

Productivity and nutritional quality of Flechinha grass (*Echinolaena inflexa*), native grass of Brazilian Cerrado

Produção e qualidade nutricional do capim-flechinha (*Echinolaena inflexa*), gramínea nativa do Cerrado brasileiro

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ABSTRACT

Due to scarce nutritional data, this study assessed the productivity and nutritional value of *Echinolaena inflexa* (EI) grass, native to the Cerrado biome. It was compared to *B. brizantha* (BB), one of the most cultivated grasses in Brazil, during a whole year (rainy; RS and dry season; DS). Sampling was held in accordance with pasture management (entry / exit height; 50 / 5cm and 80 / 25cm for EI and BB, respectively). Dry matter production (DMP), crude protein (CP), neutral and acid detergent fiber (NDF; ADF), hemicellulose (HCEL), PB insoluble neutral and acid detergent (PIDN; PIDA), total and non-fibrous carbohydrates (TC; NFC), ether extract (EE), and mineral matter (MM), and in vitro fermentation kinetics and DM degradability (DMD) were evaluated. A completely randomized design (season as a fixed term) and average treatment compared by Tukey post test were applied. EI produced 38.5% of the DMP of BB. A higher CP (75.3; 73.5 in the RS and DS), PIDA (12.5; 8.7), PIDN (47.1; 40.1), NDF (714.4; 749.5) and ADF (396.0; 419.0) were obtained by EI in relation to BB (CP (60.3; 33.5), PIDA (6.0; 3.5), PIDN (21.4; 10.8), NDF (673.0; 675.1) and ADF (335.5; 351.4) during the RS and DS, respectively (g kg⁻¹ DM). In vitro data were directly associated with chemical composition, resulting in lower DMD of EI compared to BB. EI showed productive similarity (DMP) during RS and DS (939.3; 809.8kg DM respectively). Although EI showed greater nutritional stability (CP) between seasons, 17% of CP was linked to ADF and therefore, not available for rumen microorganisms.

Key words: forage, native pasture, natural pasture, Cerrado, bromatological quality.

RESUMO

Existem escassas informações a respeito da qualidade nutricional e potencial produtivo de *Echinolaena Inflexa*, planta nativa do Cerrado Brasileiro e que possui potencial valor forrageiro. Dessa forma, este trabalho objetivou avaliar o seu

valor nutritivo e produtividade, comparando-a com a *B. brizantha* (BB), uma das mais cultivadas gramíneas no Brasil, durante um no agrícola (Estação das Chuvas; CH e seca; SE). A coleta do material experimental foi realizada de acordo com as recomendações de manejo (altura de entrada / altura de saída 50/5cm e 80/25cm para EI e BB, respectivamente). Foram avaliadas a produção de matéria seca (PMS), proteína bruta (PB), fibra detergente neutro e ácido (FDN e FDA), hemicelulose (HCEL), PB insolúvel em detergente neutro e ácido (PIDN e PIDA), carboidratos totais e não fibrosos (CT e CNF), extrato etéreo (EE) e matéria mineral (MM), e a cinética de fermentação ruminal e degradabilidade in vitro da MS (DMS). Utilizou-se o delineamento inteiramente casualizado e as médias de tratamento comparadas pelo post test de Tukey. A EI apresentou 38,5% da PMS da BB. Foram obtidos maiores teores de PB (75,3 e 73,5), PIDA (12,5 e 8,7), PIDN (47,1 e 40,1), FDN (714,4 e 749,5) e FDA (396,0 e 419,0) para a EI em relação a BB (PB; 60,3 e 33,5), PIDA (6,0 e 3,5), PIDN (21,4 e 10,8), FDN (673,0 e 675,1) e FDA (335,5 e 351,4) na estação chuvosa e seca, respectivamente (g kg⁻¹ MS). Os dados in vitro da EI foram diretamente associados à composição química, resultando em menor DMS comparativamente BB. A EI apresentou estabilidade produtiva (PMS) durante a estação chuvosa e seca (939,3 e 809,8kg MS), respectivamente. Apesar da similaridade nutricional (PB) nas estações, cerca de 17% da PB está ligada a FDA e, portanto, não disponível para os microrganismos ruminais.

