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BEEF PRODUCTION WITH LOW CARBON EMISSION IN TROPICAL PASTURES: A CASE STUDY FOR THE VALIDATION OF GUIDELINES

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ABSTRACT
The Low Carbon Brazilian Beef (LCBB) concept brand seeks to value livestock systems that do not include the forest component but hold the potential to mitigate greenhouse gas (GHG) emissions, by adopting conservationist production criteria and concepts. At present, there is no commercial production system in Brazil with validated LCBB guidelines. In this scenario, the LCBB Technological Reference Unit proposed to examine beef cattle production in systems with well-managed pastures to validate the guidelines in a commercial environment. The initial results show that by implementing the LCBB guidelines, it is possible to ensure productivity and meat quality as well as increase the profitability of the producer without giving up the maintenance or increase in the soil carbon stock and the mitigation of GHG emission, in addition to the land-saving effect. This is another step towards productive efficiency that takes into account the quality of the product and its environmentally friendly production.
Key words: Low Carbon Brazilian Beef; pasture management; soil carbon stock

INTRODUCTION

Similarly to the Carbon Neutral Brazilian Beef (CNBB) brand values livestock systems that involve the forest component (ALVES et al., 2015, 2017; ALMEIDA et al., 2016), which accounts for around 2% of the cultivated pasture area in Brazil, the Low Carbon Brazilian Beef (LCBB) brand emerges to include livestock systems that do not have the forestry component but hold the potential to mitigate GHG emissions, which represent a higher area percentage in Brazil (BARIONI et al., 2007; BODDEY et al., 2012; ALMEIDA et al., 2013; MEDEIROS et al., 2017).

The guidelines for Low Carbon Brazilian Beef production are part of a set of protocols that contribute to strategies of the ABC (Agricultura de Baixa Emissão de Carbono, or Low Carbon Emission Agriculture) Plan. These guidelines are based on criteria, concepts and practices to value these more efficient livestock systems in mitigating GHG emissions by the herd during its productive cycle through the implementation of adequate practices of herd and pasture management, soil correction and fertilization, intercropping and crop-livestock integrated systems (ALMEIDA; ALVES, 2020). However, to date, there are no production systems in Brazil with validated LCBB guidelines, warranting research in reference areas.

In this scenario, this study presents the results of the first Technological Reference Unit (TRU) of Embrapa for beef production adopting the LCBB guidelines.

MATERIAL AND METHODS

The case study began in May 2019 on the Trijunção Farm, located in Jaborandi - BA, Brazil. The farm is a reference in beef cattle production under the Brazilian Good Agricultural Practices (BPA, 2008), holding structured and sequential data of the entire production system.

According to the Köppen and Geiger classification system, the climate of the region is an Aw type, characterized as hot and dry, with rains concentrated in the summer and an average temperature of 24 °C. The local altitude is 933 m and average annual precipitation ranges from 700 to 1,400 mm, with a pronounced water deficit occurring from late April to October. The predominant soils in the region are Arenosols, Oxisols and Red-Yellow and Yellow Ultisols, in the sand and loam sand or sandy loam textural classes (ALBUQUERQUE FILHO et al., 2020).

The TRU was composed of two plots as well as a native vegetation (Cerrado biome) area that will be monitored, over time, to improve the comparative analysis of the farm's history and to evaluate the areas enrolled in the future LCBB certification process. Both plots are formed by *Urochloa brizantha* pasture, one plot being 115 ha of *Urochloa brizantha* cv. Marandu divided into four paddocks, representing the general farm management (GFM); and another consisting of 85 ha of recovered pasture, with *Urochloa brizantha* cv. BRS Piatã, also divided into four paddocks but managed according to technical guidelines for low carbon meat production in tropical pastures (LCBB), as proposed by Almeida and Alves (2020).

The plots were chosen so as to have similar soil for monitoring and comparing the carbon content. The reference, in this case, was the organic matter content. At the start of the establishment of the TRU (May 2019), the areas were subjected to soil fertility assessments, physical characterization, carbon stock quantification and soil classification (Albuquerque Filho et al., 2020). Soil was sampled from mini-trenches and at georeferenced points, at the end of the rainy season (May 2019). One mini-trench, 40 cm deep, was opened at the central point of each of the four paddocks of the LCBB and GFM plots; and another two were open in the native vegetation (Cerrado). Samples were obtained with a auger at four points arranged in a cross and spaced 100 m apart. Four perforations were made around each point with the auger to form a composite sample at the depths of 0-10, 10-20 and 20-40 cm. Undisturbed samples were also collected from three walls of the mini-trenches, at the indicated depths, using a volumetric ring. These assessments will be repeated every two years to monitor the dynamics of the evolution of fertility and carbon stock in the soil.

