



Macromineral requirements by beef cattle under pasture supplementation¹

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ABSTRACT - The objective of this work was to determine macromineral requirements by Zebu steers grazing *Brachiaria decumbens* supplemented with concentrate. It was used 24 non-castrated steers, at an average age of 7 months and at initial average weight 180 kg. Eight control animals were slaughtered for determining initial body composition. The 16 remaining animals were divided in four four-animal plots, in a complete random design. Each plot received mineral mixture or supplements at the levels 0.75; 1.50 or 2.25 kg/animal/day. The right half-carcass of eight animals, two per group, was dissected in muscle, fat and bones and all body constituents were weighted for determination of empty body weight and body composition. Net requirements of calcium and phosphorus for an animal at 400 kg body weight were 11.13 g and 5.40 g, respectively. To estimate dietary requirements of maintenance and after, sum them to dietary requirements for gain in order to obtain total dietary requirements, it was adopted endogenous losses and bioavailability present in literature for each mineral macroelement. Total dietary requirement for calcium, phosphorus, magnesium, sodium and potassium for a 400-kg BW animal with 1.0-kg daily weight gain were 34.59; 17.36; 7.82; 5.19 and 41.11 g/day, respectively. Macromineral requirements by beef cattle under pasture supplementation are similar to those recommended by BR-Corte for beef cattle in feedlots.

Key Words: calcium, nutritional requirement, phosphorus, supplementation, Zebu

Exigências de macrominerais de bovinos de corte sob suplementação a pasto

RESUMO - Objetivou-se determinar as exigências de macrominerais de novilhos zebuínos em pastagem de *Brachiaria decumbens* suplementada com concentrado. Foram utilizados 24 novilhos, não-castrados, com idade e pesos médio iniciais de 7 meses e 180 kg. Foram abatidos oito animais-referência para determinação da composição corporal inicial. Os 16 animais restantes foram divididos em quatro lotes de quatro animais, em delineamento inteiramente casualizado. Cada lote recebeu mistura mineral ou suplementos nos níveis de 0,75; 1,50 ou 2,25 kg/animal/dia. A meia-carcaça direita de oito animais, dois por grupo, foi dissecada em músculo, gordura e ossos e todos os constituintes do corpo foram pesados para determinação do peso de corpo vazio e da composição corporal. As exigências líquidas de cálcio e fósforo para um animal de 400 kg de peso corporal foram, respectivamente, 11,13 g e 5,40 g. Para estimar as exigências dietéticas de manutenção e, posteriormente, somá-las às exigências dietéticas para ganho, no intuito de se obter as exigências dietéticas totais, foram adotadas as perdas endógenas e a biodisponibilidade presentes na literatura para cada macroelemento mineral. As exigências dietéticas totais de cálcio, fósforo, magnésio, sódio e potássio para um animal de 400 kg de PC com ganho diário de 1,0 kg foram, respectivamente, 34,59; 17,36; 7,82; 5,19 e 41,11 g/dia. As exigências em macrominerais de bovinos de corte sob suplementação a pasto são semelhantes às recomendadas pelo BR-Corte para bovinos de corte em confinamento.

Palavras-chave: cálcio, exigências nutricionais, fósforo, suplementação, zebuínos

Introduction

Determination of mineral dietary requirements for bovines being raised on pasture conditions is extremely complex due to the several factors that directly or indirectly

influence their use by the animals. Among those factors, some are inherent to the food or to the diets, as bioavailability and mineral chemical form in dietary ingredients; other are attributable to the animal, as body weight, variability among breeds, production level and nutritional status

(ARC, 1980; Conrad et al., 1985; AFRC, 1991; Coelho da Silva, 1995; NRC, 2000).

Besides appropriate supplement of minerals, AFRC (1991) stresses that proper levels of protein and energy are needed for a normal development of the bones. It is listed in NRC (2000) requirements of calcium and phosphorus for protein daily gain and Conrad et al. (1985) stated that appropriate nutrition of these minerals depends on D vitamin level in the diet.

Despite of representing only 4% of body weight of the animals, minerals are present in different proportions in all tissues and they exert vital functions in the organism, which are reflected by the performance of the animal (Dayrell, 1993).

