10−20, and 20−40 cm in January 2014.

Depth(cm)	pH	P	OM	K	Ca+Mg	Al	H	S	T	m	V
	$CaCl_2$	g dm^{-3}	g dm^{-3}			cmolc dm^{-3}				%	
00−10	4.77	17.9	39.5	0.15	4.5	0.14	4.46	4.65	9.25	3.55	50.2
10−20	4.75	4.1	32.0	0.11	2.5	0.24	4.01	2.61	6.82	8.42	37.7
20−40	4.65	1.6	28.0	0.07	1.9	0.40	3.50	1.97	5.87	16.88	33.0

In order to assess the productivity and nutritional value of tropical grasses, a randomized block design was used in a split-split plot scheme with four replications. In the plots, the treatments consisted of the grasses *Brachiaria brizantha* cv. Piatã, Xaraés, and Marandu, *Panicum maximum* cv. Mombaça, and *B. ruziziensis* cv. Kennedy. In the subplots, the treatments consisted of monoculture of forages, intercropping of forages with corn without herbicide suppression, and intercropping of forages with corn with suppression by herbicide application. The sub-subplots consisted of the cutting intervals at 50, 90, 125, and 195 days after the emergence of grasses (DAE). The areas were 6.75 × 33.0 m for plots, 6.75 × 11 m for subplots, and 6.75 × 2.75 m for sub-subplots.

The sowing of corn and grasses was carried out in a single operation under a no-tillage system using a seeder-fertilizer machine. Planting fertilization consisted of 350 kg ha^{-1} of the NPK formula 08–20–20. The corn was sown in a 0.75 m spacing between rows, with 5 to 6 seeds per meter. The grasses were sown in 0.25 m spacing rows in the interrows of corn. Each plot was composed of 9 rows of corn and 27 rows of grasses.

The sowing rate of grasses was based on the traditionally recommended number of seeds per area (pure viable seeds, PVS m^{-2}), aiming at guaranteeing an adequate and uniform number of plants in the establishment of the pasture. In this sense, sowing rates of 70 and 350 PVS m^{-2} was adopted for grasses of the genus *Brachiaria* and *Panicum*, respectively (Table 3). The values of 1000 seed weight and the number of seeds per gram were obtained by means of the average of ten observations. Corn emergence occurred five days after sowing, while grass emergence was observed seven days after sowing.

Table 3. Analysis of the seeds used in planting: 1000 seed weight (g), number of seeds per gram, number of pure viable seeds (PVS) per m^2, PVS in kg ha^{-1}, and number of plants m^{-2} at 29 DAE.

Grass	1000 seed weight (g)	Seeds g^{-1}	Number of PVS m^{-2}	PVS (kg ha^{-1})	Plants m^{-2}
Kennedy	5.50	181.00	70.00	3.85	30
Marandu	8.50	117.00	70.00	5.95	35
Xaraés	10.90	91.00	70.00	7.63	33
Piatã	9.50	105.00	70.00	6.65	40
Mombaça	1.30	770.00	350.00	4.55	60
Corn	326.00	3.07	6.75	23.90	6

The assessment of the plant density of grasses was carried out in two counts, at 16 and 29 DAE, in two areas of 1 m^2 per plot.

At 22 days after the grass emergence, the herbicide atrazine was applied in total area (1,500 g a.i. ha^{-1}) to control volunteer soybean and broadleaf weeds. The herbicide nicosulfuron (0.6 g a.i. ha^{-1}), corresponding to the treatment with herbicide suppression in the subplot, was applied when the forages were in the stage of one to four tillers.

The herbicides were diluted in water to a 250 L ha^{-1} solution volume and applied with a CO_2-precision sprayer.

Topdressing fertilization consisted of 56.25 kg ha^{-1} of N as urea and was broadcasted for both grasses in monoculture and intercropped with corn at 30 DAE.

Two areas of 1.0 × 1.0 m per sub-subplot were sampled to assess the productivity of grasses, with cutting carried out at ground level and at the intervals of 50, 90, 125, and 195 DAE of grasses, on April 17, May 29, July 2, and September 10, 2014.

