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Efeitos das estratégias de suplementação para bovinos de corte em condições de pastagem tropical

Effects of supplementation strategies for beef cattle in tropical grassland conditions

Efectos de diferentes estrategias de suplementación para ganado de carne bajo condiciones de pastoreo en el trópico

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Venício Macêdo Carvalho
ORCID: https://orcid.org/0000-0002-2875-7799
Universidade Estadual do Sudoeste da Bahia, Brazil
Universidade Estadual de Maringá, Brazil
E-mail: venicio_@hotmail.com
Robério Rodrigues Silva
ORCID: https://orcid.org/0000-0003-1059-3308
Universidade Estadual do Sudoeste da Bahia, Brazil
E-mail: rrsilva.uesb@hotmail.com
Túlio Otávio Jardim D`Almeida Lins
ORCID: https://orcid.org/0000-0002-4625-6680
Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Brazil
E-mail: tuliootavio@hotmail.com
Mateus de Melo Lisboa
ORCID: https://orcid.org/0000-0002-0278-940X
Universidade Estadual do Sudoeste da Bahia, Brazil
E-mail: lisboazoot@hotmail.com
Maria Magna Silva Pereira
ORCID: https://orcid.org/0000-0001-6720-2393
Universidade Estadual do Sudoeste da Bahia, Brazil.
E-mail: magnazootecnia@hotmail.com
George Abreu Filho
ORCID: https://orcid.org/0000-0002-7115-837X
Universidade Estadual do Piauí, Brazil
E-mail: georgeabreu16@hotmail.com

João Wilian Dias da Silva
ORCID: https://orcid.org/0000-0002-2695-8255
Universidade Estadual do Sudoeste da Bahia, Brazil
E-mail: joaowiliand@yahoo.com
Sinvaldo Oliveira de Souza
ORCID: https://orcid.org/0000-0002-8841-0017
Universidade Estadual do Sudoeste da Bahia, Brazil
E-mail: sinvalsouza79@hotmail.com
Vicente Diaz Avila
ORCID: https://orcid.org/0000-0003-2550-2392
Universidade Estadual de Maringá, Brasil
E-mail: vadiaza@ut.edu.co
Ivanor Nunes do Prado
ORCID: https://orcid.org/0000-0003-1058-7020
Universidade Estadual de Maringá, Brasil
E-mail: inprado@uem.br

Resumo

Este trabalho foi realizado para avaliar a ingestão de matéria seca, a digestibilidade de nutrientes e o desempenho animal de novilhos mestiços em pastagem de *Brachiaria brizantha cv.* Marandu, durante a estação das chuvas. Trinta e três novilhos mestiços, com peso médio de 203,5 ± 39,5 kg foram distribuídos em delineamento inteiramente casualizado, com três tratamentos e onze repetições. Os resultados foram analisados por ANOVA e Tukey, com 5% de probabilidade de erro. As três dietas experimentais foram: MSA - sal mineral *ad libitum*; MSU - sal mineral + ureia *ad libitum* e PSU - suplementação proteica (0,1% do peso corporal). A ingestão de matéria seca da forragem e a ingestão de matéria seca total foram semelhantes ($P > 0,05$) entre os tratamentos. O coeficiente de digestibilidade da matéria seca, matéria orgânica, fibra em detergente neutro, proteína bruta, extrato etéreo, carboidratos não fibrosos e carboidratos totais foram influenciados ($P < 0,05$) pelos tratamentos. O peso corporal final, o ganho médio diário e a eficiência alimentar foram semelhantes ($P > 0,05$) entre tratamentos. As estratégias de suplementação utilizadas durante a estação chuvosa resultaram em desempenho semelhante, portanto, a estratégia adotada poderia ser escolhida de acordo com as condições econômicas e regionais de produção.

Palavras-chave: Novilhos mestiços; Suplementação mineral; Suplementação nitrogenada; Forragem tropical.

Abstract

This study was realized to evaluate the dry matter intake, nutrient digestibilities, and animal performance of crossbred steers grazing *Brachiaria brizantha cv.* Marandu, during the rainy season. Thirty-three crossbred steers with an average weight of 203.5 ± 39.5 kg were distributed in a completely randomized design with three treatments and eleven replications. The results were analyzed using an ANOVA and a Tukey test with a 5% probability of error. The three experimental diets were: MSA – mineral salt *ad libitum*; MSU - mineral salt + urea *ad libitum* and PSU - protein supplementation (0.1% of body weight). The dry matter intake of forage and total dry matter intake were similar (P > 0.05) among treatments. The dry matter, organic matter, neutral detergent fiber, crude protein, ether extract, non-fibrous carbohydrates and total carbohydrates digestibilitities coefficients were influenced (P < 0.05) by treatments. The final body weight, average daily gain, and feed efficiency were similar (P > 0.05) among treatments. The supplementation strategies used during the rainy season resulted in a similar performance; therefore, the strategy adopted could be chosen according to the economical and regional conditions of the production.

