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ANIMAL PRODUCTION

Level of energy supplementation in beef cattle grazing Italian ryegrass

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ABSTRACT: This study evaluated the efficiency of use and productive performance of beef cattle on Italian ryegrass (*Lolium multiflorum* Lam.) pasture supplemented with levels of energy supplementation. The trial was performed in two experiments (years 2019 and 2021) and the experimental design was randomized blocks with five treatments and two replications. The treatments corresponded to levels of supplementation: CON: Pasture without supplementation; MN: Pasture + Mineral Supplementation (commercial product): 80g animal day^{-1}; SE0.1: Pasture + Energy supplement 0.1% BW (commercial product); SE0.5: Pasture + Energy supplement 0.5% BW (commercial product 0.1% + 0.4% rice bran (RB)); SE1.0: Pasture + Energy supplement 1.0% BW (commercial product 0.1% + 0.9% RB). The variables studied were: herbage yield and bromatological composition, average daily weight gain (ADG), stocking rate (SR), weight gain per area (GPA), and the compensation exchange ratio of supplement intake in comparison to gain of weight. The data were submitted to analysis of variance using and compared by the Tukey test at 5%. The ADG data were submitted to regression analysis e segmented regression. GPA and SR showed no significant difference between treatments with levels of energy supplementation. The segmented ADG regression resulted in a break point at a low supplementation level of 0.16% BW. The exchange ratio showed an interaction between treatments and year, showing the influence of the productive and nutritional characteristics of the pasture on the efficiency of supplementation use.
Key words: animal performance, *Lolium multiflorum* Lam., ruminant nutrition, rice bran.

Nível da suplementação energética para bovinos de corte em pastagens de azevém anual

RESUMO: Objetivou-se avaliar a eficiência de utilização e o desempenho produtivo de bovinos de corte em pastagem de azevém (*Lolium multiflorum* Lam.) suplementados com níveis de suplementação energética. O delineamento experimental foi de blocos ao acaso com cinco tratamentos e duas repetições. Os tratamentos corresponderam a níveis de suplementação: CON: pastagem sem suplementação; MN: Pasto + Suplementação Mineral (produto comercial): 80g animal dia^{-1}; SE0,1: Pasto + Suplemento energético 0,1% PC (produto comercial); SE0,5: Pasto + Suplemento energético 0,5% PC (produto comercial 0,1% + 0,4% Farelo de arroz integral (FAI)); SE1,0: Pasto + Suplemento energético 1,0% PC (produto comercial 0,1% + 0,9% FAI). As variáveis estudadas foram: ganho de peso médio diário (GMD), taxa de lotação (LOT), ganho de peso por área (GPA), produção e qualidade da forragem e a relação de troca de compensação do consumo de suplemento em comparação ao ganho de peso. Os dados foram submetidos à análise de variância e comparados pelo teste de Tukey a 5%. Os dados do GMD foram submetidos à análise de regressão e regressão segmentada. O GPA e a LOT não apresentaram diferença significativa entre os tratamentos com níveis de suplementação energética. A regressão segmentada do GMD resultou em ponto de quebra num baixo nível de suplementação de 0,16% PC. A relação de troca apresentou interação entre os tratamentos e o ano, mostrando a influência das características produtivas e nutricionais da pastagem na eficiência do uso da suplementação.
Palavras-chave: desempenho animal, farelo de arroz, *Lolium multiflorum* Lam., nutrição de ruminantes.

INTRODUCTION

The use of cool season forage and its association with energy supplementation are pointed out as alternatives in the improvement of livestock production index, especially in the winter (TONATO et al., 2014). The use of supplements is a management tool that can contribute positively to the performance of ruminants in pastures, enabling the increase in body development, through greater intake by animals or increase in stocking rate (SANTOS et al., 2011).

The choice of energy supplement is important from an economic and environmental point of view, considering the use of by-products. Rice bran is an example of a by-product, which contains significant levels of starch, which makes it a highly energetic food for animals (ÜNLÜ et al., 2022). In addition to being a food with high nutritional potential, it can reduce food costs and provide greater

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economic advantages in regions where there is greater availability, as is seen in southern Brazil.

The responses to energy supplementation in pastures are complex, due to the associative effects between them (TEDESCHI et al., 2019). There are potential benefits to high levels of supplementation, ranging from 0.8 to 1.5% of body weight, as observed by CLARIGET et al. (2021). However, it is important to consider the impact on forage intake, as these high levels can lead to substitution effects (LAZZAROTTO et al., 2019). Conversely, lower levels of supplementation, ranging from 0.1 to 0.5% of body weight, can offer a more cost-effective option for farmers and especially on high quality pastures, and increase utilization efficiency of nutrients. However, more research is needed to fully understand the interactions, especially at lower levels of supplementation, as few studies have evaluated responses in terms of animal performance and nutritional efficiency (DA SILVA et al., 2009).