The initial soil characterization of the GFM plot revealed the following properties: pH H_2O = 5.9; P, K and S = 8.2, 3.7 and 15.8 mg dm^{-3}; Ca, Mg, Al and T = 1.4, 0.4, 0.0 and 3.0 $cmol_c\ dm^{-3}$; base saturation = 50.0%; OM and clay content = 0.8 and 11.9 dag kg^{-1}. The soil profile in the LCBB plot was as follows: pH H_2O = 6.6; P, K and S = 24.9, 52.1 and 8.0 mg dm^{-3}; Ca, Mg, Al and T = 1.8, 0.6, 0.0 and 3.3 $cmol_c\ dm^{-3}$; base saturation = 78.9%; OM and clay content = 1.0 and 14.0 dag kg^{-1}.

The pastures of the plot under LCBB guidelines were managed in a rotational grazing system, with the recommended entry of the animals at 30-40 cm, keeping a minimum stubble height of 20 cm for the Piatã grass. Height was monitored every two weeks, using a graduated ruler, by sampling approximately 100 points per paddock along a zigzag walking. The load adjustment in the LCBB field was determined based on this monitoring. In this same plot, two doses of 50 kg ha^{-1} of N were recommended during the summer cycle, applied after grazing in the paddocks, plus one dose of 50 kg ha^{-1} of K_2O based on recommendations by Embrapa (MARTHA JUNIOR et al., 2007) and on the intensification level adopted.

Ground cover, pasture height and forage availability were assessed once per season (rainy; rainy-dry transition; dry; and dry-rainy transition), in all paddocks. Ten georeferenced points were sampled per paddock, using a 1 m × 1 m frame. The ground cover with pasture, within this frame, was visually assessed by at least three people, who assigned coverage scores ranging from 0 to 100%. Additionally, the pasture height was measured in each of the vertices of the square and in its central region. After these evaluations, all the forage was cut close to the ground. The material was packed in paper bags, which were later used for weighing the fresh mass and oven-drying at 65 ºC for 72 h until constant weight to determine the forage dry mass and estimate its availability.

To monitor the animal component, two lots of intact Nellore males at an average age of 10 months were selected to be monitored as tester animals, in accordance with the Ethics Committee for the Use of Animals of Embrapa (CEUA/CPPSul n. 09/2019). The lot in the LCBB plot was composed of 104 animals, whereas the lot in the plot under the Farm management consisted of 72 animals (average weights of 259 and 241 kg, respectively). These animals entered the system in July 2019 and remained on pasture for 346 days in GFM and 354 days in the LCBB management, receiving only mineral salt and being weighed at least once per season. Notes of the date of entry, number of animals, average weight and date of departure were made whenever animals were needed for load adjustment. Based on these data, the average daily gain of the animals and the gain per area were estimated. After this period, the animals were sent for feedlotting on the farm itself for 100 days (GFM) and 95 days (LCBB), ensuring that the final product (meat) would be produced mostly on pasture, under the premise of maintaining the carbon soil stocks fixed, in accordance with the LCBB guidelines.

At the end of the feedlot period, on September 30, 2020, the animals were sent for slaughter. The carcasses of ten animals under LCBB management were evaluated for carcass weight and yield, fatness (score on a scale from 1 to 5 points) and maturity (teeth). After chilling for 24 h, the carcasses were sectioned in the rib region, at the 12th-13th vertebra, to expose the *longissimus* muscle, where backfat thickness and ribeye area were measured. Samples of the *longissimus* muscle were sent to the laboratory for evaluation of marbling (score on a scale from 1 to 18) and shear force (in kg, using a Warner-Bratzler Shear instrument).

Enteric methane emissions were estimated using the equation proposed by Medeiros et al. (2014) and following Alves et al. (2017).

RESULTS AND DISCUSSIONS

Data from the initial characterization (ground zero) of the soil under the LCBB management revealed a carbon stock of 20.59 Mg ha^{-1} in the 0-20 cm soil layer. This value is higher than the 15.18 Mg ha^{-1} found in the native Cerrado vegetation and the 18.16 Mg ha^{-1} found in the pasture under GFM, which is the result of pasture recovery management and which will be monitored over the years. Because these values were obtained in an initial characterization, analyses will be carried out at two-year intervals to follow the evolution of this carbon in the soil of the evaluated areas. However, it is already noted that the soil carbon stock in the LCBB management can be considered appropriate according to the guidelines proposed by Alves et al. (2017).

As shown in Table 1, the average pasture height in the LCBB areas was always very close to the recommended range for the management of Piatã grass, and the minimum recommended height for the cultivar was met throughout the year. Ground cover remained always above 70%, as recommended in the guidelines for forages with a cespitose growth habit (ALMEIDA; ALVES, 2020). This always-high ground cover in the LCBB plot serves to contribute straw to the soil organic matter and carbon retention in the system.

As of January 2020, the pasture in the plot under GFM was taller and, likely due to the presence of green leaves, improved ground cover. However, for both these traits and forage availability, the values were always higher in the plot under LCBB management (Table 1), which made it possible to maintain an average load of 4.34 AU ha^{-1}, versus 1.93 AU ha^{-1} in the plot under GFM.

