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This publication is dedicated to Odo Primavesi, for his outstanding contribution for the sustainability of the Brazilian Agriculture.

Sumário

Artigos

N_2O fluxes evaluation in pasture management system under different densities of babassu palms

Antonio Carlos Reis de FREITAS[1], Luciano Cavalcanti MUNIZ[2], André MANTEGAZZA[3], Lucieta Guerreiro MARTORANO[4], Falberni Souza COSTA[5]

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Introduction

The intensification of beef cattle production systems for recuperation of degraded pasture and increase animal support capacity in the Amazonia biomes has been showed how key strategy of Low Carbon Agriculture Plan (BRASIL, 2012). However, in 2012, N_2O emissions of Brazilian Agriculture Sector were 541.2 Gg been 43% of direct emissions from pasture animal sector (BRASIL, 2013). The objective in this research is comparing the effect of nitrogen fertilization in the N_2O emissions pasture management system under different densities of babassu palms.

Material and Methods

The experiment was installed in area of Campus IFMA, municipality of Codo, Maranhao State, coordinated Latitude 4º 29′ 20″ S and Longitude 43º 56′ 0″ W no period from March to July 2014. Total area of 12 hectares of Neossolo Quartzarenic under Mombasa grass divided into twenty-four plots been 0.5 hectare each. This research had two treatments: pasture management system with low density of babassu palms and pasture management system with high density of babassu palms, beside an area of twenty hectares with babassu forest as reference area. The methodology of field work was based on PECUS Network protocols like this for characterization of soil carbon stocks

(Fernandes et. al. 2012) and for measuring gases fluxes Greenhouse soil (Zanatta et. al. 2014). DNDC model was applied for predicting the N_2O emissions (UNIVERSITY 2012)

Results and Conclusions

The evaluation the daily N_2O emissions in two steps (May/5/2014 and June/15/2014) indicated there is a tendency for decreasing the emissions in rainfall due the end of rainy season in both pasture management systems, see Table 1.

Table 1. Daily N_2O fluxes in pasture management systems under different densities of babassu palms.

Treatments	Day	Daily N_2O fluxes (g N $ha^{-1}day^{-1}$)	
		N measured	N predicted
Pasture management system with low density of babassu palms	133	3,77	174
Pasture management system with high density of babassu palms	133	8,18	189
Babassu forest	133	-0,03	1
Pasture management system with low density of babassu palms	167	3,08	100
Pasture management system with high density of babassu palms	167	6,33	103
Babassu forest	167	0,00	1

Pasture management systems based absence N mineral fertilization present low N_2O emissions. On other hand, conform was predicted by DNDC model, the application nitrogen fertilization in pasture management system with high density of babassu palms become the annual N_2O emission rate bigger as management system with low density of babassu palms, see Table 2.

Table 2. Annual N_2O fluxes in pasture management systems under different densities of babassu palms.

Treatments	Pasture management system with low density of babassu palms		Pasture management system with high density of babassu palms	
	N_2O fluxes (Kg N $ha^{-1}day^{-1}$)	Annual N_2O emission rate (%)	N_2O fluxes (Kg N $ha^{-1}day^{-1}$)	Annual N_2O emission rate (%)
Fertilization (360 kg N)	5,03	1,4	6,22	1,73
Fertilization (180 kg N)	3,34	1,9	3,91	2,17
Fertilization (0 kg N)	0,47	0,0	0,28	0,00

Finally, DNDC model was applied for evaluation N_2O emissions of pasture management systems under different densities of babassu palms which over estimated daily N_2O emissions that limited the its capacity to compare measured and modeled data how show the Figure 1.

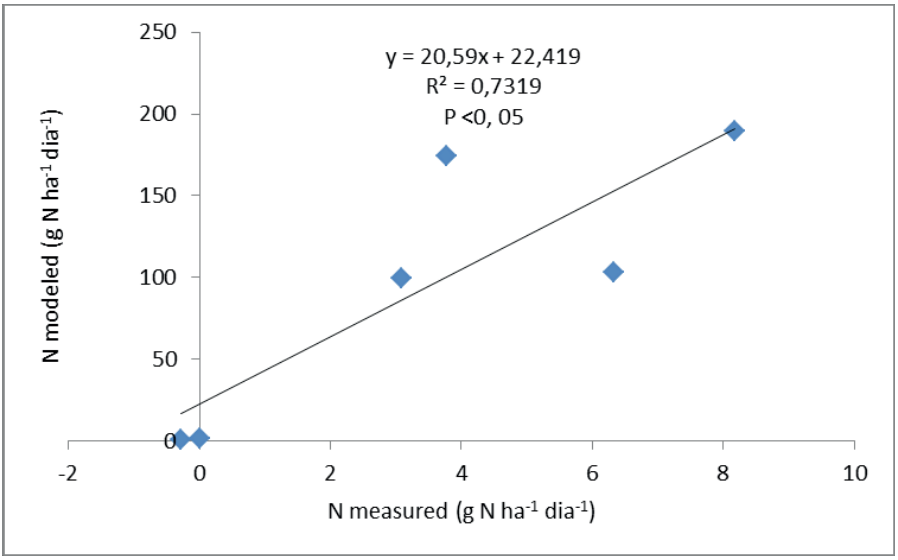

Figure 1 Compare measured and modeled data of N_2O emissions in pasture management systems

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Edaphoclimatic factors and interactions with nitrous oxide emissions in integrated production systems

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Introduction

The worldwide increase in the concentration of greenhouse gases (GHGs) has caused climate changes that have not been observed since 800,000 years ago. As a result, the heating of the Earth's surface has been higher in the last three decades than recorded until 1950 (IPCC 2013). N2O is considered a very active gas in the process of global warming due to its high ability to absorb infrared radiation and is a stable gas in the atmosphere, contributing approximately with 6% of the radiative potential of GHGs, and has a half-life of 120 years. Its global warming potential (GWP) is 310 times higher compared to CO_2 and its concentration in the atmosphere has increased in recent decades, reaching $324,2 \pm 0,1$ ppb. This increase has been attributed to increased amounts of nitrogen fertilizers used in agriculture, conversion of forest areas for agriculture, increased fires, intensification of livestock, etc. (Bustamante et al. 2012). Thus, agriculture is the main activity responsible for N_2O emissions to the atmosphere as a result of oxidation of organic matter and complex microbial processes associated with management practices on ecosystems. Integrated production systems can be considered a strategy to reduce soil N_2O emissions in the Brazilian Cerrado (Carvalho et al., 2014).

