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REGULAR ARTICLES

Intake, digestibility, and growth performance of Girolando bulls supplemented on pasture in Bahia, Brazil

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Abstract
The objective of this trial was to evaluate intake, digestibility, and growth performance of Girolando bulls submitted to two nutritional planes while grazing on *Brachiaria brizantha* cv. Marandu pasture. Twenty-two animals, with average initial body weight = 209.1 ± 8.2 kg, were used in this trial. The experimental design was repeated measurements, in a 2 × 3 factorial arrangement, with two nutritional planes (NP1 and NP2) and three seasons of the year, with 11 replicates per treatment. The animals of the NP1 received mineral mixture ad libitum during rainy season 1 (15 February through 5 July 2014), energy protein supplement in the amount of 1 g d kg BW^{-1} during the dry season (from 6 July through 22 November 2014), and again mineral mixture ad libitum during rainy season 2 (from 23 November 2014 through 9 March 2015). The NP2 animals received 2 g d kg BW^{-1}, 2 g d kg BW^{-1}, and 1 g d kg BW^{-1} of energy-protein supplement in the respective seasons of the year. Forage intakes were similar between nutritional planes, 6.8 and 7.6 kg DM day^{-1} and 2.1 and 2.22% BW for NP1 and NP2, respectively. There was no statistical difference (level) between the intakes of neutral detergent fiber corrected for ash and protein (4.1 and 4.3 kg day^{-1} and 1.2 and 1.3% BW, respectively for nutritional planes 1 and 2). For the other nutrients, NP2 showed greater values. The highest intakes and digestibilities of dry matter, organic matter, and non-fiber carbohydrate were in rainy season 2. Performance and feed conversion were similar among NPs. This study showed that lower levels of supplementation could be done in order to reduce feeding costs with no impact on performance.

Keywords *Brachiaria brizantha* · Cattle · Nutritional planes · Weight gain

Introduction

Tropical pastures, which form the basis of bovine diets, constitute an important and affordable feed resource. Ruminant animals kept on pasture contribute to the positive trade balance of cattle; however, the exclusive use of these resources in Brazil provides a longer productive cycle causing economic losses, minimizing final income (Moreira et al. 2015).

Forage crops show qualitative and quantitative variations due to seasonality during the year (Boval et al. 2015). Tropical grasses are rarely available as a balanced diet for cattle because they present nutritional restrictions that limit consumption and digestibility (Detmann et al. 2014).

The use of complementary feeds boosts performance, reducing cycle length and increasing livestock efficiency. These technologies aim to supplement the nutritive value of the pasture, allowing greater assimilation of the nutrients by the animal and, in most of the cases, improve their digestibility (Marquez et al. 2014).

Therefore, the objective of this study was to evaluate intake, apparent digestibility of nutrients, and growth performance of bulls supplemented with two nutritional planes, during growing and finishing phases, in order to show if a lower level of supplementation would impact performance.

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Materials and methods

Study area

The experiment was conducted according to the standards of the Ethics Committee on Animal Use of the State University of Southwest of Bahia (CEUA-UESB protocol 15/2012) approved on June 3, 2013.

The study was conducted at the Princesa do Mateiro Farm, in southwestern Bahia, between February 2014 and March 2015, 387 days total, with adaptation period of 14 days prior to the experimental period. The climate in that region is tropical (AW) according to the Köppen-Geiger classification.

Animals and treatments

The experimental area, predominantly with *Brachiaria brizantha* cv. Marandu, consisted of 7 ha divided into 14 0.5 ha paddocks. The grazing system was intermittent, in which animals from each of the two treatments remained 5 days in each paddock, with 30 days of pasture rest for each of the paddocks.

Twenty-two non-castrated bulls (½ Holstein × ½ Zebu), with average initial BW = 209.1 ± 8.2 kg and 8 months of age, were submitted to ectoparasite and endoparasite control and vaccinations according to the sanitary authority of Bahia. The experimental design was repeated measurements, in a 2 × 3 factorial arrangement, with two nutritional planes (NP1 and NP2) and three seasons of the year, with 11 replicates per treatment. The effects of the nutritional planes, the seasons of the year, and the possible interactions between the two factors were tested.

