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PROFITABILITY OF INCREASING SUPPLEMENTATION LEVELS FOR BEEF CATTLE GRAZING TROPICAL PASTURES

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Abstract

This study assessed the economic feasibility of supplementation levels for beef cattle grazing tropical pastures during the dry season. The central question was whether higher supplementation rates could improve system profitability and what level would provide the most advantageous balance between biological efficiency and economic return. Two experiments were conducted with 36 Angus × Nelore bulls each, receiving 0.2, 0.4, or 0.8% of body weight (BW) of a protein–energy supplement while grazing Brachiaria brizantha (1) or Brachiaria decumbens (2). Performance variables were measured over 110–150 days, and economic responses were calculated from feed costs and carcass revenues. A deterministic simulation was also run to determine how supplementation would affect feedlot finishing at 580 kg slaughter BW. Profitability was further scaled to a 300-ha pasture base to integrate both per-animal and per-area perspectives. Supplementation linearly enhanced average daily gain (ADG) and stocking rate, but marginal advantages were greater between 0.2 and 0.4% BW than 0.4 and 0.8% BW. In Experiment 1, ADG increased from 0.33 to 0.67 kg/day and final BW from 302 to 351 kg; in Experiment 2, ADG improved from 0.41 to 0.74 kg/day and final BW from 365 to 415 kg. Revenues increased with supplementation, but net margin peaked at 0.4% BW (US$ 101 in Exp. 1; US$ 83 in Exp. 2) and declined at 0.8% BW due to higher costs and reduced efficiency. The simulation confirmed that greater supplementation could shorten finishing time and reduce projected feedlot costs; however, system profit margin was maximized at 0.4% BW (US$ 183 in Exp. 1; US$ 127 in Exp. 2). At the 300-ha scale, output increased with higher supplementation, but total profit was optimized at 0.4% BW (US$ 253,000 in Exp. 1; US$ 129,000 in Exp. 2). In conclusion, dry season beef cattle supplementation at 0.4% BW on tropical pastures yielded the best performance, cost management, and profitability in simulated pasture and feedlot finishing.

Key words: Average daily gain; *Brachiaria*; dry season; grazing; supplementation cost.

Introduction

Nutritional supplementation of grazing beef cattle is a widely adopted strategy to partially offset seasonal declines in forage quality and quantity. By providing concentrated nutrients during the dry season, supplementation can increase average daily gain (ADG), raise final body weight, and effectively increase pasture stocking rate (Faria et al., 2024). However, the relationship between supplementation level and animal response shows diminishing returns, meaning that higher supplementation levels improve performance, but not at the same rate as the increase in supplement intake, which impacts the cost effectiveness of this strategy. Understanding the biological response to different levels of supplementation, and how this response translates into productive and economic outcomes, is critical for profitability in tropical beef production systems.

The present study was designed to evaluate economic trade-offs associated with three supplementation levels (0.2, 0.4, and 0.8% of body weight) offered to beef cattle grazing tropical pastures during the dry season. Our primary objective is to identify an optimal supplementation level that maximizes economic margins when considering only feed costs (i.e. partial budgeting). To make recommendations that are useful to farmers, we also simulate a scenario in which animals are finished in feedlots after the pasture supplementation phase. This framework allows us to clarify whether investments in stockers' higher supplementation rates during the dry season can reduce the time to slaughter sufficiently to justify their costs, or whether lower supplementation remains the more cost-effective option under typical production conditions.

Methods

Two experiments were carried out during the dry season of 2024 at Embrapa Beef Cattle, Campo Grande, Mato Grosso do Sul, Brazil (20°27′ S, 54°37′ W; 530 m a.s.l.). The experimental site is located in a tropical savanna region, with marked seasonality in rainfall distribution. During the experimental period, average monthly precipitation was 16 mm. All procedures involving animals followed the guidelines of the National Council for Animal Experimentation Control (CONCEA) and were approved by the Animal Ethics Committee of Embrapa Beef Cattle.