The hypothesis of this study is that low energy supplementation levels are sufficient to achieve better animal performance in Italian ryegrass pastures. Therefore, this study evaluate the performance of beef cattle grazing Italian ryegrass using different levels of energy supplementation.

MATERIALS AND METHODS

Two experiments were conducted on-farm conditions in Uruguaiana, RS, Brazil, (29°50' S latitude, 57°06' W longitude and 80 m altitude) in two years (2019 and 2021), in a randomized block design with five treatments and two replications per year. The blocking criterion was the slope of the paddocks. The treatments corresponded to mineral and energy supplementation strategies for beef cattle on Italian ryegrass pasture (*Lolium multiflorum* Lam): CON: Pasture without supplementation; MN: Pasture + Mineral Supplementation (commercial product Nutrigold Núcleo Tortuga®, DSM Tortuga, Brazil): 80g animal day^{-1}; SE0.1: Pasture + Energy supplement 0.1% BW (commercial product Fosbovi aveia-azevém Tortuga®, DSM Tortuga, Brazil); SE0.5: Pasture + Energy supplement 0.5% BW (commercial product 0.1% + 0.4% rice bran (RB)); SE1.0: Pasture + Energy supplement 1.0% BW (commercial product 0.1% + 0.9% RB). The chemical composition of the energy supplement was: TND (600 g/kg); Ca (34 g/kg); P (25 g/kg); S 23 (g/kg); Na (27.3 mg/kg); Co (5 g/kg); Cu (450 mg/kg); Cr (8 mg/kg); I (18 mg/kg); Mn (700 mg/kg); Se (700 kg/kg); Zn (1200 mg/kg); F (250 mg/kg); Sodic Monesin (435 mg/kg). The formulation of the concentrates and their chemical composition were: Commercial product (10.1% CP, 1.8% EE); RB (15.3% CP, 31.2% NDF, 7.1% ADL, 14.7% EE); Supplement 0.5% BW (14.7% CP, 30% NDF, 6.4% ADL, 13.4% EE); Supplement 1% BW (15.2% CP, 30.5% NDF, 6.7% ADL, 13.1% EE). The supplements were weighed and offered daily in troughs located in each paddock between 11:00 am and 1:00 pm throughout the experimental period. The climate of the region is of the subtropical Cfa type with no defined dry season. In 2019, the total rainfall during the experimental period was 382 mm with an average temperature of 16.5 ºC. In 2021, the total rainfall recorded was 606 mm and the average temperature was 16.6 ºC.

Experimental animals

Experiment 1

One-year-old Angus heifers with an initial body weight (BW) of 173.9 ± 6.5 kg were used. Three heifers per paddock were designated as test animals and remained in the same paddock throughout the experiment, totaling 30 test animals to evaluate the animal performance. The experimental area was divided into ten paddocks (experimental units) of 2.5 ha. It was managed under continuous stocking with the animals always remaining in the paddock with access to its entire area, with a variable number of animals, recommending a forage allowance of 4 kg of DM per kg of BW (SOLLENBERGER et al., 2005). Italian ryegrass was implemented in June 2019, with a grazing period from August to October, corresponding to an area of 95% ryegrass and 5% native species, totaling 84 days. The animals had access to water fountains located in the paddocks.

Experiment 2

One-year-old Angus steers with an initial body weight (BW) of 186.9 ± 4.2 kg were used. Three steers per paddock were designated as test animals to evaluate animal performance. The experimental area was divided into ten paddocks (experimental units) of 2.0 ha. It was managed under continuous stocking with the animals always remaining in the paddock with access to its entire area, with a variable number of animals, recommending a forage allowance of 4 kg of DM per kg of BW. Italian ryegrass was implemented in April 2021, with a grazing period from July to October, corresponding to an area of 95% Italian ryegrass and 5% native species, totaling 105 days. The animals had access to water fountains located in the paddocks.

Pasture characteristics

Pasture height was measured at least 150 points in each paddock every 15 days. Herbage

mass measurement was carried out at five random points in each paddock in all sample periods, using a 0.25 m^2 square every 15 days. The bromatological composition of the pasture was determined in herbage samples collected at each experimental period (every 21 days) by means of a hand-plucking technique. The samples were dried in an oven with ventilation at 55 ºC for 72 hours, then ground for laboratory analysis. The following contents were determined: dry matter (DM) (method 967.03, AOAC, 1990), organic matter (OM), crude protein (CP) (method 981.10,AOAC, 1990), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (ADL) (VAN SOEST et al., 1991), and ether extract (EE) (method 920.29, AOAC, 1990).