Animals in the NP1 received mineral mixture ad libitum during rainy season 1 (15 February through 5 July 2014), energy protein supplement in the amount of 1 g/d/kg BW^{-1} during the dry season (from 6 July through 22 November 2014), and again mineral mixture ad libitum during rainy season 2 (from 23 November through 9 March 2015). The NP2 animals received 2 g kg BW^{-1}, 2 g kg BW^{-1} and 1 g kg BW^{-1} of energy protein supplement in the respective seasons of the year. Table 1 shows supplement composition formulated according to the NRC (2000) for gain of 700 g (animal day)$^{-1}$.

The concentrate was supplied daily at 1000 h. The evaluation of the forage occurred every 28 days. Forty samples were taken per paddock at soil level using a 0.25 m^2 square according to methodology described by McMeniman (1997). One sub-sample per paddock was weighed and taken immediately to a forced air circulation oven set at 55 °C for 72 h for DM determination. Forage collection for chemical composition analysis was performed according to Sollenberger and Cherney (1995), by grazing simulation. Approximately 300 g of fresh forage per paddock was collected manually at the beginning of each 28-d period, identified, and frozen at − 10 °C for analysis.

Table 1 Composition of supplements, as-is

Ingredient (g.kg^{-1})	Supplement	
	Energy protein	Mineral mix
Ground corn	454.4	
Soybean meal	449.4	
Urea + ammonium sulfate[1]	49.9	
Mineral mix[2]	46.3	1000

[1] Urea + ammonium sulfate (9:1)

[2] Composition (per kilogram): calcium 175 g, phosphorus 60 g, sodium 107 g, sulfur 12 g, magnesium 5 g, cobalt 107 mg, copper 1300 mg, iodine 70 mg, manganese 1000 mg, selenium 18 mg, zinc 4000 mg, iron 1400 mg, fluorine (maximum) 600 mg

The residual biomass of dry matter (RBM; kilogram of DM per hectare) was performed in the two pickets occupied by the double sampling method (Wilm et al. 1994). The estimation of the daily DM accumulation rate was performed by the equation proposed by Campbell (1966):

$$DAR_j = (G_i - F_{i-1})/n, \quad (1)$$

Where DAR_j = rate of accumulation of daily dry matter in period j, in kilogram DM per ha day; G_i = mean final dry matter of the two empty pickets at time i, in kilogram DM.ha^{-1}; F_{i-1} = average initial dry matter present in non-populated pickets at time i_{-1}, in kilogram DM.ha^{-1}; n = number of days in period j.

The estimate of the pasture potentially digestible dry matter (DMpd) was performed according to Detmann et al. (2016):

$$DMpd\ (\%) = 0.98\ (100 - \%NDFap) + (\%NDFap - \%NDFi) \quad (2)$$

Where 0.98 = coefficient of digestibility of the intracellular content; NDFap = neutral detergent fiber corrected for ash and protein; NDFi = indigestible NDF.

Forage availability (FA) was calculated according to Prohmann et al. (2004):

$$FA = \left\{ \left(RBM^{*}\ Area + DAR^{*}\ Area \right) / BWtotal \right\}^{*}\ 100 \quad (3)$$

where FA = forage availability, in kg DM (100 kg BW day)$^{-1}$; RBM = total residual biomass, in kg DM ha^{-1}; DAR = daily accumulation rate, in kg DM (ha day)$^{-1}$; BWtotal = total body weight of animals in the area.

Fecal excretion was estimated with chromium oxide, 10 g (animal/day)$^{-1}$, packed in paper cartridges, supplied orally at 600 h, the initial 7 days being for the regulation of the flow of excretion, and the five following days for fecal collections.

For the complementary feed consumption (DMIs), titanium dioxide, 15 g $(\text{animal/day})^{-1}$, was used according to Valadares Filho et al. (2006).