Palavras-chave: forrageira, pastagem nativa, pastagem natural, cerrado, qualidade bromatológica.

INTRODUCTION

Cerrado is the second largest Brazilian biome, comprising approximately 21% of the national territory, characterized for its extremely

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rich fauna and flora. However, with the development of agricultural activities, serious environmental impacts have caused irreversible losses in that biome (LAURENCE et al. 2014). In order to improve the productivity of the national livestock, African grasses (such as *Braquiaria brizantha* cv. 'Marandu') have been brought to Brazil as forage source; however, they have become intrusive to natural ecosystems, especially in areas where agricultural activities border Cerrado areas (KLINK & MACHADO 2005).

Native Cerrado grasses could be used as alternative source of forage since they are available in natural environments and adapted to local climate and soil conditions besides contributing to a more sustainable way to breed livestock in such biome (FILGUEIRAS, 1992). However, the biomass production and nutritional value are needed, as it is grazed by ruminants. In addition, little is known about the chemical composition of *Echinolaena inflexa* grass. For these reasons, the objective of this study was to evaluate the productivity and nutritional value of Flechinha grass (*Echinolaena inflexa*), native from Brazilian Cerrado.

MATERIALS AND METHODS

The experiment was conducted in a rural area that has a partnership with the Universidade Federal de São João del-Rei (UFSJ); located in the city of Coronel Xavier Chaves, MG, 21°01'78.55" S and 44°22'90.04" W, from February, 2011 until February, 2012. The property comprises a conjoint area of native forage (Flechinha grass – *E. inflexa*) and exotic forage (Braquiária grass – *B. brizantha* cv 'Marandu') in a Cerrado area. *B. brizantha* was included in the experiment as it is the most widely cultivated grass in Brazil (Cerrado) and was used for comparison reasons. The climate is classified as Cwa (mesothermal) in the Köppen classification system, humid subtropical climate, with dry winters and hot summers, with average annual precipitation of 1.600±500mm, average annual temperatures of 14°C in winter and 25°C in summer, and an approximate altitude of 972 meters.

The experimental area never received fertilization before the experiment started, nor during the year in which the study was conducted. The soil was classified as dystrophic red latosol, acid (5.3), average texture, low phosphor content (0.4mg/dm³), presence of toxic aluminum (1.1cmolc dm⁻³ Al³⁺) and average organic matter content (2.1dag kg⁻¹) (RIBEIRO et al., 1999). Initially, an uniformization cut was made mechanically at 5cm above the ground

for *E. inflexa* and 25cm above the ground for *B. brizantha*. Sampling cuts were made manually with scissors when *E. inflexa* reached 50cm and *B. brizantha* reached 80cm in height, respecting the same height of the uniformization cut (FILGUEIRAS, 1992). This cut recommendation provided, during the year in which the experiment was conducted (2011), two samplings during the rainy season (September through March - 1701mm) and one sampling during the dry season (April through August - 113mm). Four 1.80m × 1.80m × 90cm exclusion cages were used in each experimental area (*E. inflexa* and *B. brizantha*) and were randomly positioned.

The following methods (AOAC, 1990) were used to determine the chemical composition of the forages: 934.01, 990.03, 920.39, 942.05 and 973.18, respectively, for dry matter (DM), crude protein (CP), ether extract (EE), mineral matter (MM), acid detergent fiber (ADF). Neutral detergent fiber (NDF) was determined according to VAN SOEST et al. (1991), without adding sodium sulphite and amylase. Acid detergent insoluble protein (PIDA) and neutral detergent insoluble protein (PIDN) were determined according to LICITRA et al. (1996). Total carbohydrates (TC, dry mass %) were estimated with the equation proposed by SNIFFEN et al. (1992), and non-fibrous carbohydrates (NFC, dry mass %) were estimated with the equation given by HALL et al. (1999).