Mineral retention depends on the weight gain composition (bones, muscles and fat). Greater fat depositions reduce mineral depositions and, consequently, their requirements by the animals inasmuch as concentration of these inorganic elements in the adipose tissue are lower than in the muscles and in the bones, which contain approximately 99% and 80% of body calcium and phosphorus, respectively (NRC, 2000).

Thus, factors that modify gain composition as type of the diet, sex, genetic group, age and weight of the animals, affect mineral composition and net requirement for weight gain (Paulino et al., 1999).

Macromineral nutritional requirements are, in general, estimated by factorial methods (ARC, 1980), which are based in net quantities deposited in the body of the animal, added by the needed quantity to meet endogen secretions, considered net requirement of maintenance. The sum of maintenance fractions and production is the total net requirement that, when corrected by one coefficient of absorption of the inorganic element in the digestive tract of the animal results in the mineral dietary requirement (Coelho da Silva, 1995).

This work aimed at determining requirements of macro minerals by Zebu steers grazing *Brachiaria decumbens* Stapf under supplementation with concentrate.

Material and Methods

The experiment was carried out in Setor de Bovinocultura de Corte in Departamento de Zootecnia at Universidade Federal de Viçosa, from July 4th 2005 to April 6th 2006.

It was used 24 non-castrated Zebu steers at initial age of 7 months and weight of 180 kg. Those animals were slaughtered following a slaughter protocol divided in four steps aiming at determining body composition and empty body weight at different ages and body weight (BW) ranges.

Body composition obtained in each slaughter was used to estimate initial body composition of the animals in immediately subsequent slaughters.

After the start of the experiment, on July 14th 2005, in the middle of the dry season, two animals at 7 months of age and 180 kg were slaughtered; at the second slaughter, performed on October 10th 2005, at the beginning of dry-rainy period transition phase, three animals at 9 months of age and 190 kg were slaughtered; and at the third slaughter, carried out on January 10th 2006 during the wet season, three other animals at 15 months of age and 305 kg were slaughtered.

During slaughters, all the constituents of the body (organs, guts, blood, leather, head, and members) were weighted and sampled for determination of empty body weight (EBW) and body composition of the animals in different weight ranges.

Data concerned to the third slaughter were used to estimate initial body composition in sixteen of the animals that remained in the experiment.

The 16 remaining animals were at 14 months of age on average and 316 kg of body weight, and they were divided into four four-plot animals, following a complete random block design. Each plot was supplemented with mineral mixture or supplement at the levels 0.75; 1.50 or 2.25 kg/animal/day.

The supplement given at different quantities presented 33% of crude protein (Table 1) and the mineral mix (47.15% sodium chloride - NaCl, 50% dicalcium phosphate, 1.5% zinc sulfate, 0.75% copper sulfate, 0.05% cobalt sulphate, 0.05% potassium iodated and 0.5% magnesium sulphate) was ad libitum fed for all the animals.

The experimental area for the animals was made up of four 2.0-ha pickets, formed with *Brachiaria decumbens* Stapf., provided with covered wooden drinkers and feeders with simultaneous access on both sides. Aiming at reducing influences from possible variation in pasture dry matter availability, animals were kept in each picket for seven days. After that, rotation among pickets was carried out.

All animals were submitted to a grazing digestion trial for a 10-day period, in which the seven first days were

Table 1 - Supplement percentage composition based on natural matter

Ingredient	% in the supplement
Urea/amonium sulphate (9:1)	2.50
Corn	31.00
Soybean meal	16.50
Cottonseed meal	25.00
Wheat meal	25.00

designed for adaptation of the animals and for stabilization of flow marker as described by Titgemeyer et al. (2001).

To evaluate bromatological composition of the forage consumed by the animals, it was used four esophagus-fistulated animals, which, after a 16-hour food and water fast, were conducted to the experimental paddocks for esophageal extrusa collection. Collections were made at 7 a.m. on the fifth digestion trial day, using collecting bags with screen at the bottom, fitted around esophageal fistula. After 40 minutes of grazing, the bags were removed and the samples were weighted.