The concentration of the chromium oxide in the feces was performed in the DZO/UFV by the method of atomic absorption, according to the methodology described by Williams et al. (1962), using the Model GBC Avant E Atomic Absorption Spectrometer apparatus.

Fecal production was obtained by the ratio between the amount of indicator supplied and its concentration in feces, according to Smith and Reid (1955):

$$\mathrm{FP} = (\mathrm{Ip}/\mathrm{If}) \times 100 \quad (4)$$

Where FP = fecal production (g DM day^{-1}), Ip = amount of indicator provided (g day^{-1}), and If = fecal indicator concentration (%DM).

The titanium concentration was estimated according to a methodology described by Detmann et al. (2012). To determine the DM intake (DMI) of the supplement (SI), titanium dioxide was used as an external marker, according to equation

$$\mathrm{SI} = (\mathrm{FP} \times \mathrm{CTF})/\mathrm{CTS} \quad (5)$$

Where SI is the DMI of the supplement (g day^{-1}), FP is the daily fecal production (g day^{-1}), CTF is the concentration of titanium dioxide (TiO_2) in feces (g g^{-1} DM), and CTS is the concentration of titanium dioxide in the supplement (g g^{-1} DM). For roughage intake estimate, the indigestible neutral detergent fiber (NDFi) was used, according to Detmann et al. (2012):

$$\mathrm{DMI} = [(\mathrm{FP} \times \mathrm{IMF}) - \mathrm{IMS}]/\mathrm{IMF} \quad (6)$$

Where DMI = dry matter intake (kg d^{-1});FP = fecal production (kg d^{-1}); IMF = concentration of the internal marker (iNDF) in feces (kg kg^{-1}); IMS = iNDF intake from complementary feed (kg d^{-1}); IMF = concentration of iNDF present in forage (kg kg^{-1}).

The chemical composition of the complementary feed, forage, and feces was performed according to Detmann et al. (2012). Ether extract contents were obtained in the apparatus Ankom® XT15 according to AOCS (2005).

Total carbohydrates (TC) were obtained according to Sniffen et al. (1992). Non-fibrous carbohydrates corrected for ashes and protein (NFCap), was determined by the difference between TC and NDFap. The NFCap of the complementary feed was obtained according to Hall (2003):

$$\mathrm{NFCap} = 100 - \%\mathrm{Ash} - \%\mathrm{EE} - \%\mathrm{NDFap} - (\%\mathrm{CP} - \%\mathrm{CPu} + \%\mathrm{U}) \quad (7)$$

Where EE = ether extract; NDFap = neutral detergent fiber corrected for ash and protein; CP = supplementary crude protein; CPu = crude protein coming from urea; U = urea content in the complementary feed.

Total digestible nutrients (TDN) was calculated as the sum of digestible crude protein (DCP), digestible neutral detergent fiber corrected for ash and protein (DNDFap), digestible non-fibrous carbohydrates corrected for ash and protein (DNFCap), and digestible ether extract (DEE) multiplied by 2.25, according to Weiss (1999) cited in NRC (2001):

$$\mathrm{TDN} = \mathrm{DCP} + \mathrm{DNDFap} + \mathrm{DNFCap} + (\mathrm{DEE} \times 2.25) \quad (8)$$

The chemical composition of the forage and the supplement is found in Table 2, and the forage production in Fig. 1 and Table 3.

Statistical analyses

The effects of the nutritional planes, the seasons of the year and the possible interactions between the two factors were analyzed through analysis of variance of the repeated measures, using the System of Statistical and Genetic Analysis—SAEG (Ribeiro Júnior 2001). For all variables, the animal within season was considered the experimental unit, despite the lack of pasture replication, because of the efforts to measure individual traits with external markers. The level of probability of 0.05 was adapted for the type I error.

Results

There was no effect of nutritional plane on forage DM intake ($P = 0.23$) and, consequently, there was no effect on NDFap intake ($P = 0.21$). Intake of all other measured nutrients was higher for nutritional plane 2 ($P < 0.01$).