Cumulative gas production (CGP) and dry matter degradation (DMD) *in vitro* studies were conducted using the semi-automatic *in vitro* gas production technique (MAURÍCIO et al., 1999), and the potential of maximum gas production, A; colonization time, CT; gas production rate, μ ; and effective degradability, ED, were determined according to FRANCE et al. (1993). A pool of inoculum (4 mL flask⁻¹) from three cannulated bovines (80% pasture and 20% concentrate) was used. The samples were incubated (0.5g) in flasks (50mL) in a growth medium, agitated at 90 rpm in an incubator (39°C), after which volume measurements were made at 2, 4, 6, 8, 10, 12, 14, 17, 20, 24, 28, 34, 48, 72 and 96 hours.

The data were analyzed using procedure GLM from SAS (SAS Inst. Inc., Cary, NC) for a completely randomized design, with subdivided terms, the terms being the forages (*E. inflexa* and *B. brizantha*), and the divided terms, the seasons (rainy season and dry season), included in the model as fixed terms; eight field runs were conducted for each forage (excluding cages randomly positioned). Average treatments were compared by variance analysis with

a Tukey post test. Results are shown with a declared significance for $P < 0.05$.

RESULTS AND DISCUSSION

There was different DMP between forages during the rainy season; *E. inflexa* had 61.5% lower production when compared to *B. brizantha* (Table 1). The *B. brizantha* high production is probably related to the extensive agronomic selective process and to the C4 metabolic pathway, which leads to a higher biomass accumulation (*E. inflexa* – C3 pathway) due to a more efficient use of water and higher number of tiller and leaves (SILVA & KLINK, 2001). Even though *B. brizantha* had higher DMP during the rainy season and both forages had similar production during the dry season. There was no difference in the DMP of *E. inflexa* in the two seasons. The impact of the season on the tropical forage was higher for *B. brizantha*, whose production biomass was dramatically reduced during the dry season. As for DM content (Table 1), there was difference between the forages and between seasons. Higher DM contents were reported during the dry season for both forages. SANTOS et al. (2009) reported an increase in the DM content of *B. brizantha* in the dry season; in this study, a similar pattern was observed for *B. brizantha* (274.2g kg and 364.0g kg⁻¹) and for *E. inflexa* (385.0 and 468g kg⁻¹) during the rainy season and the dry season.

CP contents (Table 1) were different between the forages and *E. inflexa* (75.3 and 73.5g kg⁻¹ DM) had higher values than *B. brizantha* (60.3 and 33.5g kg⁻¹ DM) in rainy and dry season respectively. During the dry season, *B. brizantha* CP content was lower in comparison to the rainy season. However, *E. inflexa* CP content was similar during both seasons. Lower CP contents are expected during the dry season due to higher DM contents and because there is, a reduced protein synthesis associated to the decreased water content in the tissues (BUERGLER et al., 2006). As for *B. brizantha*, during the two seasons, the minimum CP level of 7% was not reached, which is recommended for the maintenance of the rumen microflora (VAN SOEST, 1994). *E. inflexa* maintained the CP content at around 7.5%, which is a favorable feature, since the low CP production of tropical pastures is one of the limitations of livestock breeding (VAN SOEST, 1994).