To estimate fecal dry matter excretion (FE), it was used chromic oxide as external marker, following recommendations by Smith & Reid (1955), and used in a unique daily dose (10 g/animal) packed in a paper cartridge and introduced using an applicator directly in the esophagus of the animals during nine consecutive days. After seven days of adaptation, it was collected samples of the animal feces on the eighth (16 hours), ninth (12 hours) and tenth (8 hours) days. Calculation of fecal extraction was performed using the ratio between quantity of the supplied indicator and its concentration in the feces, according to the following equation:

$$FE = (\text{Supplied Cr} / \text{Fecal Cr}) \times 100$$

in which: supplied Cr = quantity of supplied Cr (g) and fecal Cr = concentration of the marker in the feces (%).

Voluntary dry matter intake (DMI) was estimated by using as internal marker indigestible ADF (iADF), obtained after 264-hour *in situ* incubation (Casali et al., 2008) by the following equation:

$$DMI = \left\{ \left[(FE \times iADF_{Feces}) - iADF_{Supplement} \right] \div iADF_{Forage} \right\} + DMIS$$

in which: iADF present in the feces; iADF present in the supplement; iADF present in the forage (kg/kg) and DMIS = dry matter intake of supplement (kg/day).

For determination of individual dry matter intake of supplement (DMIS), it was used titanium dioxide at the average quantity 10 g/animal, mixed to the supplement right before supply, following procedure described by Valadares Filho et al. (2006b), following the same fecal collection scheme described for chromic oxide, following the equation:

$$DMIS = (FE \times \text{Fecal TiO}) \div \text{Supplement TiO}$$

in which: fecal TiO and supplement TiO refers to titanium dioxide concentration in the feces and in the supplement, respectively.

After collection, samples of extrusa and feces were dried in a forced air ventilation oven at 65°C for 72 hours, processed in Willey-type mill (1.00 mm) and then submitted to laboratorial analyses according to the techniques

described by Silva & Queiroz (2002) except for NDF and ADF determinations, which followed methods described by Mertens (2002) and Van Soest & Robertson (1985).

The last slaughter was carried out on March 27th 2006, March 29th 2006 and on April 5th 2006 in staggered way after 76, 78, 83 and 85 days, when it was slaughtered four animals per turn, one from each treatment. At the slaughter, animals were at 17 months of age and at 378 kg BW.

Before slaughtering, all animals were fasted (solid and liquid) for 16 hours to obtain shrunk body weight (SBW).

The gastrointestinal tract of each animal was weighted, emptied and washed as well, and its weight were added up to the organs and other parts of the body (carcass, head, leather, tail, feet and blood) for determination of empty body weight (EBW). The obtained ratio between empty body weight and body weight of the animals, in each slaughter, was used to estimate empty body weight of the animals that remained in the experiment. Within each treatment, two animals were raffled to represent them. It was withdrawn samples from their heads and from one former member and one posterior member for physical separation of soft tissue, bones and leather.

Blood samples were collected immediately after jugular veins of the animals were sectioned. They were packed in glass containers and left in a forced air ventilation oven at 60°C for 72 hours. Samples of industrial meat, liver, heart, kidneys, spleen, lungs, tongue, rumen, reticule, omasum, abomasum, small intestine, large intestine, mesentery, internal fat, trimmings and tail were grouped, processed and completely homogenized in a 65-L cutter, from where it was withdrawn a sample that represented the organs and the guts.

Carcass of each animal was divided in two halves, which were weighted and then cooled in a cooled chamber at -2.5°C for approximately 18 hours. After that, the right carcass of eight animals, two per treatment, were removed from the cold chamber and totally dissected and then separated into muscles, fat and bones, which were later weighted. Body composition of other eight animals was estimated through percentages of muscles, fat and bones from dissected carcasses.

Muscle and adipose tissues were ground and bone tissue was sawed into smaller parts. A representative sample of each component was removed. After the fresh parts were ground, they were processed following procedure described by Paulino et al. (2004), for obtainment of fatty dry matter and then defatted dry matter. After that, samples were processed in a ball mill for posterior quantifications of macromineral contents (calcium, phosphorus, magnesium,

sodium and potassium) according to recommendations by Silva & Queiroz (2002).

Mineral solution for determination of mineral macroelements was prepared through a wet via. After appropriate dilutions, content of phosphorus was determined through colorimetry, contents of calcium and magnesium were determined using atomic absorption spectrophotometer and contents of sodium and potassium were determined using a flame spectrophotometer.