There was an effect of nutritional plane ($P < 0.03$) and season ($P < 0.001$) on digestibility coefficients of dry matter (DCDM), organic matter (DCOM), and non-fibrous carbohydrates (DCNFCap), in which nutritional plane 2 and rainy season 2 showed greater values. There was interaction of nutritional plane and season for digestibility coefficients of crude protein (DCCP) ($P < 0.001$) and ether extract (DCEE) ($P < 0.001$).

Nutritional plane 2 presented greater DCCP ($P < 0.001$) in the rainy season 1 and dry season ($P < 0.001$) when compared to NP1. In both nutritional planes, for all three seasons, DCCP in the different seasons was lowest in the rainy season 1 ($P < 0.001$). The digestibility of the ether extract for the nutritional planes within each season presented differences only in the rainy season 1, being greater for nutritional plane 2 ($P < 0.001$). Digestibility of CP and EE was greatest in rainy season 2 due to less lignin and greater TDN content in forage (Table 2).

Table 2 Chemical composition of simulated grazing forage samples during different seasons and energy protein supplement, on a dry matter basis. In which DCP, DNDFap, DNFCap, and DEE mean the digestible CP, NDFap, NFCap, and EE, respectively

Item[1]	Pasture—*Brachiaria brizantha* cv. Marandu			Energy protein supplement
	Rainy season 1	Dry season	Rainy season 2	
DM	314.5	348.7	300.2	914.9
CP[2]	72.4	71.8	92.0	437.7
EE[2]	20.8	22.2	28.2	31.7
NFCap[2]	172.3	200.7	199.8	485.1
NDFap[2]	635.0	589.5	606.2	39.9
ADF[2]	315.2	303.1	289.8	42.0
Lignin[2]	23.1	28.4	20.0	8.0
Ash[2]	99.5	109.5	73.8	96.9
NDFi[2]	197.3	230.1	136.0	12.1
TDN[2,3]	512.7	489.6	635.6	670.6

[1] *DM*, dry matter; *CP*, crude protein; *EE*, ether extract; *NFCap*, non-fiber carbohydrate corrected for ash and protein; *NDFap*, neutral detergent fiber corrected for ash and protein; *ADF*, acid detergent fiber; *NDFi*, indigestible neutral detergent fiber; *TDN*, total digestible nutrients

[2] $g\ kg^{-1}$ of DM

[3] TDN was estimated according to Weiss (1999) cited in NRC (2001): TDN = DCP + DNDFap + DNFCap + (2.25 x DEE) (8)

Performance variables were similar between nutritional planes ($P < 0.33$). However, there was effect of season ($P < 0.001$) on growth performance parameters. Average daily gain was greatest in rainy season 2, followed by rainy season 1 ($P < 0.001$).

Discussion

The hypothesis was that, under this experiment conditions, lower supplementation levels would be able to promote similar performance when compared to higher supplementation levels, which would be of great importance to reduce feed costs and improve efficiency. The absence of a difference in the intake of forage dry matter and neutral detergent fiber corrected for ash and protein NDFap (in kg day^{-1}) between nutritional planes (Table 4) shows that the higher level of supplementation used in the nutritional plane 2 did not promote an additive effect on forage consumption. Differences observed in other nutrients intake can be attributed to the greater quantitative participation of the supplement in nutritional plane 2, allowing a greater intake in comparison to nutritional plane 1.

Forage DM intake (in kg day^{-1}) was greater in rainy season 2 than rainy season 1. One of the reasons that justifies the greater forage intake in rainy season 2 is that the animals were in the finishing phase, with greater body weight, needing more feed to meet their nutritional needs. The highest forage intake in the rainy season 2 (8.4 kg day^{-1}) was also associated with higher forage availability at this season (Fig. 1), contributing to the greater total DM intake (8.6 kg day^{-1}). Total DM, crude protein, and TDN intakes in both rainy seasons, regardless of nutritional plane, were satisfactory for gains of 700 g day^{-1} (NRC 2000).