Keywords: Crossbred steers; Mineral supplementation; Nitrogen supplementation; Tropical forage.

Resumen

El objetivo de este trabajo fue evaluar el consumo de materia seca, digestibilidad de nutrientes y rendimiento productivo de novillos mestizos en pastura de *Brachiaria brizantha cv.* Marandu, durante la temporada de lluvias. Treinta y tres novillos mestizos, con peso medio de 203.5 ± 39.5 kg, fueron distribuidos en un diseño completamente aleatorizado con tres tratamientos y once repeticiones. Los resultados fueron analizados por ANOVA y las medias comparadas por análisis de Tukey con 5% de probabilidad de error. Las tres dietas experimentales fueron: MSA - sal mineral *ad libitum*; MSU - sal mineral + urea *ad libitum*; PSU - suplementación proteica (0,1% del peso corporal). La ingestión del forraje y la ingestión de la materia seca total fueron semejantes (P> 0,05) para todas las estrategias de suplementación. El coeficiente de digestibilidad de la materia seca, materia orgánica, fibra en detergente neutro, proteína cruda, extracto etéreo, carbohidratos no fibrosos y carbohidratos totales fueron influenciados (P < 0,05) por las estrategias de suplementación adoptadas. El peso corporal final, el promedio de

ganancia diaria de peso y la eficiencia alimentar fueron semejantes (P > 0,05) entre las estrategias de suplementación. Las estrategias de suplementación utilizadas durante la época de lluvias resultaron en un desempeño semejante, sin embargo, la estrategia adoptada podría ser escogida de acuerdo con las condiciones económicas y regionales de la producción.

Palabras clave: Novillos mestizos; Suplementación mineral; Suplementación nitrogenada; Pastura tropical.

1. Introduction

Brazil has the largest commercial cattle herd in the world, with nearly 200 million animals, and Brazilian cattle farming is a major contributor to the production and commercial system (ANUALPEC, 2019). Among the advantages of Brazilian beef cattle production, climate characteristics stand out above forage production. However, there are disadvantages of production in the tropical climate region, especially in the dry period. During dry seasons, there is a decrease in the amount and nutritional value of the available forage, which directly affects the performance of animals raised in a pasture system (Porto et al., 2009; Silva et al., 2010). However, the rearing of cattle exclusively in a pasture system is very common in Brazilian regions, where there are variations in the productive performance throughout of the year (Ferraz & Felício, 2010), increasing the slaughter age, and, consequently, resulting in a smaller financial return of the system (Pesqueira-Silva et al., 2015; Silva et al., 2010).

Therefore, new technologies to improve the system of beef cattle production are being used in Brazil, such as feed supplementation in the dry and rainy seasons of the year (Neves et al., 2018; Rocha et al., 2019; Souza et al., 2019). However, the level of supplementation is dependent on the rearing and finishing system of the animals, as well as the geographical location, pasture type, and management (El-Memari Neto et al., 2003).

This work was carried out to evaluate the dry matter intake, nutrient digestibility, and performance of crossbred steers reared in different supplementation strategies during the rainy season.

2. Materials and Methods

Ethical considerations

This study was conducted in strict conformity with the Brazilian legislation on experimentation involving the use of animals adopted by the National Council of Experimental Control (CONCEA) and was approved by the Ethics Committee in Animal Use (CEUA) of the State University of Southwest Bahia, located in Itapetinga, Bahia, Northeast Brazil, under approval number 100/2015.

Local and animals

The experiment was conducted in Princesa do Mateiro farm, located in the Ribeirão do Largo, Bahia, Brazil Northeast (15°26'46" S, 40°44'24" W) from March to July in 2015, comprising the rainy season in the region.

Thirty-three crossbred steers (½ Holstein *vs.* ½ Zebu) in the rearing period with an average body weight of 203.5 ± 39.5 kg and an average age of 12 months were distributed across 12 ha of *Brachiaria brizantha* cv. Marandu equipped with covered troughs that could be accessed from both sides and water troughs. The start of the experiment was preceded by a period of 14 days adaptation of the steers to the management and the experimental diets. At the beginning of the acclimatization period, all steers were treated for endoparasites and ectoparasites using Long-acting Injectable Ivermectin LA 3.5% (200 µg/kg BW; Ivomec Merial®, Paulínia, Brazil). The steers were immunologically castrated with the application of Bopriva® (Pfizer Animal Health – EUA) according to the manufacturer's recommendations.