Material and Methods

The study was conducted in the experimental field of Embrapa Cerrados, located in Planaltina, DF (15º35`30" S, 14º42`30"W and altitude 1007 m) from February 2012 to April 2014. The treatments consisted of four areas with different land use: a cultivated area with Eucalyptus urograndis in alley cropping, spaced 2 x 2 m between plants and 22 m between rows (ICLF); a cultivated area at full sunlight in absence of tree species (ICL); and two adjacent areas used as a reference: a native Cerrado and low productivity pasture. The ICL and ICLF areas consisted of experimental plots with 1.2 ha in a complete randomized block design with three replications. In March 2012, after soybean harvest, seeds of *B. brizantha* cv. BRS Piatã were broadcasted immediately before sowing the sorghum to establish the intercropping system in the off-season growth. After harvesting the sorghum (July 2012), the pasture of *B. brizantha* was left to establish for the entrance of the livestock (cattle).

Soil N_2O sampling period was from February/2012 to February/2014. Three static chambers were placed in each plot, totaling 24 chambers in the integrated systems experiment (ICL and ICLF). For each reference area (native Cerrado and continuous pasture) three chambers were installed. Each chamber consisted of a rectangular hollow metal frame (38 cm wide, 58 cm long, 6 cm in height) that was inserted 5 cm into the soil and a top polyethylene tray that was coupled and sealed to the base during gas sampling. The top of the tray contained a triple Luer valve for fastening the sampling syringes, thus allowing the removal of the gases at the time of sampling. The samples were collected and immediately transferred to 20 ml glass pre-evacuated vials (-80kPa). Gas sampling frequency was carried out, on average, three to four consecutive days a week during the rainy season, weekly during short period of drought during the rainy season, and biweekly during the dry season. In the rainy season, samples were collected 5 following days after nitrogen fertilizer applications. The analysis of N_2O concentrations were performed at the Laboratory of Gas Chromatography of the Embrapa Cerrados, using a gas chromatograph.

In addition to the gas sampling, soil samples were also collected at each gas sampling to determine the gravimetric water content, the concentration of mineral forms of nitrogen in the soil ($N\text{-}NO_3^-$ and $N\text{-}NH_4^+$), carbon and nitrogen microbial biomass and total carbon and nitrogen. Soil samples, composed of three sub-samples were collected at each plot at depths of 0-5 cm and 5-10 cm. The gravimetric soil water content was determined after drying soil samples at 105 ºC for 48 h. Based on these results and the bulk density, the percentage of WFPS was calculated, using the following formula: WFPS (%) = (gravimetric moisture (%) x bulk density) / total soil porosity x 100; Where: total soil porosity = [1- (bulk density / 2.65)], with 2.65 [g cm^{-3}] is the density of the particles assumed soil. Nitrate ($N\text{-}NO_3^-$) and ammonium ($N\text{-}NH_4^+$) were analyzed following Embrapa (1997). Nitrogen microbial biomass (MBN) was determined with the method of chloroform fumigation-extraction and carbon microbial biomass (MBC) was determined according to Vance et al. (1987) and Wardle (1994). Basal respiration (BR) was estimated by measuring CO_2 released from pre-incubated soil samples for a period of seven days. Total organic carbon (TOC) and total nitrogen (TN) were analyzed according to Embrapa (1997).

Pearson's correlation and multiple linear regression were used to correlate the cumulative emissions of N_2O and the edaphoclimatic factors and soil properties.

Results and Conclusions

The dynamics of N_2O emissions can be attributed to differences between the integrated systems, continuous pasture and native Cerrado, due to their environmental conditions. Thus, the covariables (NO_3^-, NH_4^+, WFPS and rainfall) correlate with the N_2O fluxes with values less than 0.45, but highly significant (Table 1). In addition, all correlations were positive, reinforcing the relationship and direct influence that these covariables present with N_2O fluxes. Among these factors, the WFPS was the most significant. Generally, high flows coincide with periods after precipitation, which was also observed by Ussiri and Lal (2013), thereby providing the elevation of the WFPS. During this study there was good distribution of rainfall in the rainy season (October to April) with daily rainfall records higher than 40 mm. N_2O emissions can be positively correlated with the availability of inorganic N as observed in his study (Table 1). The N-NO_3^- content showed higher correlation with N_2O emissions than the N-NH_4^+ levels. Nitrification is the NH3 oxidation process for NH_4^+ or NO_3^- to under aerobic conditions, whereas denitrification is the process in which NO_3^- is reduced again to N_2O and/or N_2 under anaerobic conditions (Signor and Cerri 2013). The Cerrado soils are very aerated, providing conditions for nitrification, so that the processing reactions of NH_4^+ to NO_3^- occur more frequently. When the rainfall amounts elevate the soil WFPS above 60%, the denitrification becomes more intense, consuming NO_3^- in the soil and promoting more intense emission of N_2O (Cameron et al. 2013).