PIDN and PIDA contents (Table 1) varied between the forages and seasons. During the rainy season, PIDN and PIDA contents were higher than those observed during the dry season for both grasses. That could be related to the higher protein content of *B. brizantha* during the rainy season. However, *E. inflexa* had higher PIDN and PIDA contents compared to *B. brizantha*, even though the same protein content was maintained during both seasons. High PIDN contents may compromise nitrogen use by rumen microorganisms because

Table 1 - Dry matter (DM, g kg⁻¹), mineral matter (MM, g kg⁻¹ DM), crude protein (CP, g kg⁻¹ DM), neutral detergent insoluble protein (PIDN, g kg⁻¹ DM), acid detergent insoluble protein (PIDA, g kg⁻¹ DM), neutral detergent fiber (NDF, g kg⁻¹ DM), acid detergent fiber (ADF, g kg⁻¹ DM), hemicellulose (HCEL, g kg⁻¹ DM), total carbohydrates (TC, g kg⁻¹ DM), non-fibrous carbohydrates (NFC, g kg⁻¹ DM) and ether extract (EE, g kg⁻¹ DM) of *E. inflexa* and *B. brizantha* during seasons.

	-----Rainy season-----		-----Dry season-----		CV (%)
	<i>B. Brizantha</i>	<i>E. inflexa</i>	<i>B. Brizantha</i>	<i>E. inflexa</i>	
DMP	2444.8 ^{aA}	939.3 ^{bA}	971.9 ^{aB}	809.8 ^{aA}	45.6
DM	274.2 ^{bB}	385.0 ^{aB}	364.0 ^{bA}	468.0 ^{aA}	6.3
MM	86.7 ^{bA}	100.9 ^{aA}	77.5 ^{aB}	72.5 ^{bB}	8.3
CP	60.3 ^{bA}	75.3 ^{aA}	33.5 ^{bB}	73.5 ^{aA}	15.5
PIDN	21.4 ^{bA}	47.1 ^{aA}	10.8 ^{bB}	40.1 ^{aB}	16.7
PIDA	6.0 ^{bA}	12.5 ^{aA}	3.5 ^{bB}	8.7 ^{aB}	14.9
NDF	673.0 ^{bA}	714.4 ^{aB}	675.1 ^{bA}	749.5 ^{aA}	3.6
ADF	335.5 ^{bA}	396.0 ^{aB}	351.4 ^{bA}	419.0 ^{aA}	4.0
HCEL	337.5 ^{aA}	318.4 ^{bA}	323.6 ^{aA}	330.5 ^{aA}	3.8
TC	875.8 ^{aA}	835.1 ^{bA}	834.8 ^{aB}	802.2 ^{bB}	1.2
NFC	211.6 ^{aA}	167.7 ^{bA}	183.5 ^{aB}	98.8 ^{bB}	13.4
EE	18.1 ^{aA}	17.2 ^{aA}	13.2 ^{bB}	17.4 ^{aA}	9.5

Average values followed by different small letters are statistically different in the comparison between forages, and average values followed by different capital letters are statistically different in t comparison to the same species in different seasons.

nitrogen associates with indigestible components of the cell wall. However, such aspect must be better evaluated with PIDA contents (MILFORD and MINSON, 2005). According to VAN SOEST (1994), PIDA contents between 3% and 15% of the total N are considered normal. Therefore, the PIDA contents observed for *B. brizantha* during both seasons are in the normal range (10% and 10.5% during the rainy season and dry season, respectively). For *E. inflexa*, the PIDA content was 11.83% of the total N content during the dry season, while, during the rainy season, it was 16.7% of the total N, which is higher than recommended and may compromise the availability of N in the ruminant gastrointestinal tract (MILFORD and MINSON, 2005). The higher contents of PIDN and PIDA observed during the rainy season can be explained because forages have higher total N or CP content during the wet season, since those parameters are expressed as percentages of total N (LICITRA et al., 1996).