The experimental design was completely randomized, with three treatments and eleven replications. The concentrate supplement was formulated according to the NRC (2000), targeting an average daily gain of 600 g/animal/day. The three experimental diets were: MSA – mineral salt *ad libitum*; MSU - mineral salt + urea *ad libitum*; PSU - protein supplementation (0.1% of body weight) (Table 1). These strategies were chosen based on past studies (Neves et al., 2018; Rocha et al., 2019).

Table 1. Composition of the supplements (% of DM).

Ingredients	Treatments[1]		
	MSA	MSU	PSU
Sorghum	-	-	56.55
Soybean meal	-	-	19.38
Urea	-	25	14.93
Mineral salt[2]	100	75	9.14

[1]Mineral salt; mineral salt + urea; Protein supplement (0.1% BW). [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. Source: Authors.

The total area used was 12 hectares subdivided into three paddocks. In order to avoid the possible effects arising from the pasture, the paddocks were rotated such that they had an occupation period of seven days for therefore, at the end of the cycle, which corresponded to a complete evaluation period; the steers were transferred back into their starting paddock. In this way, all the animals experienced the similar experimental conditions. The pasture was evaluated at the pre-established 28-day intervals, when the entry and exit paddocks of the steers were evaluated.

Sampling and chemical analyses

To estimate the fecal excretion (FE), chromic oxide (Cr_2O_3) was used as an external marker. The marker was provided daily at 07:00 in a single dose of 10 g/animal/day inside paper cartridges that were administered orally for a period of 11 days, consisting of seven days of adaptation of the animals to the management procedures and the regulation of chromium excretion in the feces, and four days of collection. Subsequently, the fecal output was calculated according to Smith & Reid (1955), using the formula below:

$$FO = OP/CMF$$

Where FO = daily fecal output (g/day); OP = amount of chromic oxide provided (g/day); and CMF = concentration of chromic oxide in the feces (g/g DM).

The intake of dry matter from the supplement (SDMI) was estimated using the titanium dioxide marker (TiO2), which was provided at 15 g/animal/day, mixed with concentrate, for 11 days, and supplied directly in the trough at 10:00, in accordance with the procedure described by Detmann et al. (2012). Subsequently, SDMI was calculated using the equation below:

SDMI = (EF X TIO_2 feces)/ TIO_2 supplement

Where TiO_2 feces and TiO_2 supplement correspond to the concentration of titanium dioxide in the feces and supplement, respectively.

The estimate of the voluntary intake of roughage was calculated on the basis of the internal indicator indigestible neutral detergent fiber (iNDF), following the methodology proposed by Casali et al. (2008), obtained after ruminal incubation for 288 h, following the methodology and equation described by Detmann et al. (2012).

To determine animal performance, the steers were weighed at the beginning of the experiment (after fasting of solids for 16 h) and at 28 days intervals throughout the study. The average daily gain (ADG) was calculated as the total body weight (BW) gain divided by the length of the experimental period (112 days). Feed conversion was calculated as the ratio between dry matter intake (DMI) and ADG.

The chemical composition of the forage, concentrate, and supplement were determined at the Laboratório de Misturas e Separações Químicas (LABMESQ) at the UESB, following the methodologies described by Detmann et al. (2012) to determine the dry matter (DM), ash content, ether extract (EE), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF). The total carbohydrate content was estimated following the procedure described by Sniffen et al. (1992). The non-fibrous carbohydrate (NFC) content was determined as the difference between the total carbohydrate and NDF. The metabolisable energy of the feedstuffs was estimated according to NRC (2000) recommendations. The content of non-fibrous carbohydrates (NFCap) corrected for ash and protein of forage and feces was calculated using the equation proposed by Weiss et al. (1992):

NFCap = 100 – CP – EE – NDFap – MM.

Where NFCap, non-fibrous carbohydrates corrected for ash and protein; CP, crude protein content; EE, ether extract content; NDFap, neutral detergent fiber corrected for ash and protein; and MM, mineral matter content. All terms are expressed as % of DM.