In Experiment 1, 36 cross-bred Angus-Nellore bulls with an initial average body weight (BW) of 250 kg were used. The experimental design was a randomized block with three treatments (0.2, 0.4, and 0.8% BW of a protein–energy supplement, as-fed basis) and three area replicates per treatment (0.95-ha paddocks of *Brachiaria brizantha* cv. Marandu). The evaluation period lasted 150 days, covering the entire dry season. In Experiment 2, another 36 cross-bred Angus-Nellore bulls were used, with an initial average BW of 325 kg. The design was also a randomized block with three supplementation levels (0.2, 0.4, and 0.8% BW of a protein–energy supplement) and three area replicates per treatment (1.5-ha paddocks of *Brachiaria decumbens*). The trial lasted 110 days. *Brachiaria brizantha* cv Marandu and *B. decumbens* are some of the most popular pasture species in Brazilian cattle farming.

The supplement offered in both experiments was a protein–energy mixture made of ground soybean grain (17.6%), ground corn grain (70.6%), feed-grade urea (6.1%), and a commercial mineral mixture (5.7%). On a dry matter basis, the supplement contained 29% crude protein (CP), 9.9% neutral detergent fiber (NDF), and 78.5% total digestible nutrients (TDN). The cost of the supplement, recorded at the beginning of the experimental period, was set at US$ 0.23/kg and used for the economic analysis. Supplement was offered once daily at 10:00 h. Quantities were adjusted every 28 days based on the mean BW of animals in each paddock, maintaining the target intake levels (0.2, 0.4, or 0.8% BW). Feed troughs were inspected daily to verify complete consumption.

Animals were managed under continuous grazing with variable stocking rate to maintain a relatively constant forage allowance within treatments. Stocking adjustments were made by adding or removing animals from the paddocks, ensuring that treatment differences were due to supplementation and not confounded by forage restriction. Body weights were recorded at the start and end of the experiments, and at 28-day intervals throughout, following a 16-h fasting period with access to water only. These measurements were used to calculate total BW gain and average daily gain (ADG) for each period and for the overall experimental duration. Stocking rate was calculated as the product of mean BW and the number of animals per paddock, expressed in animal units per hectare (AU/ha), assuming 1 AU = 450 kg BW. Total gain per hectare was calculated by multiplying ADG by stocking rate.

Data from both experiments were analyzed separately using a randomized block design, in which blocks were defined according to the initial body weight of the animals. For each variable evaluated (initial and final body weight, average daily gain, total gain, stocking rate, and gain per hectare), the effect of supplementation level was assessed by regression analysis to test for linear and quadratic trends in the responses. Statistical significance was declared at $P < 0.05$.

Economic analysis was based on feed costs and carcass revenue. Gross revenue per animal was obtained by converting total BW gain into carcass equivalent, using a fixed dressing percentage of 50%. Carcass weight was expressed in *arrobas* (1 arroba = 15 kg carcass weight) and multiplied by the prevailing market price at the end of each experiment (US$ 53.51/arroba). Average supplement intake was estimated from mean BW of the animals in each treatment and the supplementation level (%BW). Net revenue was calculated as gross revenue minus supplementation cost, which was determined from estimated supplement intake and price per kilogram.

Additionally, a deterministic simulation routine was run in a Microsoft Excel spreadsheet to evaluate the potential impact of supplementation levels, during the grazing stage, on the length and cost of feedlot. The simulation used the observed final body weights from Experiments 1 and 2 as starting points for each treatment. From these values, the number of feedlot days required for animals to reach a slaughter weight of 580 kg was calculated, assuming an ADG of 1.5 kg. Feedlot costs were estimated by assuming a daily dry matter intake equivalent to 2% of body weight and a total mixed ration price of US$ 0.24/kg on a DM basis. Profit margin was estimated by calculating total weight gain during the feedlot stage. This gain was converted into carcass equivalent using a fixed dressing percentage of 50% and expressed in arrobas to determine gross revenue (US$ 53.51/arroba), which was then compared against the total feed costs, obtained from the sum of pasture supplementation expenses at each level and the estimated feedlot costs.