Animal assessment and evaluations

Every 21 days, animals were weighed on a digital scale, preceded by a 12 hour fast to adjust the level of supplementation and evaluate animal performance. The average daily gain (ADG, kg BW day^{-1}) was calculated by the difference in weight of the test animals between two successive weighing divided by the number of days in the interval between weighing. The gain per area (GPA, kg ha^{-1}) was calculated by the product of the ADG of all animals, the number of animals that remain in the area and the number of days. The supplement intake (SPI) was measured for the animal group, and it was assessed daily by evaluating the offering and refused. The compensation exchange ratio of supplement intake compared to ADG was calculated by the ratio of daily supplement intake (kg day^{-1}) to the difference in ADG (kg BW day^{-1}) in relation to treatment without supplementation.

Statistical analysis

The data were submitted to analysis of variance using Proc GLM and compared by the Tukey test at 5% according to the following mathematical model: $Yijk = \mu + Ti + bj(Aj) + Rk(Ti) + (TA)ij + \varepsilon ijk$ where Yijk represents the dependent variables; μ, the average of all observations; Ti, the effect of the ith treatment; bj(Aj), the effect of the j-th year within the j-th block; Rk (Ti), the effect of the kth reproduction within the ith treatment (error a); (TA) ij, the interaction between the ith treatment and the jth year; and εijk. The ADG data were submitted to regression analysis with adjustment of the polynomial model up to third order. In addition, to determine the optimal level of %BW supplementation, segmented regression was performed by the Broken line model (ROBBINS et al., 2006). This model is obtained by the method of least squares and aimed to determine the breaking point, that is, the point that represents the smallest sum of squares. These determinations were performed in SAS Proc NLIN.

RESULTS

Herbage mass did not show a significant difference ($P > 0.05$) in the treatments and year of evaluation. Pasture height showed an interaction between treatments and year ($P < 0.05$), in the first year the MN and SE0.1 treatments differed from the CON, SE0.5 and SE1.0 treatments. In the chemical composition of the herbage, the CP showed a significant difference ($P < 0.05$) between years, NDF showed a significant difference ($P < 0.05$) between treatments and year, ADF showed no significant difference ($P > 0.05$) and ADL showed an interaction between treatments and year ($P < 0.05$), showing lower levels of ADL in the second year (Table 1).

The ADG variable showed no interaction ($P > 0.05$) between treatments and year. The treatments showed a significant difference ($P < 0.05$), where the levels of energy supplementation (SE0.1, SE0.5 and SE1.0) presented respective average values of 0.882, 0.976 and 0.960 kg BW day^{-1}, differing significantly of the CON and MN treatments (Table 2). In the year factor, there was a significant difference ($P < 0.05$), with ADG year 2021 on average 0.958 kg BW day^{-1} compared to 0.759 kg BW day^{-1} in 2019. The regression segmented model resulted in a breakpoint in the supplementation level of 0.16% BW (Figure 1), indicating that from these levels there is no significant difference in the increase in supplementation levels ($P < 0.05$).

In the stocking rate (SR kg BW ha^{-1}) there was no significant difference ($P > 0.05$) between treatments. In the gain per area (GPA kg BW ha^{-1}) the treatments with levels of energy supplementation differed ($P < 0.05$) from the CON and MN treatments, presenting higher GPA (Table 2), besides presenting difference ($P < 0.05$) for year, where in the second year presented higher GPA in all treatments, with an average of 270.8 kg BW ha^{-1} (Table 2). The compensation exchange relationship for supplement intake in comparison with ADG (Table 2), showed an interaction between treatment and experimental year ($P < 0.05$).

DISCUSSION

Our hypothesis that lows levels of supplementation are sufficient to achieve better animal performance in cool season pastures can be observed based on segmented regression analysis (Figure 1), where the level of 0.16% BW presented

Table 1 - Characteristics and chemical composition of Italian ryegrass pasture from different supplementation levels for beef cattle.

