Carbon Neutral Brazilian Beef: testing its guidelines through a case study

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Introduction

The Carbon Neutral Brazilian Beef (CNBB) is a new concept for sustainable beef production in the tropics, developed by Embrapa and first reported by Alves et al. (2015). The CNBB concept is based in silvopastoral or agrosilvopastoral systems and requires greenhouse gases emissions to be neutralized, at first, by timber production. Aim of this work is to report the first case study of CNBB application for finishing steers and to present animal performance, beef quality, pasture characteristics, microclimate parameters and carbon balance estimates.

Material and Methods

The study was carried out at Boa Aguada Farm, Mutum Group, in Ribas do Rio Pardo, MS, Brazil. Local climate is Aw according to Köppen Climate Classification, with average anual temperature of 24.1 °C and 1425 mm average annual rainfall. Site soil major characteristics were: 880 ± 44 g kg^{-1} sand, 11.5 ± 0.7 g dm^{-3} organic matter, 4.1 ± 0.1 pH ($CaCl_2$), and 17.5 ± 2.1% of soil basic saturation. Twenty-two Nellore steers, with 437 ± 7 kg initial live weight and 27 ± 1 months of age were finished in a silvopastoral system. The animals were kept from December 2015 to May 2016 (154 d) in a paddock with 69.1 ha and 52.8 ha of grazing area. Grasses were *Brachiaria brizantha* cv. Piatã (89%) and *B. dictyoneura*

(11%) between tree alleys. Trees were eucalyptus clones, I-144 (*Eucalyptus urophylla* x *E. grandis*) and VM-01 (*E. urophylla* x *E. camaldulensis*), with spacing of 10 m between tree alleys and 3 m between alley rows and 2 m between trees in the row [(3 m × 2 m) × 10 m arrangement], totaling 769 trees ha^{-1}. Eucalyptus seedlings were planted in December 2010. During experimental period, cattle were fed with balanced dry feed supplement on pasture (dry matter intake of 0.5% of live weight daily). Animal weight was monitored every 50 days. Pasture was managed to be kept a minimum sward height of 30 cm and forage availability about 2,000 kg ha^{-1}. The pasture was evaluated every 50 days, for height, ground cover, forage availability and nutritional value (crude protein, CP, neutral detergent fiber, NDF, and *in vitro* organic matter digestibility, IVOMD). Microclimate assessment (wind speed, temperature and relative humidity) and photosynthetically active radiation (PAR) were also carried out using a portable thermo-hydro-anemometer (Homis, model HMM-489) and a ceptometer (Accupar, model PAR-80), respectively, in 15 points under the silvopastoral system and in a reference area under full sun exposure from 9:00 am to 1:00 pm. The Temperature and Humidity Index (THI) was calculated as proposed by Thom (1959). Evaluations of tree total height, diameter at breast height (DBH) were performed at 60 months after planting. From the total height and DBH data, the volume of timber and carbon per plant was calculated and, from it, timber yield per hectare was estimated using the *SIS Eucalipto* software (Oliveira, 2011). The trunk's carbon content was converted in CO_2 eq. using the 3.66 conversion factor. Individual enteric methane (CH_4) emissions were calculated considering the index reported by Gomes et al. (2015) for silvopastoral systems (66 kg head^{-1} year^{-1}), adjusted for the period of 154 d. Total CH_4 emission was multiplied by 23 to calculate CO_2 eq. emissions. At the end of the trial the steers were slaughtered at a commercial slaughterhouse (JBS) in Campo Grande, MS. Carcasses were evaluated for hot carcass weight, backfat score (1 to 5) and maturity (teeth). After 24-h chilling, carcasses were sectioned at the 12th-13th ribs region to expose Longissimus muscle, where backfat thickness and ribeye area were measured. Longissimus muscle samples were taken to the laboratory to evaluate marbling, color, pH, cooking losses and Warner-Bratzler shear force. The carcass weight gain during the experimental period was calculated as the difference between the initial and the final carcass weight. Initial carcass weight was estimated multiplying initial live weight by 0.5, considering 50% as the initial carcass backfat.