Samples collected at 125 DAE, when corn was harvested and grasses would be available for use in animal feed, were used to assess the nutritional value. In addition, crude protein (CP) contents of grasses were assessed at cutting intervals of 50, 90, 125, and 195 DAE only for the monoculture treatment.

The samples were weighed in the field using a dynamometer scale. The grass samples were separated into the leaf, stem, and dead material in the laboratory. These samples were dried in a forced air ventilation oven at 55–60 °C for 72 hours. After drying, the samples were ground in a Willey mill with a 20-mesh sieve in order to determine the nutritional value.

For the assessment of crude protein (CP), neutral detergent fiber (NDF), acid detergent lignin (ADL), and in vitro digestibility of dry matter (IVDDM), the near infrared reflectance spectroscopy (NIRS) was used, as in Marten et al. (1985). The reflectance data of the samples in the wavelength range of 1,100 to 2,500 mm were stored by an NR5000 spectrometer coupled to a microcomputer. The leaf blade proportion and the variables of nutritional value were expressed as a dry matter (DM) basis.

The experimental design was a randomized block design a sub-split plot scheme with four replications. The data were submitted to analysis of variance and the means of qualitative variables (grasses and cropping systems) were compared by means of the Tukey's test, while the means of the quantitative variable (cutting intervals) were submitted to the regression analysis. A 5% probability level was adopted and the statistical software SISVAR version 5.3 was used.

Results and Discussion

The rainfall indices during the experimental period (February to September 2014) were 744 mm (Table 1), which is similar to the historical average of 20 years of 715 mm in the experimental area (INMET, 2016). However, rainfall from May to July 2014 was 332 mm and the historical average in the same period was only 192 mm, representing an increase of 72.9%. In this context, these meteorological values potentiated by ICL effects, with pasture cultivation in the interseason corn harvest following soybean harvest, justified the high productivity of dry matter (DM) and the nutritional value of forages obtained in this period, which is normally considered as critical for the activity of beef and dairy cattle, goats, and sheep.

No difference for the average density of plants was observed between Kennedy, Xaraés, Marandu, and Piatã grasses, with an average of 35 plants m^{-2} and establishment efficiency of 50% in relation to the sowing rate of 70 seeds m^{-2}. However, the density of Mombaça grass was 60 plants m^{-2}, with an efficiency of 17% in relation to the sowing rate of 350 seeds m^{-2}. According to Zimmer et al. (2008), the density of grass plants for a good pasture formation should be of at least 15 to 20 plants m^{-2} for the genus *Brachiaria* and *Panicum*.

A significant difference ($P<0.05$) was observed between the different cropping systems (monoculture and without and with suppression) regarding dry matter productivity (t ha^{-1}) (Table 4). Dry matter productivity (average among forages) was 12.17, 4.17, and 1.53 t ha^{-1}, respectively, showing a high competition of corn on grasses, which reduced their productivity by 8.0 t ha^{-1}, i.e. by 191.8%. On the other hand, the herbicide effect reduced the grass productivity by 2.6 t ha^{-1}, which corresponds to 172.5% in relation to the treatment without suppression.

Similar results were obtained by Almeida et al. (2011) when studying the simultaneous cultivation of corn and Piatã grass in the interseason corn harvest with different levels of grass suppression by the herbicide. The authors observed that corn competed with grass, reducing forage productivity by 68%, with no difference in corn grain productivity between the monoculture system and simultaneous cultivation with Piatã grass with suppression by the herbicide.

Table 4. Dry matter productivity (t ha^{-1}) (mean of four cuts) of the different tropical grasses in three cropping systems in the interseason corn harvest.

Cropping system	*Brachiaria brizantha*			*Panicum maximum*	*Brachiaria ruziziensis*	CV (%)
	Marandu	Piatã	Xaraés	Mombaça	Kennedy	
Monoculture	12.13^{Aab}	12.69^{Aa}	11.94^{Aab}	13.44^{Aa}	10.69^{Ab}	
Without suppression	3.75^{Bb}	3.88^{Bb}	3.56^{Bb}	5.56^{Ba}	4.12^{Bab}	25.30
With suppression	1.25^{Cab}	1.19^{Cb}	1.31^{Cab}	2.75^{Ca}	1.19^{Cb}	
CV (%)				25.71		

Means followed by the same uppercase letter in the columns and lowercase letter in the rows do not differ from each other ($P<0.05$) by the Tukey's test.