Item	Year	CON	MN	SE0.1	SE0.5	SE1.0	Mean	SEM	----------Probability----------		
									Treat	Year	Treat*year
HM, kg ha^{-1}	2019	1496	1277	1361	1498	1423	1411				
	2021	1822	1760	1708	1750	1515	1711	90.4	0.19	0.06	0.25
	Mean	1659	1519	1534	1624	1469					
SH, cm	2019	18.3 a	15.9 b	15.6 b	17.3 a	17.6 a	16.9				
	2021	19.6	19.3	21.0	20.5	18.9	19.9	1.19	0.02	0.16	< 0.01
	Mean	18.9	17.6	18.3	18.9	18.4					
CP, %DM	2019	12.6	11.0	10.8	11.6	12.8	11.7				
	2021	14.9	15.0	14.1	15.2	13.5	14.5	0.91	0.69	< 0.01	0.43
	Mean	13.7	13.0	12.4	13.4	13.2					
NDF, %DM	2019	60.7	61.6	59.4	59.6	57.2	59.7				
	2021	53.1	46.3	46.2	45.3	45.8	47.3	1.41	0.02	< 0.01	0.10
	Mean	56.9 a	53.9 b	52.8 b	52.4 b	51.5 b					
ADF, %DM	2019	47.2	44.8	45.9	45.8	42.9	45.3				
	2021	45.6	41.9	39.9	41.1	41.0	41.9	2.35	0.25	0.28	0.73
	Mean	46.4	43.4	42.9	43.5	41.9					
ADL, %DM	2019	8.7 a	6.3 b	8.1 a	8.5 a	8.3 a	8.0				
	2021	6.0	6.4	6.6	6.1	5.8	6.2	0.35	0.06	0.02	0.02
	Mean	7.3	6.3	7.3	7.3	7.0					

Averages followed by different lowercase letters in the rows differ from each other by Tukey test at 5% probability of error. CON: Pasture without supplementation; MN: Pasture + Mineral Supplementation (commercial product): 80g animal day^{-1}; SE0.1: Pasture + Energy supplement 0.1% BW (commercial product); SE0.5: Pasture + Energy supplement 0.5% BW (commercial product 0.1% + 0.4% rice bran (RB)); SE1.0: Pasture + Energy supplement 1.0% BW (commercial product 0.1% + 0.9% RB); HM: Herbage mass; SH: sward height; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin. SEM: standard error of the mean.

the breakpoint, indicating that from this level there is no significant difference in the increase in the level of supplementation in ADG. Energy supplementation can decrease herbage intake (BARBERO et al., 2020; CANOZZI et al., 2023), so higher levels of supplement may have compromised performance, due to reduced rumen digestibility of dry matter, due to the possible reduction in pH changes in the rumen environment (CATON & DHUYVETTER, 1997). Performance results remained consistent regardless of the sex of the animals, indicating that performance disparities between male and female

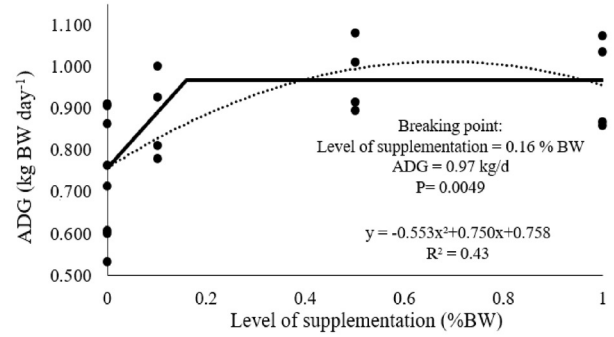


Figure 1 - Application of segmented regression and linear quadratic models (continuous line) to the results of supplementation levels, expressed as % of body weight (BW), adjusted to the average daily gain (ADG) of beef cattle in Italian ryegrass pasture.

Table 2 - Animal performance and efficiency of supplementation use of different supplementation levels for beef cattle on Italian ryegrass pasture.

Item	Year	CON	MN	SE0.1	SE0.5	SE1.0	Mean	SEM	----------Probability----------		
									Treat	Year	Treat*year
ADG, kg BW day^{-1}	2019	0.57	0.66	0.80	0.91	0.86	0.76				
	2021	0.89	0.84	0.96	1.05	1.06	0.96	0.10	<0.01	0.01	0.23
	Mean	0.73 b	0.75 b	0.88 a	0.98 a	0.96 a					
SR, kg BW ha^{-1}	2019	608	502	565	592	533	560				
	2021	617	620	605	626	697	633	64.34	0.87	0.29	0.66
	Mean	612	561	585	609	615					
GPA, kg BW ha^{-1}	2019	130	125	185	205	200	169				
	2021	258	245	243	320	342	282	23.25	0.01	< 0.01	0.46
	Mean	194 b	186 b	214 a	262 a	271 a					
SPI, kg day^{-1}	2019	-	0.08 d	0.20 c	1.04 b	2.09 a	0.85				
	2021	-	0.08 d	0.24 c	1.16 b	2.32 a	0.95	0.02	< 0.01	< 0.01	0.02
	Mean	-	0.08	0.22	1.10	2.20					
≠ADG, kg BW day^{-1}	2019	-	0.09	0.23	0.34	0.29	0.23				
	2021	-	-0.05	0.08	0.16	0.17	0.09	0.07	< 0.01	< 0.01	0.92
	Mean		0.02 b	0.15 a	0.25 a	0.23 a					
SPI:ADG	2019	-	1.09 a	0.95 b	0.28 b	0.12 b	0.61	0.45	0.21	< 0.01	0.04
	2021	-	-0.60 b	0.39 a	0.15 b	0.08 b	0.01				