By using data concerned to initial, intermediate and final slaughter, it was possible to calculate contents of mineral macroelements withheld in the body of the animals in different body weight ranges, through logarithm regression equation of content of calcium, phosphorus, magnesium, sodium or potassium in function of EBW logarithm, according to ARC (1980), following the model:

$$Y = a + bx + e_{ij}$$

in which: Y = logarithm of the total content of the total inorganic macroelement withheld in the empty body; a = constant; b = regression coefficient of logarithm of the inorganic macroelement content in function of EBW logarithm; X = EBW logarithm and e_{ij} = random error.

By deriving prediction equations of the body contents, it was obtained the net requirements of macrominerals (Ca, P, Mg, K e Na) per kg of empty body gain (EBG), from the following equation:

$$Y' = b \cdot 10^a \cdot X^{b-1}$$

in which: Y' = inorganic macroelement requirements; a and b = intercept and regression coefficient, respectively of

equations of prediction of net requirement of mineral macronutrients; and X = EBW (kg).

To estimate maintenance requirements of each mineral macroelement and, afterwards, adding them to gain requirement to obtain total dietary requirements, they were fitted according to recommendations by ARC (1980) and by NRC (2000) for endogenous losses of calcium, phosphorus, magnesium, sodium and potassium and bioavailability from these elements in the food, according to ARC (1980) and NRC (2000) (Table 2).

Results and Discussion

The ratio obtained for estimate of empty body weight from body weight of the animals in the present work was: $EBW = BW \times 0.8997$, a value close to that suggested by NRC (2000), 0.891 and by BR-Corte (Valadares Filho et al., 2006a), 0.8960, although those relationships had been obtained for feedlot animals.

When the relationships obtained in this work are compared to those available on grazing animals, it is observed that data from this work are superior to those found by Zervoudakis et al. (2002), Fregadolli (2005) and Moraes et al. (2010), who reported values of 85.75; 87.46; and 88.77 respectively, for grazing animals.

To convert requirements for EBG into requirements for body weight gain (BWG), it was obtained the following relationship: $EBG = 0.930 \times BWG$, almost the same of that recommended by Valadares Filho et al. (2006a) of 0.933.

Table 2 - Total endogenous losses and bioavailability of macrominerals in the food

Element	Total endogenous	Bioavailability (%)
Calcium	15.4 mg/kg BW ¹	50 ¹
Phosphorus	16.0 mg/kg BW ¹	68 ¹
Magnesium	3.0 mg/kg BW ¹	17 ²
Sodium	6.8 mg/kg BW ¹	91 ²
Potassium	Feces - 2.6 g/kg DM consumed ² Urine - 37.5 mg/kg BW ² Saliva - 0.7 g/100 kg BW ² Through skin - 1.1 g/day ²	100 ²

¹Data obtained from NRC (2000); ²Data obtained from ARC (1980).

Table 3 - Parameters of regression equations of logarithm of content of macrominerals in the empty body in function of logarithm of empty body weight of beef cattle under grazing

Macromineral	Parameters		r ²
	Intercept (a)	Coefficient (b)	
Calcium	-0.9922	0.6876	0.80
Phosphorus	-1.3989	0.7168	0.85
Magnesium	-3.6365	0.9173	0.92
Sodium	-2.7918	1.0319	0.97
Potassium	-2.8869	1.0437	0.97

EBW = BW × 0.8997.

Table 4 - Net requirements of macrominerals by beef cattle under pasture supplementation

Body weight (kg)	Net requirement (g per kg of empty body weight gain)				
	Calcium	Phosphorus	Magnesium	Sodium	Potassium
150	15.127	7.132	0.141	1.949	1.678
200	13.827	6.574	0.138	1.966	1.699
250	12.896	6.171	0.135	1.981	1.716
300	12.182	5.861	0.133	1.992	1.729
350	11.609	5.610	0.132	2.002	1.741
400	11.135	5.402	0.130	2.010	1.751

EBW = BW×0.8997.

Determination coefficients (r^2) of regression equations of the logarithm of contents of calcium, phosphorus, magnesium, sodium and potassium in the empty body, in function of empty body weight (kg), overall, showed good adjustment of the equation to the data (Table 3).

As body weight of the animals increased, it was observed that net requirement of minerals was reduced, except for sodium and potassium (Table 4). Reduction of requirements of calcium, phosphorus and magnesium is in agreement to many reports in literature, among them, the ones by Fontes (1995), in analysis with many works; Paulino et al. (1999), when working with Zebu cattle; and Ferreira et al. (1998), with F1 Simmental × Nelore steers.