When comparing dry matter productivity between the grasses in monoculture, only Mombaça and Piatã grasses were superior to the Ruziziensis grass ($P>0.05$), not differing from the Marandu and Xaraés grasses. However, in the pasture intercropped with corn without suppression, the grass that suffered the least competition was the Mombaça when compared to the cultivars of *B. brizantha*, with the Ruziziensis grass not differing from the others.

The results of corn intercropping with grass suppression showed that the Ruziziensis and Piatã grasses presented the lowest productivity in relation to Mombaça grass (P> 0.05). The Marandu and Xaraés grasses did not differ from the others.

Ceccon et al. (2010) found similar results for *B. ruziziensis* in an intercropping with corn in the interseason corn harvest when considering nicosulfuron doses of 8 and 16 g a.i. ha^{-1}. The authors did not observe interferences of herbicide doses on corn grain productivity, but they observed leaf chlorosis with necrosis and a reduced growth, without a full recovery of *B. ruziziensis* plants during corn growth, leading to a low forage mass yield.

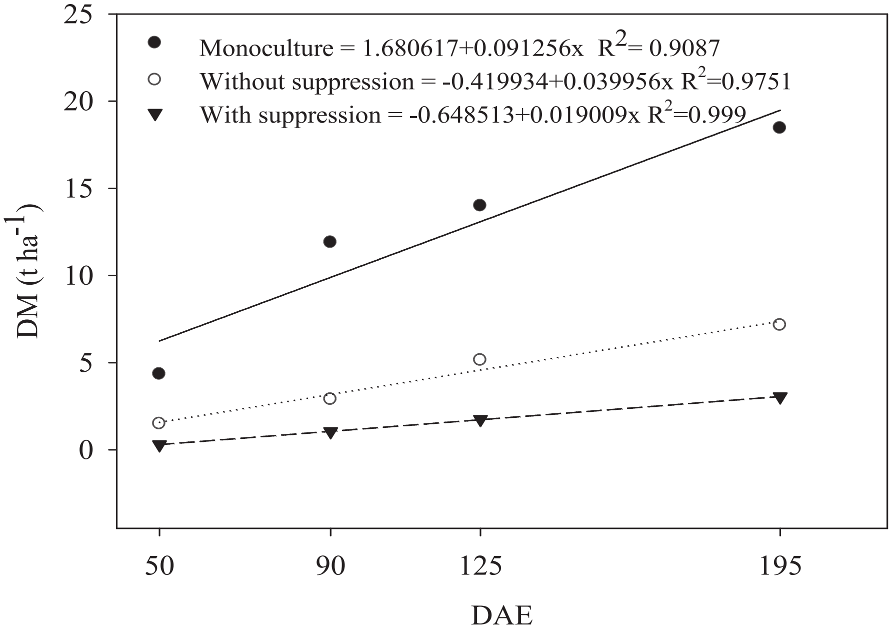
The average dry matter productivity (t ha^{-1}) (Figure 1) among the five grasses, assessed in the period from February 28 to September 10, 2014, at 195 DAE, referring to the three cropping systems (monoculture, without suppression, and with suppression) were 18.45, 7.15, and 3.05 t ha^{-1}, respectively.

When comparing the productivities of the cropping systems regarding the cutting seasons, a linear response was observed (Figure 1), with forage productivities being considered high due to the most critical season of the year for the great majority of Brazilian regions.

The pastures recovered with ICL systems present a higher availability of forage with higher nutritional value, stocking rate, and meat productivity per area, as demonstrated in the studies carried out by Costa et al. (2014) and Macedo et al. (2007).