MBC and BR were significantly correlated with the emissions of N_2O, whereas CBM showed a positive correlation and the BR, a negative correlation (Table 2). BR is a biological process resulting in the release of CO_2 by microorganisms and parts of plants in soil, becoming more intense in conditions of increased O_2 concentration in the soil (Moreira and Siqueira 2006). In this study, the largest BR values occurred in the dry season, a time when the lower humidity values were observed in the soil. Under these conditions, soil macropores are mostly filled with air, thus facilitating the diffusion of O_2, and the micropores are partially filled with water, promoting the diffusion of soluble substrates. On the other hand, N_2O emissions are mainly stimulated by increasing the availability of water in the soil, since the main process for the production of N_2O in the surface denitrification (Baggs and Phillipot 2010), justifying the negative relationship obtained between BR and N_2O emissions.

The significant correlation between MBC and N_2O can be associated with the relationship between the microbial biomass and the quantity and quality of the biomass produced, the reflected vegetable waste decomposition process in the integrated systems evaluated.

Table 1. Pearson correlation coefficients representing the relationship between N_2O emissions and soil and climate variables.

Variables	Total	Dry Season	Rainy season w/N	Rainy Season wo/N
NO_3^- 0-5 cm	0,203***	0,074**	0,159***	0,086***
NO_3^- 5-10 cm	0,226***	0,050*	0,217***	0,052*
NH_4^+ 0-5 cm	0,144***	0,109***	0,056*	0,069***
NH_4^+ 5-10 cm	0,058***	0,124***	-0,029^{ns}	0,015^{ns}
WFPS 0-5 cm	0,336***	0,266***	0,412***	0,212***
WFPS 5-10 cm	0,277***	0,237***	0,313***	0,145***
Rainfall Precipitation	0,073***	0,184***	0,070**	-0,003^{ns}

^{ns}Not significant. ***, ** and * Significant at 1, 5 and 10% probability, respectively.

Table 2. Linear correlation between N2O emissions and microbiological attributes in Cerrado soil in ICL, ICLF, native Cerrado and low productivity grassland.

	MBC	MBN	BR	TOC	TN
N_2O	0,453*	0,249	-0,474*	0,006	-0,218

* Significant at 5% probability.

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Ratio of nitrous oxide (N_2O) emission from soil to forage productivity in the Amazon of Mato Grosso

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Introduction

Fertilizers used as sources of nitrogen (N) are essential to increase the forage production (Costa et al., 2009), however, they lead to a higher N_2O emission from soil (Gagnon et al., 2011). Nowadays, researches are establishing relationships between grass production and gas emission to figure out the better application N rates that harmonize productivity and less environmental impacts, i.e., more efficiency of N uptake by plants (Bell et al., 2016). Thus, the goal of this work was to establish the ratio between the amounts N_2O emitted from soil to forage production in the Amazon of Mato Grosso.

Material and Methods

The study was carried out at Embrapa Agrosilvopastoral in Sinop / MT. The experimental period was 28 days, a cycle of grass growth to forage production. The experimental design was a randomized block with three replicates and five treatments. The grass Brachiaria brizantha cv. Marandu was subjected to different N rates: control (without application), ammonium sulfate 40 kg N ha^{-1}, ammonium sulfate 80 kg N ha^{-1}, urea 40 N kg ha^{-1}, urea 80 kg N ha^{-1}. The gas were sampling between 8 and 11 am daily during 15 days, and each 5 days until 28 days. Samples were collected in four times in an hour period (0, 20, 40, and 60 min) between 8 and 11 am in static chambers, where four 20 mL aliquots were collected. The determination of the N2O concentration in the samples was performed in a Gas Chromatography. The amount of N_2O emitted (g ha^{-1}) was divided by the forage productivity (Mg dry matter ha^{-1}), creating a relationship, which was plotted in a graph in function of the N rates of ammonium sulfate and urea. To compare treatments was used standard error of the mean.

Results and Conclusions

The ratio between the amounts of N-N_2O emitted (g ha^{-1}) and forage accumulation (Mg of dry matter ha^{-1}) during 28 days showed the better strategy to increase the forage productivity linked to N_2O emission from soil (Figure 1). This ratio was similar independent of the N rate of ammonium sulfate. However, if compared to the treatment that no received N (control), applying 80 kg N ha^{-1} using urea as source led to a higher N_2O emission per Mg of dry matter of forage, but it is similar to that treatment which received 40 kg N ha^{-1}. Comparing both N sources at a rate of 80 kg N ha^{-1}, we observed lower N_2O emission per Mg of dry matter with application of ammonium sulfate (Figure 1). These initial results to the Amazon of Mato Grosso indicate that applying ammonium sulfate at different rates does not increase N_2O emission per Mg of dry matter of forage, so, the use of this fertilizer may increase forage productivity without emitting more N_2O per unit of product in relation to pasture that does not receive fertilization.

On the other hand, it is not true when is used urea at a rate of 80 kg N ha^{-1}, because there is more N emission per forage production when compared to the control (no N supply). Urea at a rate of 40 or 80 kg N ha^{-1} are similar in the ratio, suggesting that the choice of a higher N rate does not increase the emission of this gas from soil to atmosphere per Mg of grass produced. If the application of N fertilizers to the grass Marandu is required at a rate of 80 kg N ha^{-1}, the better choice in terms of decreasing N_2O emission should be ammonium sulfate, which emits less than urea per Mg of dry matter of forage. Nevertheless, studies in this biome must advance to achieve a more representative relationship between N_2O emissions and forage production of Marandu when applying N fertilizers.