Results

In both experiments, initial body weight did not differ within treatments, which was expected since animals had been blocked by weight at the beginning of the trials (Table 1). In Experiment 1, supplementation promoted a linear increase in average daily gain, from 0.33 kg/day at 0.2% BW to 0.67 kg/day at 0.8% BW, resulting in progressively higher final body weights (301.7 to 350.8 kg). Stocking rate also increased linearly from 2.35 to 2.73 AU/ha, indicating that as concentrate supplementation increased, forage intake per animal was likely partially substituted by supplement intake. In Experiment 2, the same linear patterns were observed. Average daily gain increased from 0.41 to 0.74 kg/day, leading to an increase in final body weights that ranged from 365.4 to 415.1 kg. Stocking rate was also positively affected by supplementation, varying linearly from 2.31 to 2.63 AU/ha.

Table 1. Performance and stocking rate of beef cattle supplemented at different levels during the dry season, Campo Grande, MS, Brazil (2024).

Experiment 1				
Supplement level, % BW	0.2	0.4	0.8	Regression trend
Initial body weight, kg	250.04	249.79	249.5	Not significant
Final body weight, kg	301.67	328.83	350.75	Linear
Average daily gain, kg/day	0.33	0.488	0.673	Linear
Total weight gain, kg	51.87	78.8	101.25	Linear
Stocking rate, AU/ha[1]	2.35	2.56	2.73	Linear
Experiment 2				
Supplement level % BW	0.2	0.4	0.8	Regression trend
Initial body weight, kg	320.08	319.79	333.7	Not significant
Final body weight, kg	365.37	386.08	415.12	Linear
Average daily gain, kg/day	0.41	0.6	0.74	Linear
Total weight gain, kg	45.29	66.29	81.41	Linear
Stocking rate, AU/ha[1]	2.31	2.45	2.63	Linear

[1] AU = animal unit, defined as 450 kg BW.

However, the analyzes of the marginal increments indicated that the gains were less than proportional to the increase in supplement level, as expected. In Experiment 1, the improvement in ADG per unit of supplement was nearly twice as high when supplementation increased from 0.2 to 0.4% BW compared with the interval from 0.4 to 0.8% BW, and the same pattern was observed for total weight gain. In Experiment 2, ADG and total weight gain also increased at a faster rate in the lower supplementation interval, with smaller incremental benefits observed at the higher levels. Taken together, these results demonstrate that the biological response followed a linear pattern, but the magnitude of the gains declined as supplementation level increased, which is consistent with the reduced efficiency of weight gain at higher growth rates, reflecting changes in the composition of tissue deposition, with a greater contribution of fat relative to lean tissue (Tedeschi et al., 2004).

Consistent with these biological responses, the economic analysis showed that higher supplementation levels increased revenues but also raised feed costs. In Experiment 1 (Figure 1), revenue per animal increased from US$ 92.52 at 0.2% BW to US$ 180.60 at 0.8% BW, while supplementation costs were US$ 19.03, 39.92, and 82.83, respectively, for the supplementation levels of 0.2, 0.4, and 0.8% BW. Consequently, profit margin improved from US$ 73.48 at the lowest supplementation level to a peak of US$ 100.63 at 0.4% BW, but then decreased slightly to US$ 97.76 at 0.8% BW.