Considering these productivities for each production system, with grazing starting at 50 DAE and ending at 195 DAE (period from May 29 to September 10, 2014) (145 grazing days), an average daily forage intake of 2.5% of live weight, and a grazing efficiency of 50% on the total forage produced in the period, we could estimate the average stocking rate among grasses for the treatments (monoculture, without suppression, and with suppression) as being 6.36, 2.46, and 1.05 AU ha^{-1}, respectively.

Figure 1. Accumulated dry matter productivity (t ha^{-1}) considering the average of five tropical grasses (*Brachiaria ruziziensis* cv. Kennedy, *Brachiaria brizantha* cv. Marandu, Xaraés, and Piatã, and *Panicum maximum* cv. Mombaça), with three cropping systems associated with four cutting intervals in the interseason corn harvest.



The average dry matter productivity of grasses, accumulated in the three cropping systems (Table 5), did not differ considering the cuts performed at 50 and 90 DAE. However, a significant difference ($P<0.05$) was observed between grasses for the cut carried out at 125 DAE, being the Mombaça grass superior to the Ruziziensis, which did not defer from the other grasses. On the other hand, the cut performed at 195 DAE in the Mombaça grass showed the highest productivity, followed by the Marandu, Piatã, and Xaraés grasses, with no statistical difference from each other, being the Ruziziensis the grass that presented the lowest productivity. However, Euclides et al. (2009) observed that the cultivar Xaraés under grazing during the rainy and dry periods supported a higher stocking rate, which resulted in a higher gain of live weight per hectare when compared to Piatã and Marandu.

An increasing linear response was observed when comparing the dry matter productivity (t ha^{-1}) of grasses in relation to cutting periods (Table 5). Regarding the assessment of the nutritional value of forages in relation to the contents of crude protein of leaf blades (LB) in the treatment of grass monoculture, performed at the cutting intervals of 50, 90, 125, and 195 DAE (April 17, May 29, July 2, and September 10, 2014, respectively) showed that the assessments carried out at 50 DAE, at the beginning of grazing, indicated that the Marandu grass presented a higher CP content when compared to the Mombaça grass. The other grasses did not differ ($P>0.05$).

In the assessments carried out at 90 DAE, a point for cutting hay or silage, the Ruziziensis and Piatã grass presented the highest CP content in the leaf blade when compared to Mombaça grass ($P>0.05$), with no difference in relation to the others.

Table 5. Dry matter productivity (t ha^{-1}) of five grasses according to the cutting interval (mean of three forage cropping systems: monoculture, intercropped with corn with and without herbicide suppression).

Grass	DAE				Equation	R^2 (%)
	50	90	125	195		
Marandu	1.50	4.83	6.58^{AB}	9.92^{B}	$Y = -0.784692 + 0.056461x^*$	97.92
Piatã	2.17	5.25	6.92^{AB}	9.33^{BC}	$Y = 0.407305 + 0.047907x^*$	95.84
Xaraés	1.92	4.83	7.17^{AB}	8.50^{BC}	$Y = 0.474761 + 0.044604x^*$	91.87
Mombaça	2.92	6.42	7.92^{A}	11.75^{A}	$Y = 0.469897 + 0.058957x^*$	98.22
Kennedy	1.75	5.08	6.25^{B}	8.25^{C}	$Y = 0.45301 + 0.042438x^*$	90.25
CV (%)			25.3			

Means in the same column followed by the same letter do not differ from each other ($P>0.05$) by the Tukey's test.

The results obtained at 125 DAE (indicated for silage) showed that CP content of the Ruziziensis grass was higher than the other grasses (Mombaça and Xaraés) ($P>0.05$), leaving the Piatã and Marandu grasses in an intermediate position. However, the results obtained at 195 DAE during the desiccation for the no-tillage of soybean showed that CP content in the leaf blade of Ruziziensis grass was higher than that of the Piatã grass ($P>0.05$), not differing from the other grasses (Table 6). Machado and Vale (2011) found similar results in the assessment of *B. brizantha* cv. Marandu, Piatã, and Xaraés in succession to soybean in an integrated crop-livestock system in the interseason corn harvest. Crude protein contents were 15.5, 14.9, and 14.3%, respectively. However, Euclides et al. (2009) assessed the nutritional value of *B. brizantha* cv. Marandu, Piatã, and Xaraés under a pre-grazing condition and obtained average CP contents of 8.2% in the rainy and dry periods during three years of assessment for the three cultivars under the conventional system.