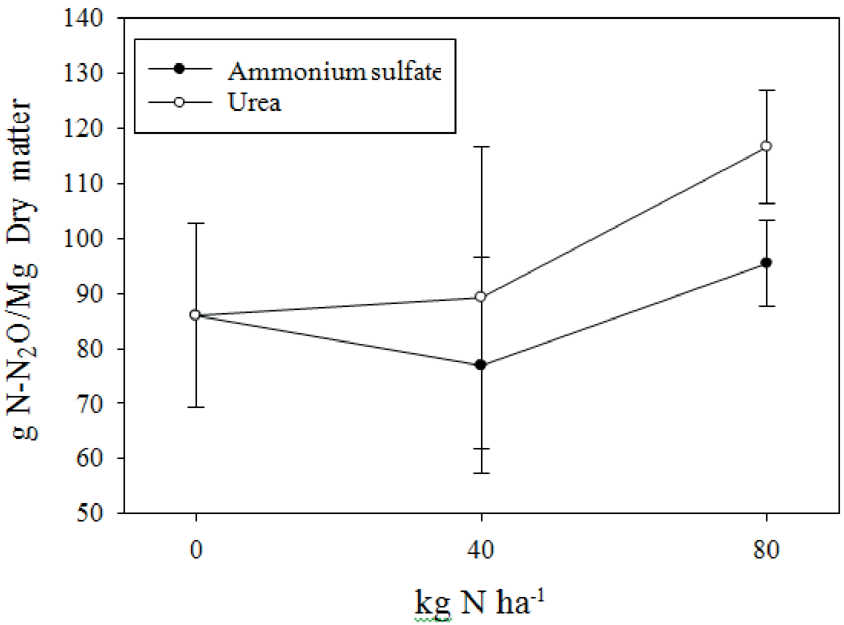

Figure 1. N-N_2O emission (g ha^{-1}) per Mg of dry matter of Marandu accumulated during 28 days after ammonium sulfate and urea fertilization at a rate of 0, 40, and 80 kg N ha^{-1}.

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Nitrous oxide (N_2O) emissions from soil cultivated with grass Marandu and subjected to rates and sources of N fertilizers in Amazon of Mato Grosso

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Introduction

Nitrogen is the nutrient required for the fodder production, and main sources are urea and ammonium sulfate, with 45% and 24% of N, respectively. The application of nitrogen may greatly increase the production of forage since improves the availability of exchangeable N in soil. The minimum and maximum rate usually applied are 40 and 80 kg ha^{-1} of N (SOUZA et al., 2004).If on the one hand it promotes the growth of plants, on the other the nitrogen fertilization increases N_2O emissions from soils. Hence, the increase in emissions because of this agricultural practice must be understood as it contributes to the increase in greenhouse gas concentrations in the atmosphere, which are related to climate changes (RODRIGUES, 2006).

Among the gases considered significant to global warming, the N_2O is importance to agricultural systems because most global emissions of this gas are from processes occurring in the soil triggered by the N fertilization (Mosier et al., 2004). N_2O has a global warming potential 310 times higher than CO_2 (GWP - Global Warming Potential) (IPCC, 1997).

The aim of this work was to measure the N_2O emissions and to calculate the emission factors of two sources and two rates of N fertilizers in pasture of *B. brizantha* cv. Marandu in the Amazon of Mato Grosso.

Material and Methods

The study was carried out at Embrapa Agrosilvopastoral in Sinop / MT. The soil of the experimental area is classified as Oxisol, with 46% of clay and flat relief. The experimental period was 28 days, a cycle of grass growth, starting on January 13 and end on February 10, 2016. The experimental design was a randomized block with three replications and five treatments. The grass *Brachiaria brizantha* cv. Marandu was subjected to different N rates (N): (1) control (without application), (2) Ammonium sulfate 40 kg ha^{-1} of N, (3) Ammonium sulfate 80 kg ha^{-1} of N, (4) Urea 40 kg ha^{-1} of N, (5) Urea 80 kg ha^{-1} of N.

The gas samples were taken daily in the first two weeks, starting two days before the application of the treatments. After two weeks of daily collections of gas samples, the sampling was made every 5 days to complete the 28-day cycle. The gases were sampling between 8 and 11 am in static chambers, top-base model, where four 20 mL aliquots were collected in one hour intervals (0, 20, 40, and 60 min). The determination of the N2O concentration in the samples was performed on a Gas Chromatography.

The N_2O emissions were presented in graph as a function of time (days). For each day the data were compared by the standard error of the mean, and this calculation was also used to compare the daily average emissions. The emission factor for the period of 28 days was calculated using the cumulative emissions of such treatment, minus the accumulated emissions of the control treatment divided by the amount of N applied, multiplied by 100, to get value in percentage (%).

Results and Conclusions

N_2O emissions were lower than 20 μg N m^{-2} h^{-1} before the application of treatments. After applying the fertilizer, the higher emission of N_2O was observed in the treatment with urea at a rate of 80 kg ha^{-1} of N, increasing the emissions till the sixth day (Figure 1). Despite the highest absolute values of emissions, the application of urea at a rate of 80 kg ha^{-1} of N resulted in N_2O emissions similar to ammonium sulfate in the same rate, with the exception only of the day January 18 and 22, in which the urea supply resulted in higher emissions.

In general, although with higher absolute values emissions than the control, treatments with rates of 40 kg ha^{-1} of N showed emissions similar to the control over the study period, with few exceptions. From the day 27/01, as observed at the beginning of the assessments, emissions were similar for all treatments.

Throughout the experimental period, the daily average flux of N_2O of the treatments with nitrogen supply was higher compared to the control (Table 1), ranging from 18.98 to 29.91 μg N m^{-2} h^{-1} for ammonium sulfate supply, and 18.88 to 45.13 μg N m^{-2} h^{-1} for urea supply. In treatment without N application the daily average flux was lower than the other treatments:

11.18 μg N m^{-2} h^{-1} (Table 1). Taking into account the standard error of the mean it was observed that the increasing order of higher average daily emission follows the sequence: control; 40 kg ha^{-1} of N via urea and ammonium sulfate (similar); 80 kg ha^{-1} of N via ammonium sulfate; and 80 kg ha-1 of N via urea.