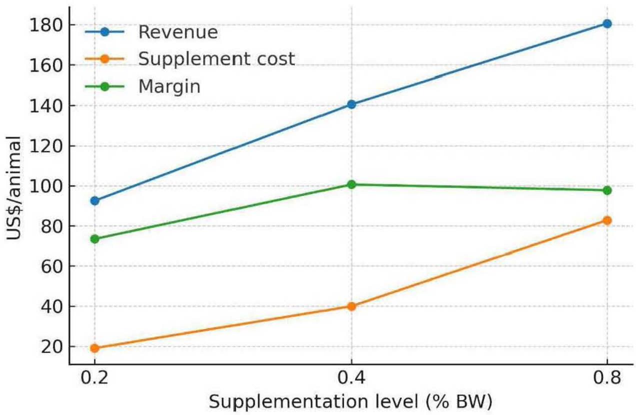

Figure 1 – Economic impact of increasing supplementation levels on Angus × Nellore bulls grazing Brachiaria brizantha cv. Marandu (Experiment 1).

In turn, in Experiment 2, revenues ranged from US$ 80.78 at 0.2% BW to US$ 145.21 at 0.8% BW (Figure 2). Total supplementation costs were lower than in Experiment 1 because the trial lasted 40 days less, averaging US$ 17.34, 35.72, and 75.78 per animal for the 0.2, 0.4, and 0.8% BW treatments, respectively. However, profit margin peaked at the intermediate supplementation level (0.4% BW, US$ 82.52) and dropped sharply at 0.8% BW (US$ 69.43), where additional revenue failed to compensate for the higher feed cost. This sharp decline appears to result from the interaction between high supplement intake and the heavy animals' reduced efficiency to put on additional weight. Since these were the heaviest cattle in this trial, their absolute intake at 0.8% BW was greater, but the incremental improvement in ADG between 0.4 and 0.8% BW was proportionally smaller than that observed between 0.2 and 0.4% BW. This pattern likely reflects changes in the composition of weight gain, as heavy animals tend to deposit more fat relative to lean tissue when growing faster. Since fat deposition is less efficient than lean tissue from an energetic standpoint (Ferrell and Jenkins, 1998), feed conversion efficiency declined, so that higher supplementation costs at 0.8% BW were not matched by proportional carcass weight gains, leading to a pronounced reduction in profit margin compared with the intermediate level.

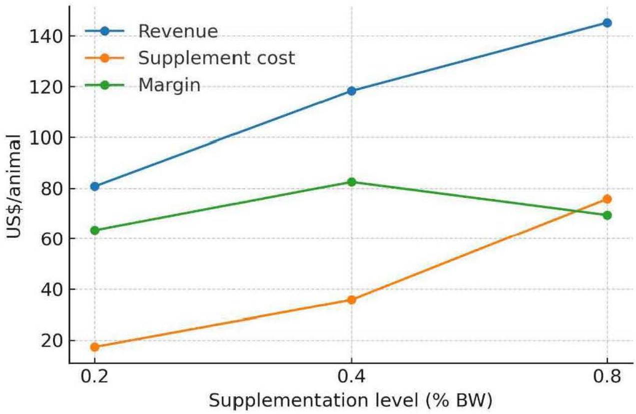

Figure 2 – Economic impact of increasing supplementation levels on Angus × Nelore bulls grazing Brachiaria decumbens (Experiment 2).

In our feedlot finishing simulation, higher supplementation levels during grazing systematically shortened days on feed and reduced feedlot costs, despite slightly higher daily intakes (Table 2). In Experiment 1, days to slaughter decreased from 186 (0.2% BW) to 168 (0.4% BW) and 153 (0.8% BW), while estimated daily intake increased modestly from 8.82 to 9.31 kg DM, yielding total feedlot costs of US$ 393.58, 366.44, and 341.77 per head, respectively. Margins for the overall system (grazing + feedlot) averaged US$ 175.93, 182.62, and 164.90, with the best outcome at the intermediate supplementation level (0.4% BW). Similarly, in Experiment 2, finishing time decreased from 144 to 130 and 110 days as supplementation increased, while feedlot costs declined from US$ 326.72 to 301.42 and 262.71

per head, respectively for 0.2, 0.4, and 0.8% BW. System margins followed the same trend, peaking at 0.4% BW (US$ 126.99) and dropping to 100.82 at 0.8% BW. Taken together, these results reinforce the superiority of the intermediate supplementation level, which combined lower feedlot costs with higher biological efficiency and superior margins.