Table 1. Variables related to pasture monitoring during the first year of applying the Technological Reference Unit (TRU), in pastures under LCBB and GFM management: pasture height (cm), ground cover (%) and forage availability (kg ha^{-1} DM).

Month/year	LCBB			GFM		
	Height	**Cover**	**Forage**	**Height**	**Cover**	**Forage**
May/2019	39±6.31	86±1.14	5549±154.5	25±3.22	32±5.19	1804±46.07
August/2019	22±3.34	91±3.51	3326±447.9	13±2.21	33±3.21	1464±93.46
November/2019	27±3.45	92±3.12	4976±665.2	18±3.23	41±4.96	2237±48.11
January/2020	42±4.14	90±3.93	4218±1068	23±1.52	75±5.00	2141±108.80
May/2020	36±6.45	80±1.96	2901±704.4	25±1.98	64±4.73	1740±341.2

Mean values per plot at the sampling times.

In compliance with the guidelines, the tester animals were weighed once per season (rainy; rainy-dry transition; dry; and dry-rainy transition) and on June 20, 2020, when they entered the feedlot. Table 2 describes the average lot data. It is important to note that both lots received the same mineral supplementation on pasture. Throughout this first year of evaluation, the animals in the LCBB plot and under Farm management gained an average of 154 kg and 149 kg on pasture, respectively. Therefore, in addition to the higher number of AU ha^{-1}, the animals in the LCBB plot entered the feedlot about 23 kg heavier and reached slaughter weight having spent at least 20 fewer days in confinement than those in the plot under Farm management.

Table 2. Animal production performance during the first year of applying the Technological Reference Unit, in pastures under LCBB and GFM management.

LCBB				GFM			
Average live weight (kg)		ADG	Gain per area	Average live weight (kg)		ADG	Gain per area
Initial	Final	(g d^{-1})	(kg ha^{-1})	Initial	Final	(g d^{-1})	(kg ha^{-1})
259±15	414±26	440±170	538±146	241±11	391±71	430±240	166±46

With pasture fertilization, strategic supplementation and pasture management, high body weight production per unit area was ensured in the LCBB plot, whose recorded yield values were above the Brazilian average (ABIEC, 2020). In the field under farm management, although the average daily gain was not very different from that of the LCBB plot, gain per area was below the potential.

In the evaluation of carcass and meat quality of the animals in the LCBB plot, the average slaughter and carcass weights were 573 kg and 306 kg, respectively, which provided an average carcass yield of the order of 53.4%. Additionally, 100% of the carcasses showed type-3 fatness (medium fat) and maturity of two teeth. In the analysis of meat quality, the average marbling score was 7.7, that is, the average marbling was low, with only one animal showing traces (the lowest grade) and 30% of them exhibiting marbling in a higher degree than the observed average. Average shear force was 6.3 kg, varying between 4.87 and 8.17 kg. While none of the animals showed meat considered to be hard (> 9 kg), practically two out of three animals produced meat with a shear force value of less than 7 kg, which could be considered as acceptably tender meat if evaluated by a panel of trained tasters.

Thus, the observed meat quality, marbling and shear force are compatible with the existing production systems in Brazil and meet the market requirements. Similarly, in terms of carcass quality, if these animals were slaughtered and evaluated according to the PROAPE PRECOCE-MS system, they would produce a type-2 product and receive the second highest possible bonus within the program, i.e., this bonus could only be increased if the animals were slaughtered even younger.

Based on the NDF contents of the pasture and the feedlot diet, 74 and 32.4% and 76 and 32.3% for the LCBB management and GFM, respectively, the estimated enteric methane emissions were 169 and 159 g CH_4 day^{-1}, 75.88 and 71.10 kg CH_4 $animal^{-1}$ and 476 and 181 kg CH_4 ha^{-1}, respectively. However, emission intensity did not vary between the management strategies, averaging 6.285 kg CO_2 eq. kg $carcass^{-1}$. The LCBB management allowed a 147% increase in the number of animals ha^{-1} and a 163% gain in kg carcass ha^{-1} relative to GFM. This result indicates an important land-saving effect in addition to the potential for greater carbon incorporation into the soil for the maintenance of the productive condition of the pasture and the mitigation of GHG emissions from the system.

Through planning, adjustments and improvements are also expected to be made in the gains of the area managed under LCBB. At the same time, we expect that the benefits arising from the adoption of the future protocol can be noticeable so that it can be expanded to other areas of the property as well as to contribute to the transfer of this technology in the region.

CONCLUSIONS

The LCBB Technological Reference Unit examined beef cattle production in systems with well-managed pastures to validate the guidelines in a commercial environment that values sustainable production systems. The initial results demonstrate that it is possible to ensure productivity and beef quality so as to increase the profitability of the producer without giving up the maintenance or increase of the soil carbon stock and mitigation of GHG emissions, in addition to the land-saving effect. This is another step towards productive efficiency that takes into account the quality of the product and its environmentally friendly production.

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