In 28 days, the highest emission factor (0.19%) was observed with the application of urea at the rate of 80 kg ha-1 N, followed by ammonium sulfate at a rate of 80 kg ha-1 N, urea at a rate of 40 kg ha-1 of N, and ammonium sulfate at a rate of 40 kg ha-1 with values of 0.11%, 0.09% and 0.04%, respectively. These values are below the default emission factor used by the IPCC (1997) for inventory calculations. Thus, for the conditions of the Amazon of Mato Grosso recommends the revision of this factor.

Therefore, regardless of source, treatments in which the N rates were lower proved more environmentally suitable in relation to the daily emissions of N_2O. The daily average emissions were higher at higher N rates, mainly when using urea as a source. However, future works should advance to correlate the emissions of N_2O with forage yield in treatments with N rates and fertilizers in order to identify the best ratio productivity/emission.

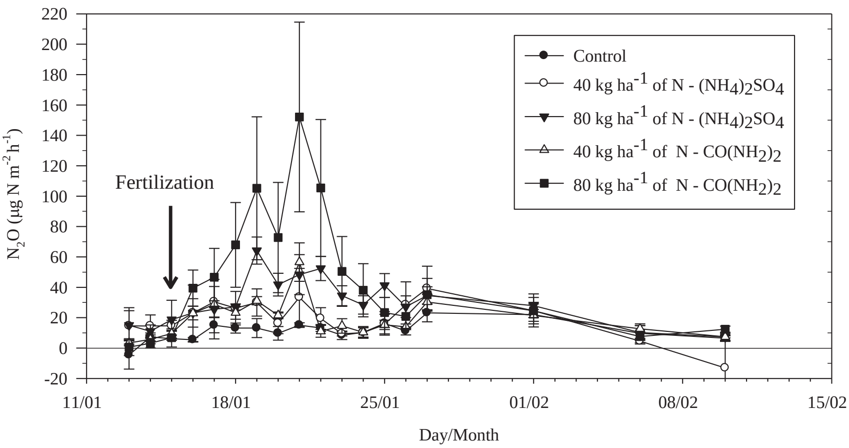

Figure 1. N2O emissions from two rates and two sources of N fertilizer on grass Marandu. Vertical bars represent the standard error of the mean.

Table 1 – Average N2O emissions and emission factors of two rates and two sources of N fertilizer on grass Marandu

Treatment	Average emission N_2O (µg N m^{-2} h^{-1})	Emission factor %
Control	11,18 ±1,5	-
40 kg ha^{-1} de N - $(NH_4)_2SO_4$	18,98 ±2,9	0,04
80 kg ha^{-1} de N - $(NH_4)_2SO_4$	29,91 ±3,6	0,11
40 kg ha^{-1} de N - $CO(NH_2)_2$	18,88 ±3,0	0,09
80 kg ha^{-1} de N - $CO(NH_2)_2$	45,13 ±9,8	0,19

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CO_2 flux of soil-atmosphere system in different land uses in the Atlantic Forest

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Introduction

On the 5th IPCC report stated that 95% of the increase in global average temperature being influenced by human actions. The paper also reports that the concentration of carbon dioxide (CO2) in the atmosphere is currently around 400 ppm, the highest concentration in the last 800.000 years (IPCC, 2014). The main anthropogenic contribution is associated with the burning of fossil fuels, industrial activities, deforestation and changes in land use, which in turn generate the gases causing the greenhouse effect, such as carbon dioxide (CO_2), which is concentrating the atmosphere. The change in land use is the second largest emitter of greenhouse gases, evidenced in tropical areas due to deforestation and burning (PAIVA; FARIA, 2007).

Brazil is the country with the largest area of tropical forest in the world, and the Atlantic Forest biome occupied $1,3x10^8$ ha the country (RODRIGUES; MELLO, 2012). The Atlantic Forest is one of the biomes of Brazil that suffers most from the degradation, and the expansion of agriculture and livestock, added to industrial expansion and urbanization, the main decomposers. With these changes in land use, physical, chemical and biological properties are altered, causing negative impacts on biogeochemical cycles. In Brazil, the land use change accounts for 77% of CO_2 emissions and the burning of fossil fuels only 18% (MIGUEZ; OLIVEIRA, 2010).

Few studies have been done in Brazil related to fluxes soil-atmosphere CO_2 in the Atlantic Forest (RODRIGUES; MELLO, 2012). This work aims to evaluate the differences of CO_2 flux of soil atmosphere system in different land uses in the Atlantic Forest.

Material and Methods

The study was conducted in experimental watershed Concordia river, located in Lontras in Itajai Valley region in the state of Santa Catarina, Brazil. The watershed covers an area of 30.93 km^2. The Concordia river is a tributary of the Lontras river which in turn is a tributary of the Itajaí river, main river watershed of the Itajaí-Açu. According to Thornthwaite classification, the region's climate is humid Mesothermal type B3 B'3 ra ', no dry season defined and annual rainfall between 1800 and 2200 mm. The soils found in the basin are Cambisols (66.2%), Argissols (32.9%) and Gleysols (0.9%). The native forest (Ombrofilus Dense Forest) is predominant (45.11%), followed by pasture (17.54%), reforestation (16.77), agriculture (15.65%) and others (4.93%). Field campaigns carried out between the months of January to December 2015. The land uses were surveyed: pasture, agriculture, eucalyptus reforestation and native forest. The study was carried out on pasture on a natural field with perennial pastures (Paspalum notatum) with constant presence of animals. Agriculture area is occupied by the bean (Phaseolus vulgaris) in the summer and Oats Black cultivation (Avena strigosa) in winter as ground cover. For reforestation, an area with eucalyptus cultivation was adopted (Eucalyptus grandis) with seven years old, planted with spacing 4 x 3 m. The native forest is the physiognomy of the Ombrofilus Dense Forest in medium to advanced regeneration stage. The method used for collecting samples of CO_2 gas soil-atmosphere system flux was as Piva et al. (2014). The static chamber was comprised of two main parts: a base which is permanently fixed on the ground, and a chamber. The base is made of metal (10 x 39 x 49 cm) with a channel (5 x 5 cm). The chamber was built with transparent acrylic material (25 x 40 x 50 cm) and covered with 1 cm Izopor plates. Internally it was asked a fan to promote the homogenization of the gases.