Evaluating the supply of energy protein supplement at 2 g kg BW^{-1} and mineral supplement in the growing phase

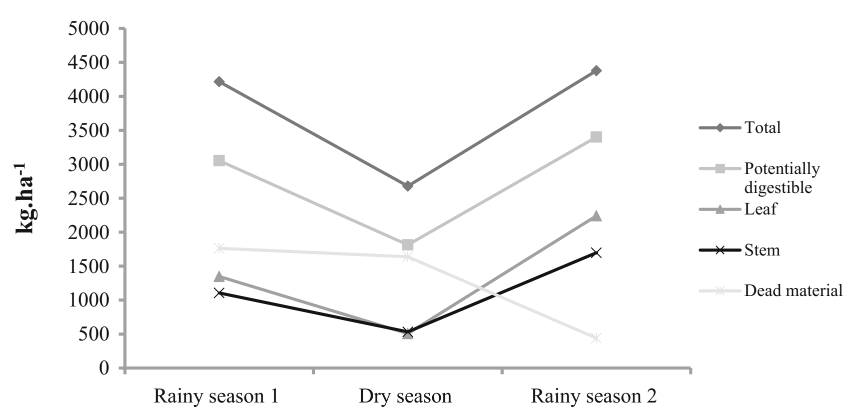

Fig. 1 Dry matter availability of total, potentially digestible, leaf, stem, and dead material of *Brachiaria brizantha* cv. Marandu throughout the experiment

Table 3 Structural components of the sward of *Brachiaria brizantha* cv. Marandu throughout the experiment

Item	Rainy season 1	Dry season	Rainy season 2	Average
Daily residual biomass[1]	150.6	95.7	156.4	134.2
Daily accumulation rate[1]	30.1	19.1	40.9	30.1
Forage availability[2]	21.8	10.6	15.0	15.8
Leaf-to-stem ratio	1.2	1.0	1.3	1.2

[1] kg DM ha^{-1}

[2] kg DM 100 kg BW^{-1}

of grazing bulls, Dias et al. (2015) showed similar results to those observed in the present study. They found that pasture consumption was not influenced by supplementation strategy, with values of 6.3 and 6.0 kg day^{-1}, respectively.

The current study showed similar forage intake (in % of BW) results as those observed by Silva et al. (2010) when steers on pasture were supplemented mineral salt or energy protein supplement at the level of 3 g kg BW^{-1}, with intake of 1.9%BW and 1.9%BW for mineral and supplement treatments, respectively. The lower forage intake (1.8% of BW) observed during the dry season (Table 4) can be explained by the lower TDN content (Table 2) and lower forage availability (Table 3). In pasture-based systems, forage intake is the most important factor influencing animal performance (Riaz et al. 2014). During both rainy seasons, maximum voluntary pasture intake was achieved because of the greater forage availability (Hodgson 1990; Berchielli et al. 2011). There was no difference between forage DM intake in % of BW between both rainy seasons; although there was a numeric difference, which is in tune with NRC (2000) that animals in the growing phase have greater %BW intake than older ones.

According to Silva et al. (2009), when supplementation levels exceed 2 or 3 g kg BW^{-1}, there is an increased possibility of forage intake reduction, which is called substitutive effect. These authors also mentioned that this effect is more pronounced when forage is of better quality because the chemical composition of the low-quality forage is responsible for its reduced intake by the animal. On the other hand, the substitution of forage intake by the supplement allows to raise the pasture stocking rate and increase gains per area. However, in regions where the cost of ingredients is high, it would be ideal to maximize intake of low-cost feed. Pasture is the main nutritional resource for bovine production in the tropics, and the main objective of supplementation is to optimize the use of

Table 4 Nutrient intake by bulls on pasture supplemented two nutritional planes throughout the experiment