Table 6. Crude protein contents (CP, %) of leaf blades (LB) of different tropical climate grasses under monoculture and four cutting intervals (days after emergence – DAE).

Grass	DAE				Equation according to DAE	R^2 (%)
	50	90	125	195		
Marandu	21.00^{A}	14.75^{AB}	13.25^{BC}	9.75^{AB}	Y = 23.008535 − 0.072357x	89.63
Piatã	20.50^{AB}	15.75^{A}	14.50^{AB}	8.75^{B}	Y = 23.803965 − 0.077643x	97.66
Xaraés	19.50^{AB}	13.75^{AB}	12.25^{C}	9.25^{AB}	Y = 21.273954 − 0.065969x	88.92
Mombaça	18.50^{B}	13.25^{B}	12.00^{C}	9.25^{AB}	Y = 20.076542 − 0.059361x	88.63
Ruziziensis	20.25^{AB}	15.75^{A}	16.75^{A}	11.50^{A}	Y = 22.369769 − 0.054846x	87.72
CV (%)		8.53				

Means in the same column followed by the same letter do not differ from each other (p>0.05) by the Tukey's test.

These results demonstrated a high increase in productivity and quality of forage provided by the integrated crop-livestock (ICL) system.

Among the assessed grasses, the Mombaça presented the lowest CP content when compared to the others in the cutting intervals of 50, 90, and 125 DAE because it produced seed in this period, with a consequent decrease in its nutritional value.

The grasses cultivated in monoculture after soybean harvest in the second season (Table 6) showed a decreasing linear response of CP content as a function of cutting intervals. When the results of the average CP contents between grasses obtained at 50 and 90 DAE are compared, a decrease of 26.56% was observed, indicating the great importance of using forages when they reach their best nutritional value.

According to the results found in the literature, we did not expect that *P. maximum* cv. Mombaça presented a nutritional value equal to or lower than the grasses of the genus *Brachiaria*. These results are probably due to the time of implantation and assessment of the experiment, favoring its reproduction and reducing its nutritional value. However, grasses of the genus *Brachiaria*, when planted from February to March, produce few seeds in most of the cases, maintaining the highest nutritional value at this time of year when compared to the rainy period.

Mombaça and Xaraés are grasses belonging to different species, but to the same functional group since they reach the peak of growth rapidly (CRUZ et al., 2002). They are grasses not indicated for long cutting intervals because their shorter leaf life leads to high biomass losses due to foliar senescence and high stem accumulation, with a consequent lower nutritional value.

The reduction in quality of Mombaça grass, as observed in this experiment, can be minimized with its use in cut or grazing with rotational management with an adjusted stocking rate according to grass productivity, respecting the height of entrance and exit of animals. These practices reduce seed production while maintaining or improving the nutritional value of Mombaça grass.

In the harvest of second crop corn at 125 DAE, an assessment of productivity and nutritional value of tropical grasses was carried out. The grasses (hay or silage) would be available for grazing in the most critical period of the year for the great majority of Brazilian regions, which occurs from July to September.

No significant difference was observed between grasses in each of the cropping systems (P>0.05) for dry matter productivity at 125 DAE (Table 7). Mombaça, Xaraés, and Marandu grasses did not present significant differences (P<0.05) between cropping systems (without and with suppression), but in the system with suppression, Piatã and Ruziziensis grasses had the lowest productivity in relation to the system without suppression, indicating a higher herbicide effect on these two forages.

Table 7. Dry matter productivity (t ha^{-1}) of different tropical climate grasses and cropping systems at 125 days after emergence.