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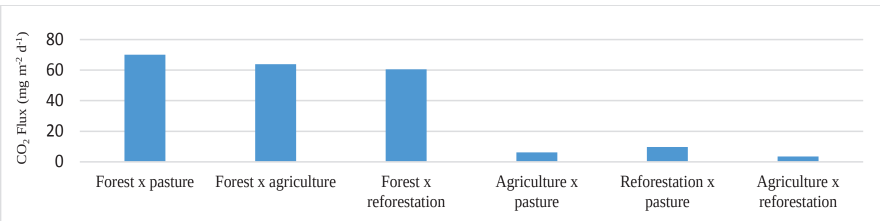
In the chamber they were coupled spit thermometer and a silicone tube with three-way valve to collect the gases. The gas samples were collected in the period from 9 to 13 hours with the aid of syringes with Luer Lock nozzle, and the gas transferred to a vial of 40 mL identified. Vacuum was carried into the vial using a manual vacuum pump and applied -800 mBar. The data was collected at 0, 15, 30, 45 and 60 minutes in order to check the linearity of concentrations. For each gas collection was noted the internal temperature of the static chamber and the temperature of the soil to 5 cm in depth. To quantify CO_2 was Schimadzu using a gas chromatograph GC-17A Model equipped with flame ionization detector (FID) and Thermal Conductivity (TCD). The column used was 60/80 Carboxen 1000, with 5 m long and 2 mm stainless steel tube diameter. The injector temperature was 100°C, with injection in Splitless mode and injected volume of 250 uL using a syringe type Gastight®. The temperature of the TCD was 200°C with 40 mA. The FID temperature is 250°C. The carrier gas used was argon with preset pressure of 220 kPa (6 min) min^{-1} kPa @ 230 kPa (19 min). The furnace temperature was 40 °C (6 min), 20°C min^{-1} 220°C (20 min). The temperature was 375ºC methanator with H_2 flow 50 ml min^{-1} and synthetic Air 300 ml min^{-1}. Calibration curves were made at 5 points, respectively at concentrations of 50, 100, 150, 200, and 250 uL.

As the gas was collected in 5 different time and temperature range between time 0 and 60 minutes was high, the concentration was corrected to NCTP using the equation C = Ca (P/1013)*(298/273 + T), where: C =concentration of fixed gas (ppm); Ca =concentration of the measured gas (ppm); P =the static pressure inside chamber (hPa); T =temperature inside the static camera (K). For quantification of the flow of CO_2 gas soil-atmosphere system was using equation (adapted from JACINTHE, 2015) Fgas =(dC/dt)*(V/A), where: Fgás =gas flow (mg CO_2 m^{-2} h^{-1}); dC/ dt = change of the gas concentration (ppm), between t0 and t1 (day); V =chamber volume (m³); A =area of the chamber (m²).

Results and Conclusions

Assessing the CO_2 flux of soil-atmosphere system in relation to land use, we realized that the biggest difference between the average CO_2 flux of soil-atmosphere system for the year 2015 is between the Native forest and Pasture, witch 70.19 mg CO_2 m^{-2} h^{-1}. The difference between the Native forest and Agriculture and Native forest and Reforestation was 63.99 and 60.50 mg CO_2 m^{-2} h^{-1}, respectively. Thus, when we look at Figure 1, we see that the Native forest was responsible for the largest emissions of CO_2 and the lower pasture. This may be related to the higher amount of organic matter in soil, mainly due to litter formed by the plant material remains and animal (CARNEIRO et al., 2014). Another factor that may be related is the higher moisture content in the first layers of the soil, also favoring microbial action (JACINTHE, 2015). As for the Pasture, a factor that may be related to lower CO_2 stream are the physical characteristics of the soil and can infer the greater compression due to grazing animals, making the gas diffusion, as mentioned Jacinthe (2015) and a smaller contribution organic matter in the soil.

Figure 1 - CO_2 fluxes differences soil-atmosphere system between land uses. CO_2 fluxes difference between land uses



Minor differences between the CO_2 flow was between Agriculture and Pasture (6.20 mg CO_2 m^{-2} h^{-1}), Native forest and Pasture (9.69 mg CO_2 m^{-2} h^{-1}) and Agriculture and Native forest (3.49 mg CO_2 m^{-2} h^{-1}). The Agriculture and Native forest have greater dispersion in CO_2 fluxes of soil-atmosphere system. This is possibly because they have a use of less conservative ground, with greater demand for water due crops, resulting in greater sensitivity to factors such as temperature, humidity and precipitation.

With this assessment, we concluded that there is a spatial difference in CO_2 flux of soil- atmosphere system. Should be object of further studies to verify the sensitivity of the CO_2 flow with hydroclimate variables such as air temperature, soil moisture, among others.

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Acknowledgements

To CAPES and laboratory chromatography - FURB.