It is reported in AFRC (1991) a reduction in calcium and phosphorus body concentrations per kilogram of gain when body weight increased. This could be explained by the increase in body fat content, which had been previously discussed, and the concomitant reduction in bone proportion with increase of weight and age of the animals. Reduction in bone proportion in the body of the animal induces a fall of the concentrations of calcium and phosphorus inasmuch as bones contain around 99% and 80% of body calcium and phosphorus, respectively.

Calcium net requirements for an animal with 400 kg BW were 11.13 g, a value which was close to 11.95 g reported by BR-Corte (Valadares Filho et al., 2006a) for the same body weight. Phosphorus net requirements for an animal with 400 kg (5.40 g) were close to those reported by Fontes (1995), 6.87 g for non-castrated animals, by BR-CORTE, 6.30 g and by Ferreira et al. (1998), 4.37g.

By using the AFRC (1991) mathematical model, for a bovine with 400 kg BW, and taking into account weight at maturity of 500 kg, net requirement per kilogram of estimate gains for calcium and phosphorus are 10.3 and 6.1 g, respectively.

Magnesium net requirements (g/kg of EBW), verified in the present work (0.130 g) were much lower than the value granted by BR-Corte (Valadares Filho et al., 2006a), which was 0.340 g and those found in most of the national literature, as for example works by Vêras et al. (2001), 0.210 g;

Ferreira et al. (1998), 0.280 g; Silva et al. (2002), 0.320 g; Paulino et al. (1999), 0.227 g, and by Paulino et al. (2004), 0.250 g. In addition, it is stated in ARC (1980) a constant magnesium net requirement of 0.45 g/kg of EBW, regardless to weight of the animal, a value much superior to the one found in this study.

Contrary to the behavior showed by most of the published works on mineral requirements by beef cattle in Brazil, net requirement of sodium and potassium increased when body weight of the animals increased. It was not found in the consulted literature, biological explanations for this behavior. Because variations in the requirements of these minerals are low, ARC (1980) advocates established net requirements of sodium and potassium of 1.50 and 2.0 g/kg of empty body weight.

The net requirement found in the present work for animals with body weight of 250 and 400 kg were, respectively, 1.98 and 2.01 g/kg of EBG for sodium and 1.72 and 1.75 g/kg of EBG for potassium. Fontes (1995) estimated potassium net requirements ranging from 1.76 to 1.87 per kg of EBW for non castrated animals and body weight from 300 to 500 kg.

From average coefficients of real absorption suggested by NRC (2000) for calcium and phosphorus and by ARC (1980) for magnesium, potassium and sodium (Table 2) and from estimates of net requirement for gain (Table 3), it was estimated dietary requirements of calcium, phosphorus, magnesium, sodium and potassium, per kg of empty body weight (Table 5). By applying the factor 0.93 found in this work, it could be calculated net requirement for body weight gain (BWG).

For determination of dry matter intake (DMI) of the animals in this experiment, in a determined body weight and range of weight gain, it was generated the following equation from experimental data:

$$\text{DMI (kg/day)} = -1.80 + 0.0113 \text{ BW} + 6.40 \text{ BWG} - 1.15 \text{ BWG}^2$$

$$(R^2 = 0.83)$$

Based in this equation and taking as example an animal with 350 kg BW, gaining 1.0 kg/day, there is a dry matter

Table 5 - Dietary requirements of macrominerals for weight gain of beef cattle under pasture supplementation

Body weight (kg)	Dietary requirement for weight gain (empty body weight gain g/kg)				
	Calcium	Phosphorus	Magnesium	Sodium	Potassium
150	30.25	10.49	0.83	2.14	1.68
200	27.65	9.67	0.81	2.16	1.70
250	25.79	9.08	0.80	2.18	1.72
300	24.36	8.62	0.78	2.19	1.73
350	23.22	8.25	0.77	2.20	1.74
400	22.27	7.94	0.77	2.21	1.75

EBW = BW × 0.8997; EBG= BWG × 0.93.