The supplements contained urea; for this reason, the NFCap content in them was obtained by using the equation proposed by Detmann and Valadares Filho (2010):

NFC = 100 – Ash – EE – NDFap – (CP – CPu + U);

where CP is the crude protein; CPu is the crude protein from urea; EE is the ether extract; NDFap, is the neutral detergent fiber corrected for ash and protein; and U is urea. All terms are expressed as % of DM. All terms are expressed as % of DM. Fecal samples were processed the same as forage and their chemical composition was determined in the same way as for the supplements.

The digestibility coefficient (DC) was calculated by the following equation:

DC = (nutrient intake – nutrient excreted)/nutrient intake).

Statistical analyses

All variables under study were tested for normality and showed a normal distribution. Data were analyzed by ANOVA using the general linear model (SAS, 2004) including diet as a fixed effect. A Tukey's test was used to compare the treatment means and they were considered to be significantly different when $P < 0.05$.

3. Results

The chemical compositions of the simulated grazing and concentrate are shown in Table 2.

Table 2. Chemical composition (%) of the simulated grazing samples of *Brachiaria brizantha* and the concentrate.

Item	DM[1]	OM[2]	CP[3]	EE[4]	TC[5]	NFCap[6]	NDFap[7]	iNDF[8]	TDN[9]
Simulated grazing	28.10	90.50	9.00	1.60	80.80	18.60	71.58	17.00	48.81
Concentrate	89.57	89.44	46.58	3.29	40.00	15.84	27.65	1.22	61.38

[1]*DM*, dry matter
[2]*OM*, organic matter
[3]*CP*, crude protein
[4]*EE*, ether extract
[5]*TC*, total carbohydrates;
[6]*NDFap*, neutral detergent fiber corrected for ash and protein
[7]*NFCap*, non-fiber carbohydrate corrected for ash and protein
[8]*iNDF*, indigestible neutral detergent fiber
[9]*TDN*, total digestible nutrients. Source: Authors.

Animals had free access to the concentrate and *ad libitum* access to forage. This value from production of forage is similar to that found by Rocha et al. (2019), in the same location and under the same experimental conditions. The lack of an effect on the total dry matter intake is

due to the similarity in the diet compositions (Table 2). Therefore, since the crude protein levels in the present study were above the minimum required values, the basal diet (forage) promoted the higher use of neutral detergent fiber (NDF) as the main source of energy for animals kept under grazing conditions.

The mean total dry matter availability and the stocking rate found during the experimental period were 6.32 tons per hectare and 1.46 AU/ha. The use of supplementation strategies during the rainy season did not influence ($P > 0.05$) the dry matter intake of the forage (Table 3). Thus, additional sources of protein and non-protein nitrogen did not promote forage intake.

Table 3. Intake and coefficients of digestibility of dry matter and nutrients ingested by beef cattle in the rearing phase

Item[1]	Treatments			CV[2] (%)	*P* – value
	MSA	MSU	PSU		
Intake kg/day					
ForDM	5.26	5.45	5.21	16.74	0.804
Total DM	5.26	5.45	5.43	16.32	0.855
OM	4.84	5.02	4.99	16.33	0.859
Digestibility coefficient %					
DM	54.05^{c}	54.67^{b}	55.80^{a}	0.90	0.001
OM	55.80^{c}	58.38^{b}	60.25^{a}	1.49	0.001
NDFap	54.85^{b}	60.05^{a}	60.25^{a}	1.92	0.001
CP	45.13^{c}	51.07^{b}	53.69^{a}	4.98	0.001
EE	62.21^{b}	64.53^{ab}	69.30^{a}	7.38	0.006
NFCap	54.89^{c}	60.21^{b}	63.96^{a}	5.58	0.001
TC	53.39^{c}	58.87^{b}	61.20^{a}	1.80	0.001

[1]ForDM, forage dry matter; Total DM, total dry matter; OM, organic matter; DM, dry matter; NDFap, neutral detergent fiber corrected of ash and protein; CP, crude protein; EE, ether extract; NFCap, non-fiber carbohydrate corrected for ash and protein; TC, total carbohydrate.
[2]Coefficient of variation %
[a, b, c]Means followed by letter different in the same row were different ($P < 0.05$). Source: Authors.

Although the intake of dry matter and organic matter was not influenced by the supplementation strategies, the apparent digestibility of these nutrients was influenced ($P < 0.05$). The association of structural and non-structural carbohydrates in the diet enhances nutrient digestibility due to the synchrony of energy and protein availability, resulting in improvements in the absorption efficiency of the nutrients ingested. In general, the digestibility coefficients analyzed were influenced ($P < 0.05$) by the supplementation strategies, with the PSU treatment presenting the highest digestibility coefficient, indicating that provided compounds that were easily digestible. Given the changes in the digestibility coefficients during the rainy season, the use of supplements containing protein resulted in improvements in all the

analyzed digestibility coefficients. Nevertheless, such effects were not evident the in steers' performance, which can thus be explained by the similarity in the total intake of dry matter and nutrients.