Results and Conclusions

It was observed that the PAR strongly decreased from the December (summer) to May (autumn) in the silvopastoral system. However, forage availability was maintained within the limits expected for the grass species (Table 1). Stocking rate ranged from 0.4 to 0.5 AU ha^{-1}. In March, the forage had levels of 8.7 ± 1.5% CP, 71.5 ± 2.1% NDF and 51.7 ± 2.9% IVOMD. Regarding microclimate variables, silvopastoral system presents better THI when compared to full sun areas. In December, THI under full sun was at emergency level (84) of its scale and danger (83) in shaded areas. In May, improvement of microclimatic conditions under shaded areas was more significant, changing from danger (80) under full sun to critical (77) in shaded areas.

Table 1. Pasture and microclimate variables during experimental period: pasture height (cm), ground cover (GC, %), forage availability (kg ha^{-1} dry matter basis), photosynthetically active radiation (PAR, μmol m^{-2} s^{-1}), wind speed (WS, m s^{-1}), air temperature (T, °C) and relative humidity (RH, %)

Month	Height	GC	Forage	PAR	WS	T	RH
December	44.9±3.2	57.0±11.2	3516±846	1051±306	0.40±0.29	32.9±1.5	56.0±4.7
March	48.4±4.3	73.3±13.1	3603±757	621±446	0.23±0.26	29.0±1.0	66.1±5.6
May	31.7±3.0	64.7±9.1	2395±400	106±20	0.82±0.43	27.2±1.3	74.7±2.6

Trees management plan foresees a 50% thinning in the 6th year and clear cut in the 12nd year. Estimated mean annual increment (MAI) of trees, for six year old trees has reached 30 m^3 ha^{-1} $year^{-1}$.

This MAI value was entered in *SIS Eucalipto* software (Oliveira, 2011) to estimate carbon content fixed by remaining trees (timber logs) at year 12. This resulted in a total of 98 ton CO_2 eq. ha^{-1} from which, approximately 60% of the volume of timber logs are suitable for processing into lumber and therefore be accountable for neutralizing of GHG emissions from cattle (Alves et al., 2015). The steers had a daily live weight gain of 490 g and were slaughtered at 514.3 ± 21.9 kg live weight (Table 2).

Table 2. Performance of finishing Nellore steers under a 154-days CNBB guidelines

Live weight (kg)		Average daily gain (g d^{-1})	Carcass weight (kg)		Carcass gain (kg)
Initial	Final		Initial	Final	
437±7.4	514.3±21.9	490±121	218±3.7	274.6±11.7	56.2±10.7

The nutritional protocol (silvopastoral grazing system plus dry feed supplement) allowed cattle to reach adequate carcass weight (greater than 240 kg), maturity degree (≤ 4 definitive teeth) and backfat score (scores 3 or 4) at slaughter (Table 3). These figures are within Brazilian common values and met requirements set by the CNBB guidelines. The beef produced using CNBB guidelines presented adequate pH, color and tenderness (Table 4).

Table 3. Carcass quality of Nellore steers (n = 15) submitted to CNBB guidelines

Maturity degree (0 to 8)	Backfat score (1 to 5)	Backfat thickness (mm)	Ribeye area (cm^2)	Marbling score (1 to 18)
3.24±0.4	3.2±0.2	6.98±0.77	75.50±1.94	3.07±0.67

Table 4. Meat quality of Nellore steers (n = 15) submitted to CNBB guidelines

pH	L* (CIELAB)	Chroma	Hue (radians)	W-B shear force (kg)	Cooking losses (%)
5.50±0.01	37.04±0.40	23.29±0.37	0.66±0.01	5.37±0.19	26.27±0.55

Total enteric methane emission from Nellore steers was estimated to be 33.40 ton CO_2 eq. $year^{-1}$ or 0.63 ton CO_2 eq. ha^{-1} $year^{-1}$. Whereas carbon fixed in lumber, was estimated to reach 59 ton CO_2 eq. ha^{-1} or 5.35 ton CO_2 eq. ha^{-1} $year^{-1}$ after 11 years of grazing. Therefore, it should be possible to neutralize the total GHG emissions from cattle kept in the system with a carbon surplus of 4.72 ton CO_2 eq. ha^{-1} $year^{-1}$ from this system. Silvopastoral and agrosilvopastoral systems in Brazil are able to ensure beef quality and animal welfare with production diversity, profitability and environmental benefits like GHG emissions mitigation. Systems with lower tree density can also increase beef production (Oliveira et al., 2014), but with lower carbon balances.

The CNBB guidelines should be suitable for certificating cleaner beef production under more sustainable systems. However, it will be necessary public and private engagement to set commercial arrangements that profit from these guidelines.

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