Averages followed by different lowercase letters in the rows differ from each other by Tukey test at 5% probability of error. CON: Pasture without supplementation; MN: Pasture + Mineral Supplementation (commercial product): 80g animal day^{-1}; SE0.1: Pasture + Energy supplement 0.1% BW (commercial product); SE0.5: Pasture + Energy supplement 0.5% BW (commercial product 0.1% + 0.4% rice bran (RB)); SE1.0: Pasture + Energy supplement 1.0% BW (commercial product 0.1% + 0.9% RB); ADG: average daily gain; SR: stocking rate; GPA: gain per area; SPI: supplement intake; ≠ADG: difference in average daily gain; SPI:ADG: exchange ratio between SPI and ADG. SEM: standard error of the mean.

cattle become more evident after puberty, in line with studies by LAGE et al. (2012), who did not observe differences in the performance of beef cattle based on gender. An improvement in animal performance was clearly reported for the treatments (SE0.1; SE0.5 and SE1.0) attributed to a possible positive associative effect, in which the inclusion of energy supplementation increases voluntary herbage intake and/or the digestibility of fibrous herbage components (NOVIANDI et al., 2014; CANOZZI et al., 2023). Although, no significant differences in feed efficiency were detected, supplementation (SE0.1; SE0.5 and SE1.0) improved growth rate compared to CON treatment, as expected and reported (AÑEZ-OSUNA et al., 2015; CANOZZI et al., 2023). The difference in ADG between years may be related to differences in the nutritional value of the herbage (SOLLENBERGER et al., 2011), since different proportions of cellular components (e.g., protein) and structural components of the cell wall, such as cellulose, hemicellulose, and lignin, affect the intake and digestibility of herbage (LI, 2021). Research shows that the larger the fibrous fractions, the lower their digestibility, resulting in lower utilization, resulting in lower animal performance (ADESOGAN et al., 2019).

When energy supplementation is provided to grazing cattle in annual cool season herbages, it is expected that pasture intake will be reduced, leading to increased stocking (GUNTER, 2019), but in the present study this effect was not observed, resulting in a similar stocking rate, regardless of supplement supply. This result indicates that energy supplementation stimulated intake, causing an additive effect on total dry matter intake, allowing a better balance of nutrients in the animal's diet (SILVEIRA et al., 2015). In addition, the results of GPA reinforce the evidence of the additive effect of the supplement, where treatments with energy supplementation (SE0.1; SE0.5 and SE1.0) showed greater gains when compared to CON and MN treatments, indicating that energy supplementation levels of up to 0.1% improve pasture utilization efficiency (BISCAÍNO et al., 2018). Considering the use of rice bran in supplements, and its higher levels of fat, it is important to highlight that even in the SE1.0, based on the supplement and herbage intake estimation (NASEM, 2016), it is possible to assume

that fat levels in the total diet were below 6% of DM, as recommended in the literature (HESS et al., 2008).

The trade-off relationship between supplement intake and daily gain represents how many kilos of supplement an animal needs to intake to gain weight relative to weight gain ingesting herbage alone. These data are fundamental for making decisions about the use of supplementation in the production system. The results showed a decrease in the exchange ratio in the second year, which may be related to the influence of dry matter intake and the nutritional value of herbage on supplement intake, in which the tendency for supplement intake is to increase as quality decreases of pasture (PILAU et al., 2004; AMARAL NETO et al., 2019). This result is evident when it was compared weight gains with supplementation in different years (Table 2), where in the first year the gains were greater with lower nutritional value of the pasture.

CONCLUSION

The supplementation level of 0.16% BW is sufficient to achieve better animal performance of beef cattle grazing Italian ryegrass. Higher levels of supplementation did not increase the SR, so the increase in GPA was a consequence only of ADG responses due to the levels of supplementation used.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the manuscript.

BIOETHICS AND BIOSECURITY COMMITTEE APPROVAL

All procedures in this study were approved by the Ethics Committee on Animal Use of the Universidade Federal do Pampa (UNIPAMPA) (Protocols No. 016/2019 and No 018/2021).

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