Beef Cattle CO2-e Emission Intensity as a Product of Performance Ratios

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Introduction

Embrapa's PECUS project[1] aims to estimate greenhouse gas emissions (GGE) and recommend technological solutions for reducing CO2--e emission intensity from beef cattle production systems. PECUS project identified 23 typical production systems that represent most of the Brazilian beef cattle production and defined mathematical models for their technical and economic performance and CO2-e emission intensity. Choosing the right performance indexes can help to compare different production systems and identify opportunities for improvement. This work describes a way of splitting emission intensity from enteric fermentation and manure decomposition of a beef cattle production system as a product of performance ratios inspired by DuPont identity used for financial performance analysis (MATT, 2016). Selected production systems identified by the PECUS project were compared through these performance ratios in order to evaluate if they can help on identifying opportunities for the reduction of CO2-e emission intensity.

[1] https://www.embrapa.br/busca-de-projetos/-/projeto/38213/projeto-da-rede-pecus

Material and Methods

We propose an identity for CO2-e emission intensity from enteric fermentation and manure decomposition in CO2-e per Kg of carcass as the product of 4 performance ratios:

emission intensity, carcass production	(kg CO2-e / kg of carcass) =
emission intensity, dry mass consumption	(kg CO2-e / kg dry mass consumed) *
dry mass consumption	(kg dry mass consumed / kg cattle live weight) *
cattle turnover	(kg cattle live weight / kg live weight for slaughter) *
carcass yield	(kg live weight for slaughter / kg of carcass)

As in PECUS project, all values were calculated for one year of production, with all production systems assumed to be in a one year cycle (all variables repeat their values after 365 days). From the 23 typical beef cattle production systems defined by the PECUS project, 10 complete cycle production systems with negligible acquisition of animals were selected, so the performance ratios proposed can be used to compare similar systems. The performance ratios were calculated using mathematical models embedded in the "Modelo Emissoes" spreadsheet developed by the PECUS project, and normalized by dividing them by the minimum value found on the 10 systems evaluated. The normalized emission intensity is the product of the normalized performance ratios. The proposed equation is an "identity" because the numerators and denominators on the right side of the equation may cancel each other and become the expression on the left side. The last three performance ratios can be seen as a way of converting emission intensity per carcass produced to emission intensity per dry matter consumed, using three efficiencies in cattle production, respectively: 1) using less dry matter for maintenance and producingan excess on live weight; 2) generating an excess of live weight for slaughter; 3) generating live weight for slaughter with a high percentage of carcass. Although "cattle turnover" and "carcass yield" would be better represented by the inverse of the performance ratios above, these 2 ratios were kept for simplicity (higher values imply proportional higher emission intensities).

Results and Conclusions

Figure 1 shows the normalized CO2-e emission intensity (blue line, Y-axis on the right) and performance ratios (columns, Y-axis on the left) for each system per biome, from more traditional and extensive production systems to improved and intensive systems.

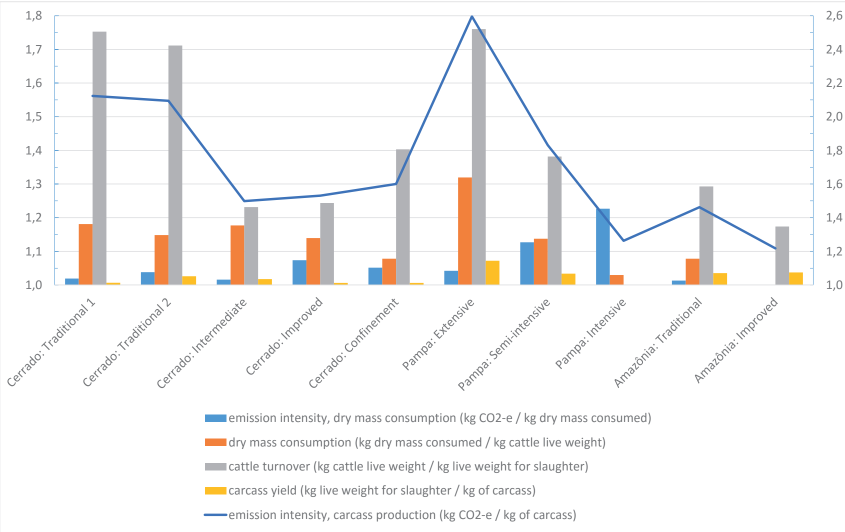

Figure 1: Normalized CO2-e emission intensity (blue line, Y-axis on the right) and performance ratios (columns, Y-axis on the left) for 10 Brazilian typical beef cattle complete cycle production systems.