Cropping system	*Brachiaria brizantha*			*Panicum maximum*	*Brachiaria ruziziensis*	CV (%)
	Marandu	Piatã	Xaraés	Mombaça	Kennedy	
Monoculture	13.53^{A}	15.2^{A}	14.55^{A}	14.41^{A}	12.38^{A}	
Without suppression	4.68^{B}	7.08^{B}	4.73^{B}	6.27^{B}	5.65^{B}	26.41
With suppression	1.54^{B}	1.15^{C}	1.99^{B}	3.09^{B}	1.03^{C}	
CV (%)				28.71		

Means followed by the same uppercase letter in the columns and lowercase letter in the rows do not differ from each other (P>0.05) by the Tukey's test.

All grasses presented a similar response regarding the proportion of leaves, with a lower average percentage among grasses for the monoculture system and a higher average percentage for the system with suppression, with values of 46.2 and 61.9%, respectively. Among all grasses, Ruziziensis grass had the lowest percentage of leaves, with an average of 46% among the cultivation systems. Mombaça and Xaraés grasses showed the highest percentage of leaves, with an average of 59%.

A significant difference (p<0.05) was observed in the productivity of leaves (t ha^{-1}) (Table 8), but only for the monoculture system, in which Mombaça, Xaraés, and Piatã were the most productive grasses, with values of 7.78, 7.53, and 7.18 t ha^{-1}, respectively. On the other hand, Ruziziensis and Marandu grasses showed the lowest productivity of leaves, with values of 4.48 and 5.86 t ha^{-1}, respectively.

Table 8. Dry matter productivity of leaves (t ha^{-1}) of different tropical grasses and in three cropping systems at 125 days after emergence.

Cropping system	*Brachiaria brizantha*			*Panicum maximum*	*Brachiaria ruziziensis*	CV (%)
	Marandu	Piatã	Xaraés	Mombaça	Kennedy	
Monoculture	5.86^{Abc}	7.18^{Aa}	7.53^{Aa}	7.78^{Aa}	4.48^{Ac}	
Without suppression	2.56^{B}	3.34^{B}	2.72^{B}	3.32^{B}	2.52^{B}	29.62
With suppression	0.94^{B}	0.66^{C}	1.35^{B}	2.05^{B}	0.59^{C}	
CV (%)				33.73		

Means followed by the same uppercase letter in the columns and lowercase letter in the rows do not differ from each other (P>0.05) by the Tukey's test.

The results of components of the nutritional value of the five tropical grasses in three cropping systems at 125 DAE are shown in Table 9. No difference (P> 0.05) was observed for crude protein in treatments without suppression, but a significant effect was observed for the interaction between grass and cropping system (P<0.05) and between grasses (P<0.05). Acid detergent lignin (ADL) was similar among all grasses.

Table 9. Contents of crude protein (CP, %), neutral detergent fiber (NDF, %), in vitro digestibility of dry matter (IVDDM, %), and acid detergent lignin (ADL, %) of leaves of different tropical grasses at 125 days after emergence (mean of three forage cropping systems: monoculture, intercropped with corn with and without herbicide suppression).

Cropping system	*Brachiaria brizantha*			*Panicum maximum*	*Brachiaria ruziziensis*	CV (%)
	Marandu	Piatã	Xaraés	Mombaça	Kennedy	
				CP (%)		
Monoculture	13.25^{Cb}	14.50^{ab}	12.25^{Bb}	12.00^{Cb}	16.75^{Ba}	
Without suppression	15.25^{B}	15.00	14.75^{B}	15.00^{B}	16.75^{B}	9.79
With suppression	18.75^{Aab}	16.50^{b}	17.50^{Ab}	17.00^{Ab}	20.00^{Aa}	
CV (%)				5.48		
				NDF (%)		
Monoculture	69.25^{Aa}	70.25^{a}	73.75^{Aa}	73.25^{a}	64.00^{Ab}	
Without suppression	65.00^{Bcd}	67.00^{bc}	70.50^{ABab}	71.75^{a}	62.25^{Bd}	3.59
With suppression	63.75^{Bbc}	68.00^{ab}	67.25^{Bab}	70.25^{a}	58.25^{Bc}	
CV (%)				3.13		
				IVDDM (%)		
Monoculture	62.50^{Ab}	64.75^{b}	57.00^{Ab}	57.50^{Ab}	70.75^{Aa}	
Without suppression	65.50^{A}	64.25	60.00^{Ab}	60.00^{AB}	66.00^{A}	7.00
With suppression	74.00^{Bab}	69.75^{b}	66.75^{Bb}	66.50^{Bb}	76.25^{Ba}	
CV (%)				5.47		
				ADL (%)		
Monoculture	3.50^{A}	3.75^{A}	3.75	4.00^{A}	3.25^{A}	
Without suppression	3.00^{AB}	3.00^{B}	3.25	3.75^{A}	3.00^{A}	12.69
With suppression	2.75^{Bab}	3.00^{Ba}	3.25^{a}	3.00^{Ba}	2.00^{Bb}	
CV (%)				11.35		