Cell wall components NDF and ADF contents (Table 1) were different between forages. In the comparison between seasons, only *E. inflexa* had difference (NDF 749.5 and 714.4, and ADF 419.0 and 396.0g kg⁻¹ DM during the dry season and rainy season, respectively) as the *B. brizantha* fiber contents were similar both during the dry season (NDF 675.1 and ADF 351.4g kg⁻¹ of DM) and the rainy season (NDF 673.0 and ADF 335.5g kg⁻¹ of DM). The highest *E. inflexa* NDF values observed in this study occurred during the dry season, which is according to EUCLIDES et al. (2009), who correlate changes in the forage chemical composition with seasonal climate conditions. During the dry season, cell components tend to decrease their concentration, while cell wall components tend to increase in concentration (MORAES et al., 2014). However, such argument cannot be applied to *B. brizantha*, which NDF and ADF levels remained stable during both seasons. *E. inflexa* showed a higher NDF level compared to *B. brizantha*; both forages, however, had higher contents than 673g kg⁻¹ of DM. According to CONRAD et al. (1999), NDF contents of tropical forages are high and usually above 650g kg⁻¹ DM. BUXTON & REDFEARN (1997) reported that NDF content is the strongest limitation in roughage intake, with cell wall components contents higher than 550-600g kg⁻¹ of DM relating negatively to forage intake. Conversely, ADF contents are related to digestibility, which means the higher the ADF content, the lower the digestibility of the forage (GAILLARD, 1962). ADF contents were lower during the rainy season, which is in accordance with results observed by HERRERO et

al. (2001), who reported that *B. brizantha* ADF was close to those observed in this study (400g kg⁻¹ DM during the dry season and 350g kg⁻¹ DM during the rainy season). The ADF contents of *E. inflexa* were higher than *B. brizantha*, which may result in a lower digestibility of *E. inflexa*.

As for HCEL contents (Table 1), no difference was observed between seasons, there was difference between the forages only during the rainy season. In general, cell wall components (NDF, ADF and HCEL) contents were higher for *E. inflexa*, which probably has a negative influence on the intake and digestibility of the forage (GAILLARD, 1962).

TC and NFC contents (Table 1) were different between the forages and between seasons. Both forages had higher TC and NFC contents during the rainy season. Tropical forages, during the dry season, have lower carbohydrate contents than those observed during the rainy season because those carbohydrates migrate to the basis of the stalk (DETMANN et al., 2009). *E. inflexa* had lower NFC contents than *B. brizantha* during both seasons. Lower NFC contents affected the rapid degradation energy supply for rumen microorganisms, which directly interferes in the energy available for the ruminant (HATFIELD, 1989).

There was significant difference between the EE contents (Table 1) of both forages only during the dry season. *E. inflexa* had similar EE contents during both seasons, while *B. brizantha* had a higher EE content during the rainy season. Tropical forages have low fat content in their chemical composition, generally lower than 24g kg⁻¹ DM. Ether extract contents higher than 60g kg⁻¹ DM affect rumen degradation because of the direct toxic effect of long-chain fatty acids on rumen microorganisms; besides, they compromise the dry matter intake (JENKINS & MCGUIRE, 2006); such contents were not observed in this study.

MM content varied between forages and between seasons (Table 1). During the rainy season, both forages had MM contents higher than those observed during the dry season. The difference in the mineral composition of the tropical forages is not high, but that variation is mainly due to the climate and seasonal conditions and nutrients found in the soil (UNDERWOOD, 1983).

Cumulative gas production (CGP) was different between the forages (Table 2). In comparison between seasons, the only differences were observed in the incubation times of 6 and 48 hours for *B. brizantha*, and 48 hours for *E. inflexa*. CGP values were similar in the rainy season and dry

Table 2 - Cumulative gas production (CGP, mL g⁻¹ of DM), *in vitro* degradability of dry matter (DIVMS, g kg⁻¹ of DM) and gas production parameters estimated with the model proposed by France et. al (1993) for forages *E. inflexa* and *B. brizantha*.