Table 2. Simulated feedlot outcomes of beef cattle after grazing tropical pastures with different supplementation levels.

	Experiment 1			Experiment 2		
Level of supplementation, % BW	0.2	0.4	0.8	0.2	0.4	0.8
Days to slaughter	186	168	153	144	130	110
Average daily intake, kg/day DM	8.82	9.09	9.31	9.45	9.66	9.95
Feedlot cost, US$/head	393.6	366.4	341.8	326.7	301.4	262.7
Total weight gain, kg[1]	330.0	330.2	330.5	259.9	260.2	246.3
Total revenue, US$/head[1]	588.5	589.0	589.5	463.6	464.1	439.3
Total expense, US$/head[1]	412.6	406.4	424.6	344.1	337.1	338.5
Total margin, US$/head[1]	175.9	182.6	164.9	119.6	127.0	100.8

[1]Considering pasture plus feedlot values.

Experiment 1 – animals grazing on *Brachiaria brizantha* cv. Marandu.

Experiment 2 - animals grazing on *Brachiaria decumbens*.

It is worth noting that the increase in supplementation levels results in higher pasture stocking rates, which, in turn, require growing number of stockers. Thus, if we scale up to a 300-ha pasture base (Figure 3), greater supplementation levels would increase the number of animals going to the feedlot after the grazing phase. For instance, in Experiment 1, the number of animals entering the feedlot would increase from 1,270 at 0.2% BW supplementation to 1,384 at 0.4% BW and 1,476 at 0.8% BW. A similar pattern was observed in Experiment 2, where head counts would rise from 961 to 1,019 and 1,094 across the same supplementation levels. However, the lower system margin per head at 0.8% BW offset the advantage of higher throughput. As a result, total system margin per 300 ha was maximized at the intermediate supplementation level, reaching approximately US$ 253,000 in Experiment 1 and US$ 129,000 in Experiment 2. In contrast, the highest supplementation level consistently generated lower overall profits despite the larger number of animals finished. Therefore, under the current assumptions, increasing supplementation from 0.4 to 0.8% BW increases the number of animals finished but does not maximize profitability in a complete finishing system.

Despite not being part of this study, a point of consideration is the indirect impact of a growing number of cattle, resulting from more intensive systems, in the cash flow and capital required to buy stockers in rearing-finishing operations.

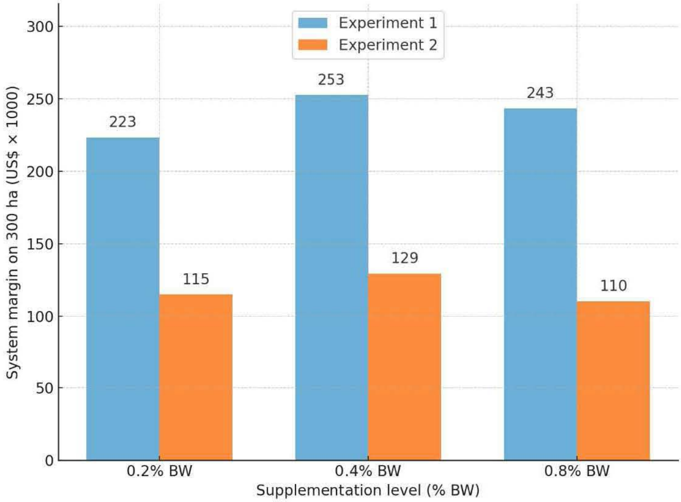

Figure 3. Economic outcomes of beef cattle production systems combining grazing at different supplementation levels (300-ha scale) and feedlot finishing.

Conclusions

Supplementing grazing beef cattle at 0.4% BW during the dry season proved to be the most feasible and profitable approach, ensuring favorable individual performance, manageable feed costs, and the best overall economic returns. These findings provide practical guidance for decision-making in tropical beef production systems aiming to optimize both productivity and profitability.

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