Means followed by the same uppercase letter in the columns and lowercase letter in the rows do not differ from each other (P>0.05) by the Tukey's test.

The data of nutritional value for pasture of *B. ruziziensis* were higher regarding CP contents (16.7 and 20.0%). These values are higher when compared to that of 7% of CP (DM) recommended by Van Soest (1994), which is considered as a minimum for the maintenance and functioning of the ruminal microbiota. Lopes et al. (2010) assessed grasses of the genus *Brachiaria* and observed that the highest nutritional quality of *B. ruziziensis* can be attributed to higher rates of effective degradability of dry matter and crude protein, in addition to a lower NDF content associated with a higher degradation rate.

The other grasses presented very high NDF values and a low digestibility. Euclides et al. (2007) pointed out that they are the limiting factors in animal production since they may decrease dry matter (DM) intake, negatively influencing animal production in the pastoral system.

The productivity of crude protein (CP) in t ha^{-1} for leaf blades, obtained at 125 DAE (Table 10), presented a significant difference (P<0.05) only for cropping systems (monoculture, without suppression, and with suppression), with average productivities of CP of 0.98, 0.44, and 0.20 t ha^{-1}, respectively. However, the results obtained among grasses were similar (P>0.05).

Table 10. Crude protein (CP) productivity of leaves (t ha^{-1}) of different tropical grasses at 125 days after emergence (mean of three forage cropping systems: monoculture, intercropped with corn with and without herbicide suppression).

Cropping system	*Brachiaria brizantha*			*Panicum maximum*	*Brachiaria ruziziensis*	CV (%)
	Marandu	Piatã	Xaraés	Mombaça	Kennedy	
Monoculture	0.78^{A}	1.03^{A}	0.92^{A}	0.94^{A}	0.76^{A}	
Without suppression	0.38^{B}	0.51^{B}	0.39^{B}	0.49^{B}	0.42^{B}	29.62
With suppression	0.18^{B}	0.11^{C}	0.22^{B}	0.35^{B}	0.12^{C}	
CV (%)				33.73		

Means followed by the same uppercase letter in the columns and lowercase letter in the rows do not differ from each other (P>0.05) by the Tukey's test.

The ICL system is a promising farming strategy since it allows higher yields with better quality forage in the interseason resulting in more efficient use of local natural resources (BALBINOT JUNIOR et al., 2009; FLÁVIO NETO et al., 2015).

Conclusions

The use of the herbicide nicosulfuron (0.6 g a.i. ha^{-1}) to suppress grass growth had higher effect over Piatã and Ruziziensis than over the other grasses.

The tropical grasses studied, when grown under integrated systems, either in monoculture or intercropped with corn, showed better yields and nutritional quality when compared to traditional grazing systems.

The tropical grasses *Panicum maximum* cv. Mombaça and *Brachiaria brizantha* cv. Xaraés and Piatã had the highest leaf and crude protein yields when compared to *Brachiaria ruziziensis* cv. Kennedy and *Brachiaria brizantha* cv. Marandu.

In terms of nutritional value, *Brachiaria ruziziensis* cv. Kennedy was superior to Mombaça and Xaraés grasses but had lower total dry matter yield.

In general, Xaraés, Piatã and Mombaça grasses are the most recommend for growing in the interseason of ICL systems when fodder grass production is the goal.

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