Table 6 - Total dietary requirements (maintenance + 1.0 kg gain BW) of macrominerals by beef cattle under pasture supplementation

Body weight (kg)	Total dietary requirement									
	Calcium		Phosphorus		Magnesium		Sodium		Potassium	
	g/day	% DM ¹	g/day	% DM	g/day	% DM	g/day	% DM	g/day	% DM
150	34.87	0.68	14.02	0.27	3.48	0.07	3.28	0.06	22.74	0.44
200	33.81	0.59	14.37	0.25	4.34	0.08	3.67	0.06	26.42	0.46
250	33.49	0.53	14.96	0.24	5.21	0.08	4.05	0.06	30.09	0.48
300	33.60	0.49	15.68	0.23	6.08	0.09	4.43	0.06	33.77	0.49
350	34.00	0.46	16.49	0.22	6.95	0.09	4.81	0.06	37.44	0.51
400	34.59	0.43	17.36	0.22	7.82	0.10	5.19	0.07	41.11	0.52

EBW = BW *0.8997; ¹DMI (kg/day) = -1.80+0.0113×BW+6.40×BWG-1.15×BWG².

intake of 7.40 kg/day. Therefore, for animal with 350 kg body weight gain 1.0 kg/day, kept in pasture conditions, it is necessary that the total diet presents 0.46% Ca and 0.22% P in dietary dry matter (Table 6).

Dietary requirements of calcium for weight gain by an animal with body weight 250 or 400 kg and weight gain of 1.0 kg/day obtained in this work (25.79 and 22.27 g, respectively), are close to the predicted by NRC (2000), which cites values of 25 and 19 g/day; to the values reported by BR-Corte (Valadares Filho et al., 2006a), 26.53 and 23.90 g; to the ones by Silva et al. (2002), 23.84 and 21.49 and to the ones the reported by Moraes (2006), 25.95 and 23.09 g, when working with animals under grazing.

Total dietary requirements of phosphorus for weight gain, determined in this experiment for animals at 250 and 400 kg (9.08 and 7.94 g), were very close to the ones recommended by NRC (2000), 10 and 8 g, for variation of body weight cited before. They were also very close to the recommendations by BR-Corte (Valadares Filho et al., 2006a), 10.37 and 9.26 g and to the values reported by Moraes (2006), with animals under grazing, of 10.24 and 8.68g.

Contrary to what was observed for gain requirements, total dietary requirement raised as body weight of the animals increased (Table 6), inasmuch as maintenance requirements, which are determined according to body weight, are included in total requirement.

Total dietary requirement of calcium and phosphorus for an animal with 400 kg BW and daily gain of 1.0 kg were,

respectively, 34.59 and 17.36 g/day. NRC (2000) estimate total dietary requirements of 31.0 g/day for calcium and 18.0 g/day for phosphorus, respectively, for the animal above described. Additionally, BR-Corte (Valadares Filho et al., 2006a) estimate total dietary requirement of calcium and phosphorus, for the animal at matter, of 400 kg with weight gain of 1.0 kg/day, in 36.22 and 18.67 g/day.

Paulino et al. (2004), in an experiment with Zebu animals, determined total dietary requirement of calcium and phosphorus for a 400-kg animal with weight gain of 1.0kg/day and found values very close (33.32 and 16.84 g/day, respectively) to the ones reported in this work.

Experimental data showed that, for a bovine with 400 kg BW and weight gain of 1.0 kg/day, total dietary requirements of magnesium, sodium and potassium would be 7.82, 5.19 and 41.11 g/day, respectively (Table 6). According to ARC (1980), for the bovine at matter, total dietary requirements of these nutrients would be 9.50; 4.64 and 43.38 g/day, respectively. BR-Corte (Valadares Filho et al., 2006a) suggests the values 9.06; 4.26 and 44.42 g/day as total dietary requirements of magnesium, sodium and potassium for a bovine with 400 kg BW gaining 1.0 kg/day.

For conditions of beef cattle herds raised in Brazil, BR-Corte (Valadares Filho et al., 2006a) suggests that total dietary requirements would be 0.41; 0.21; 0.10; 0.05 and 0.50% total DM in the diet for calcium, phosphorus, magnesium, sodium and potassium, respectively. The values

in this study, (Table 6) are very close to the recommendations by BR-Corte (Valadares Filho et al., 2006a) for mineral macroelements in Brazilian conditions.

Conclusions

Requirements of macrominerals by beef cattle under grazing supplementation are similar to those recommended by BR-Corte for bovines in feedlots.

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