Item[1]	Nutritional plane (NP)		Season (S)			CV (%)	*P* value		
	1	2	Rainy 1	Dry	Rainy 2		NP	S	NP × S
Total DM[2]	6.8b	7.6a	6.2b	6.8b	8.6a	18.40	0.012	< 0.001	0.867
Total DM[3]	2.1b	2.2a	2.3a	2.0b	2.1b	15.29	0.040	< 0.001	0.923
ForDM[2]	6.6	7.0	5.9b	6.2b	8.4a	18.64	0.231	< 0.001	0.764
ForDM[3]	2.0	2.1	2.2a	1.8b	2.0ab	15.84	0.697	< 0.001	0.889
SupDM[2]	0.1b	0.6a	0.3b	0.6a	0.2b	63.61	< 0.001	< 0.001	0.405
SupDM[3]	0.0b	0.2a	0.1b	0.2a	0.1c	60.15	< 0.001	< 0.001	0.405
NDFap[2]	4.1	4.3	3.7b	3.7b	5.1a	18.60	0.209	< 0.001	0.789
NDFap[3]	1.2	1.3	1.4a	1.1c	1.2b	15.75	0.639	< 0.001	0.910
OM[2]	6.1b	6.9a	5.5b	6.1b	8.0a	18.57	0.013	< 0.001	0.863
CP[2]	0.6b	0.8a	0.5b	0.8a	0.9a	22.04	< 0.001	< 0.001	0.817
EE[2]	0.16b	0.19a	0.13b	0.16b	0.24a	19.83	0.007	< 0.001	0.848
NFCap[2]	1.35b	1.65a	1.15c	1.48b	1.79a	19.16	< 0.001	< 0.001	0.934
TDN[2]	3.78b	4.54a	3.28b	3.60b	5.59a	22.57	0.002	< 0.001	0.984

[1] *Total DM*, total dry matter; *ForDM*, forage dry matter; *SupDM*, supplement dry matter; *NDFap*, neutral detergent fiber corrected for ash and protein; *OM*, organic matter; *CP*, crude protein; *EE*, ether extract; *NFCap*, non-fiber carbohydrate corrected for ash and protein; *TDN*, total digestible nutrients

[2] Intake in kg day^{-1}

[3] Intake in percentage of BW

[a, b, c] Within nutritional plane and season, means followed by same letter and means with no letters are not significantly different ($P < 0.05$)

Table 5 Apparent digestibility coefficient of dry matter, organic matter, and nutrients in bulls supplemented on pasture

Item[1]	Nutritional plane (NP)		Season (S)			CV (%)	P value		
	1	2	Rainy 1	Dry	Rainy 2		NP	S	NP × S
DCDM	54.6b	56.2a	51.8b	51.3b	63.1a	4.93	0.026	< 0.001	0.067
DCOM	57.4b	59.0a	55.1b	53.7b	65.8a	4.54	0.017	< 0.001	0.076
DCNDFap	54.6	53.9	52.7b	46.0c	64.0a	5.02	0.331	< 0.001	0.256
DCNFCap	66.8b	71.8a	66.6b	70.0ab	71.3a	7.24	< 0.001	< 0.001	0.100

[1] DCDM, digestibility coefficient of dry matter; *DCOM*, digestibility coefficient of organic matter; *DCNDFap*, digestibility coefficient of neutral detergent fiber corrected for ash and protein; *DCNFCap*, digestibility coefficient of non-fiber carbohydrate corrected for ash and protein

[a, b, c] Within nutritional plane and season, means followed by same letter and means with no letters are not significantly different ($P < 0.05$)

these resources with minimal substitution (Detmann et al. 2005).

The nutritional plane 2 offered a higher supplementary level (in percentage of BW), which combined with the high-chemical composition of the supplement, allowed the digestibility of most nutrients to be increased (Table 5). In another study, the use of different levels of supplementation, ranging from 2 to 5 g kg BW^{-1}, did not influence digestion or absorption, therefore the digestibility of some nutrients was similar (Neves et al. 2018).

The highest digestibility values were obtained in the rainy season 2 (Table 5). The greatest quantity (forage availability) and quality (highest TDN and CP levels, and lowest lignin and NDFi content) of forage were observed at that time (Tables 2 and 3). In the dry season, digestibility of the NDFap was reduced when compared to the other seasons. Therefore, lower forage intake (in percentage of BW) was observed in this season (Table 4).