Forage	Season	-----CGP-----			
		6	12	48	96
<i>B. brizantha</i>	Rainy	39.4 ^{aA}	65.2 ^{aA}	154.4 ^{aA}	184.2 ^{aA}
<i>E. inflexa</i>	Rainy	21.8 ^{bA}	37.4 ^{bA}	99.5 ^{bA}	123.9 ^{bA}
<i>B. brizantha</i>	Dry	33.1 ^{aB}	59.1 ^{aA}	140.0 ^{aB}	173.5 ^{aA}
<i>E. inflexa</i>	Dry	18.3 ^{bA}	30.3 ^{bA}	86.0 ^{bB}	108.5 ^{bA}
CV (%)		15.1	12.5	8.0	7.8
		-----France parameters-----			
		A ¹	CT ²	μ ³	ED ⁴
<i>B. brizantha</i>	Rainy	185.2	0:18	0.038	435.9
<i>E. inflexa</i>	Rainy	140.0	1:06	0.025	306.0
<i>B. brizantha</i>	Dry	200.5	0:14	0.035	438.9
<i>E. inflexa</i>	Dry	140.0	1:43	0.020	278.7
		-----DMD-----			
		6	12	48	96
<i>B. brizantha</i>	Rainy	210.7 ^{aA}	277.7 ^{aA}	496.7 ^{aA}	610.2 ^{aA}
<i>E. inflexa</i>	Rainy	156.2 ^{bA}	184.1 ^{bA}	345.9 ^{bA}	419.0 ^{bA}
<i>B. brizantha</i>	Dry	200.2 ^{aA}	255.4 ^{aA}	444.8 ^{aB}	573.8 ^{aB}
<i>E. inflexa</i>	Dry	129.6 ^{bA}	166.1 ^{bA}	275.8 ^{bB}	381.6 ^{bB}
CV (%)		10.9	9.9	7.8	5.3

Average values followed by different small letters are statistically different in the comparison between forages, and average values followed by different capital letters are statistically different in comparison to the same species in different seasons.

¹Maximum gas production potential (A, mL); ²colonization time (CT, hours:minutes); ³gas production rate (μ, mL h⁻¹); ⁴effective degradability (ED), of DM for the fractioned passage rate of 2% h⁻¹.

season for the 12 and 96 hours incubation times for both forages, despite the higher count during the rainy season. *B. brizantha* had higher CGP values than *E. inflexa* for all incubation times and during both seasons. These results are in accordance to lower NFC contents and higher PIDA contents of *E. inflexa* compared to *B. brizantha*, which may result in a reduced microbial growth and; therefore, lower gas production (NOGUEIRA et al., 2006). It was observed (Table 2) that the maximum gas production potential (A) and colonization time (CT) for any of the grasses (*E. inflexa* and *B. brizantha*) were not influenced by season. However, the gas production rate (μ) and the effective degradability (ED) were higher during the rainy season for both grasses, but higher for *B. brizantha*.

In the comparison between seasons, there was difference in the *in vitro* DMD (Table 2) for *B. brizantha* and *E. inflexa* only for the incubation times of 48 and 96 hours. The higher values in the rainy season are a consequence of the higher nutritional value of the forages at this time of year, which incurs higher fermentation and; therefore, higher dry matter degradation. According to VAN SOEST (1994), during

the dry season, the forage fermentation process is slower than it is during the rainy season because of the increased cell wall and decreased cell content in the plant. The DMD values for *E. inflexa* were lower than those for *B. brizantha* for all incubation times. This is explained because of the higher amounts of cell wall components found in *E. inflexa* compared to *B. brizantha*. Such behavior of *B. brizantha* is different from *E. inflexa* probably because of the higher concentrations of NFC and lower NDF and ADF contents (Table 1) observed in both seasons. According to HATFIELD (1989), the amount of cell wall components relates negatively the DMD of the forages, since the cell wall components of the grasses were different; lower DMD values for *E. inflexa* are justified.

CONCLUSION

The *E. inflexa* biomass production is lower than *B. brizantha* cv. 'Marandu' during the rainy season, but its production was similar during both seasons. It also has lower seasonal variation in nutritional value compared to *B. brizantha*. However, a high crude protein percentage is linked to acid

detergent insoluble fiber, which decreases nitrogen availability to rumen microorganisms.

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BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

This study has been approved by the Universidade Federal de São João del-Rei (UFSJ) Ethics Committee (process number 14/2012).

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