Since there was no difference in the ADG and the total DMI, the feed conversion (FC) was similar among steers from all diets (Table 4). It was observed that the supplementation strategy in rainy season did not influence the final body weight, which presented an average of 269.5 kg.

Table 4. Final live weight, average daily gain, and feed conversion of steers supplemented in a pasture system in the rainy season.

Item[1]	Treatments			CV[2] (%)	*P* - value
	MSA	MSU	PSU		
IBW, kg	204.8	202.1	202.5	19.74	0.985
FBW, kg	269.5	268.3	270.7	16.29	0.992
ADG, kg/d	0.577	0.591	0.608	15.11	0.719
F:G	9.19	9.21	9.21	18.47	1.000

[1]IBW, initial body weight; FBW, final body weight; ADG, average daily gain; F:G, feed-to-gain ratio (kilogram of DM intake per kilogram of ADG).
[2]Coefficient of variation (%). Source: Authors.

Analysis of the ADG revealed that there was no difference between the strategies, with an average of 0.592 kg/day; although the forage available to the animals during the rainy season was of excellent quality.

These results show that when animals have a good supply of grass and good pasture management, the addition of mineral supplementation only is able to provide satisfactory gains during the rainy season.

4. Discussion

The production of forage by area was higher than that observed by Neves et al. (2018), Rocha et al. (2019) and Souza et al. (2019), but consistent with the recommendations proposed by Silva et al. (2009), who proposed a grazing management procedure for quality and quantity. Forage production by area is determined by different factors, such as geographic location, soil types, fertilization level, and fodder type (Greenwood & McKenzie, 2001). Thus, the comparison of forage production among experiments should not be performed without considering these factors.

The hypothesis was that, under the conditions of this experiment, the additional supply of protein sources would be able to promote improvements in the variables related to total dry matter intake and animal performance. However, when analyzing the quality of the forage and its nutritional composition during the rainy season, no effect of the use of supplementation strategies on the variables related to consumption and animal performance was observed.

The current results suggest that for these pasture conditions and time of year, the additional supply of protein sources does not promote additional gains. It should be noted that for the normal modulation of the rumen to occur without limitations in intake, a minimum of 7% CP in the basal diet is required (NRC, 2000). Another variable that influences digestibility is ruminal pH. The mechanism found not to promote variations in ruminal pH will result in the production of higher amounts of propionate, generate less energy, and with that to obtain improvements in the digestibility of the forage and animal performance (Kozloski, 2011).

Nevertheless, a higher digestibility coefficient was observed for the treatments that received protein supplement (0.1% BW). The higher values observed here are potentially linked to increased NFC fermentation (Table 3), since the synthesis of microbial protein in the rumen is dependent on carbohydrate availability.

Animal performance is directly related to dry matter intake, and the feed conversion is used as a parameter to evaluate the amount of dry matter ingested for each kilogram of deposited body weight. Therefore, the lower the value of this index, the better the use of the food ingested. In general, it was observed (Table 4) that the use of food supplementation strategies during the rainy season containing sources of non-protein nitrogen and true protein did not have an effect on feed conversion, presenting a mean of 9.2 kg DM per kg of gain.

5. Conclusion

The effect of the supplements used here in this study (mineral salt, mineral salt + urea ad libitum and protein supplementation 0.1% of body weight) were equivalent to the daily weight gain reported for the water station, when low supplementary technological levels are adopted. However, it is worth noting that these results will only be possible in the face of adequate pasture management, ensuring a good supply of forage and availability of total dry matter sufficient to meet the animals' demands during the season.

Thus, the supplementation is a viable and extremely important tool, in which the adoption of supplementary strategies must be based on the region in which the livestock activity is inserted and the economic viability of the supplementary program.

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Conflict of interest

The authors declare no conflicts of interest.

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Percentage of contribution of each author in the manuscript

Venício Macêdo Carvalho – 15%

Robério Rodrigues Silva – 15%

Túlio Otávio Jardim D`Almeida Lins -10%

Mateus de Melo Lisboa – 10%

Maria Magna Silva Pereira 8 %

George Abreu Filho - 8%

João Wilian Dias da Silva - 8%

Sinvaldo Oliveira de Souza - 8%

Vicente Diaz Avila – 8%

Ivanor Nunes do Prado – 10%