Chemical composition of the forage (Table 2) can explain, in part, differences in CP digestibility for both nutritional planes in the rainy season 1 when compared to rainy season 2 (Table 6). We hypothesize that the lower digestibility coefficient of this fraction in the rainy season 1 for the nutritional plane 1 was likely because the animals were only supplemented with mineral mix in this period, and the higher digestibility coefficient is justified by the supplement intake of the nutritional plane 2, which was 2 g kg BW^{-1}. In the dry season, the higher supplement level of the nutritional plane 2 favored the higher CP coefficient of digestibility. The greater the availability and quality of the forage, the less the need for supplementation, and the greater the biological and economic efficiency of the grazing system (Barros et al. 2015). This assertion corroborates the results of this study. Digestibility of CP in the rainy season 1 and in the dry season was different between treatments, while it was not different in the rainy season 2, when the quality of the forage was greatest when compared to the other seasons. Same idea with digestibility of the EE, when it was different between treatments in rainy season 1, but not in rainy season 2.

Table 6 Apparent digestibility coefficient of crude protein and ether extract within nutritional plane, season, and the interaction season × nutritional plane in bulls supplemented on pasture

Season	Nutritional plane (NP)		CV (%)	P value		
	1	2		NP	S	NP × S
	DCCP[1]					
Rainy 1	46.9Cb	51.7Ba	9.57	< 0.001	< 0.001	< 0.001
Dry	54.6Bb	59.9Aa				
Rainy 2	60.8Aa	62.4Aa				
	DCEE[1]					
Rainy 1	61.9Bb	72.1Ba	21.08	< 0.001	< 0.001	< 0.001
Dry	65.8Ba	67.3Ba				
Rainy 2	76.8Aa	78.2Aa				

[1] *DCCP*, digestibility coefficient of crude protein; *DCEE*, digestibility coefficient of ether extract

[a, b] Within same row, means followed by same letter are not significantly different ($P < 0.05$)

[A, B, C] Within same column, means followed by same letter are not significantly different ($P < 0.05$)

Table 7 Growth performance of bulls on pasture supplemented two nutritional planes throughout the experiment

Item[1]	Nutritional plane (NP)		Season (S)			CV (%)	*P* value		
	1	2	Rainy 1	Dry	Rainy 2		NP	S	NP$_\times$S
IBW, kg	210.4	207.8	209.1	319.3	369.0	–	–	–	–
FBW, kg	450.7	480.6	319.3c	369.0b	465.7a	15.09	0.119	< 0.001	0.866
ADG, kg d^{-1}	0.6	0.7	0.8b	0.4c	0.9a	19.98	0.119	< 0.001	0.683
F:G	11.2	11.0	8.0b	22.8a	9.7b	18.70	0.328	< 0.001	0.317

[1] *IBW*, initial body weight (kg); *FBW*, final body weight; *ADG*, average daily gain; *F:G*, feed-to-gain ratio (kilogram of DM intake per kilogram of ADG)

In the dry season, performance was reduced (Table 7) because of lower DM intake (Table 4). This period was characterized by the lower availability of forage components (Fig. 1 and Table 3). Performance of grazing animals is directly related to the quality and quantity of forage available. In the current study, regardless of nutritional plane, ADG was highest in the best forage quality season (rainy season 2), followed by the second-best forage quality (rainy season 1), according to the chemical composition of the forage throughout the study. These results support that, in grazing systems, forage availability and quality play a more important role than supplementation level. Therefore, pasture should be considered the most important nutritional resource for beef cattle production in the tropics.

Conclusions

Under the conditions of the current experiment, just mineral supplementation during the rainy season, combined with low level of protein-energy supplementation (1 g kg BW^{-1} of the supplement per day) during the dry period, can be adopted as a supplementation strategy without reduction in animal performance when compared to a nutritional plane with greater levels of supplementation throughout the year.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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