Values in Figure 1 indicate that traditional and extensive systems have higher CO2-e emission intensities and that "cattle turnover" contributes more for the variation of emission intensity between systems, followed by "dry matter consumption", in a distant second place. Little change of CO2-e emission intensity is explained by "emission from dry matter consumption". The high values for this ratio for the "Pampa" biome production systems come from higher protein content estimated for the grass and the use of concentrate feed on that biome that leads to more N_2O emission from manure decomposition. "Carcass yield" almost does not change between systems, and its normalized value barely influences the emission intensity of any production system. As the normalized "emission intensity from dry matter consumption" and "carcass yield" ratios vary less between systems, there are probably less opportunities for reduction of emission intensities by improving (i.e., lowering) these performance ratios than what can be achieved by improving "cattle turnover" and "dry matter consumption" efficiencies, *ceteris paribus*. "Cattle turnover" can be improved through higher birth rates, lower death rates, shorter production cycles (early steer), less bulls per cow (or artificial insemination). "Dry matter consumption" requirement per live weight maybe decreased by animal selection and improvement. *Caveat*: the identity of the CO_2-e emission intensity to a product of these four performance ratios does not imply that these ratios are orthogonal or independent from each other: a strategy for improving one performance ratio will probably have to consider the worsening of another. For instance, changing the forage may improve cattle turnover but increase emission intensity per kg of dry matter consumed. The proposed performance ratios are easy to understand and to compare between systems. Three of them evaluate technical efficiency and are reasonable proxies for economic performance. The Kaya identity used for global or regional GGE estimation by the IPCC (NAKICENOVIC & SWART, 2000; KAYA & YOKOBURI, 1997). Bennetzen (2016) also presents an extension of Kaya identity for agricultural systems. These two identities have a much broader scope (regional and global GGE estimation) and are not so suitable for benchmarking production systems as the identity here proposed. The identity proposed was applied only to complete cycle production systems. For production systems that buy or supply calves, the live weight for slaughter must be replaced by the yearly net gain of live weight. Besides enteric fermentation and manure decomposition, other emissions can be included in the "emission intensity per dry matter consumption" performance ratio, by extending its scope to emissions from dry matter (forage) production (liming, fertilizing, ensilage, agricultural operations, energy, infrastructure, equipment, land use change) and transportation (fossil fuel and vehicles). In a Life Cycle Assessment approach (ISO, 2006), the inclusion of these "upstream" emissions would increase the influence of the dry matter source on the CO_2-e emission intensity. These extensions to the scope of the proposed identity must be evaluated.

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Nitrous oxide emission in pasture under rotational and continuous managements

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Introduction

One of the most important anthropogenic methane and nitrous oxide sources in Brazil are the agricultural activities. In 2010 it was estimated that the emissions of methane (CH_4) and nitrous oxide (N_2O) were 13,133 and 521 Gg, respectively (BRAZIL, 2013). Pasturelands contribute with N_2O emissions, which vary with the adopted management and other variables.

The types of management used in pastures may be distinct, with the extensive cultivation, in which there is no reseed or fertilization, and the intensive cultivation, with periodic fertilization and reseeding (HANSEN et al., 2014). The grazing method is an important mechanism in the production system, being potentially effective in providing answers to improve the productivity and sustainability of cattle production systems in pastures.

Southeastern Brazil is a region with expressive production beef cattle. Grazing methods used in the country are commonly classified as continuous or rotational pasture. In the first one, animals have uninterrupted access to the pasture area, during all the period grazing is allowed (ALLEN et al., 2011). Rotative pasture utilize grazing and rest periods between the paddocks. In this experiment, Nelore cattle grazed rotative pasture during 7 days, after which period the area rested 28 days, totalizing a cycle of 35 days at the paddock.

Mensuration of nitrogenous gas losses in tropical savanna are still scarce in literature, especially about nitrous oxide emission factors in soils with the addition of nitrogen fertilizer (SMITH, BOUWMAN, BRAATZ, 1999). This study aimed to quantify nitrous oxide emissions in pastures under two grazing methods, not fertilized and fertilized rotational, in Southeastern Brazil.

Material and Methods

This work was carried out between January 24 and March 19, 2014, corresponding to 56.7% of the rainy season in the summer, in a pasture of the experimental station of the *Faculdade de Zootecnia e Engenharia de Alimentos, São Paulo University*, located at 21°57´S-47° 28´W, 661 m altitude, in the municipality of Pirassununga, State of São Paulo, Brazil. The climate is subtropical, according to Koppen--Geiger's classification, with annual precipitation of 1,300

mm and mean temperature of 23°C, with a wet season distributed throughout the summer and a dry season in winter. However, in 2014, the precipitation in the period between January 24 to December was 19.7% below the mean, with 1,043 mm. The soil in area is classified as red Ferralsol (FAO classification), with 31% clay in the top 20 cm.

The determination of N_2O emissions from *Brachiara brizantha* was made in two grazing methods: under rotational pasture (RP) and continuous pasture (CP). In RP, an area of 0.315 ha was used, where cattle of Nelore occupied for 7 days, and after this, the pasture rested for 28 days, completing a 35 days cycle of pasture in the plot, thus, the period of this experiment was of approximately two cycles in summer. In the first cycle, nine male animals, with average weight of 279.06 kg, and seven animals in the second, with average weight of 304,29 kg. An application of nitrogen fertilizer was made on February 3, with ammonium nitrate. The quantity used was of 18.9 kg, corresponding to 60 kg of N in 1 hectare, being one part of the area isolated by canvas, not receiving the addition of fertilizer. At the continuous grazing method, animals stayed in the paddock during the whole period. Three animals with mean weight of 274.4 kg were used in the beginning and 316.0 kg in the end of the second cycle.

Gas sampling for soil N_2O flux determination occurred in alternated days, using PVC chambers installed in the experimental plots, according to the chamber technique described by Davidson & Schimel (1995). The chambers are composed for a PVC base of 30 cm diameter and 20 cm height, a 10 cm deep lid containing a septum for the collection of gas and a leak. The bases were inserted in the soil to a depth of 3 cm.

Twenty chambers were used to 15 sampling events, being eight of them to the fertilized treatment and four to not fertilized of rotational manure, and eight to the management of continuous pasture. Sampling were collected with 60 mL BD plastic syringe, and transferred to evacuated 12 to 20 mL LABCO vials. Embrapa Environment's Biogeochemistry and Trace Gases Laboratory, Jaguariúna, SP, analyzed the sampling using a Shimadzu GC-2014 gas chromatograph, equipped with an electron capture detector (ECD) and a flame ionization detector (FID). Soil N_2O flux was calculated according to Jantalia el at. (2008).

Results and Conclusions

The accumulated precipitation in the studied period was 141.8 mm, of the total 299.4 mm registered in the summer season, 66% below the summer of the year before, when 905 mm were registered. The mean temperature was 25.2°C, according to USP (2016). Figure 1 presents precipitation and temperature data to the summer season.

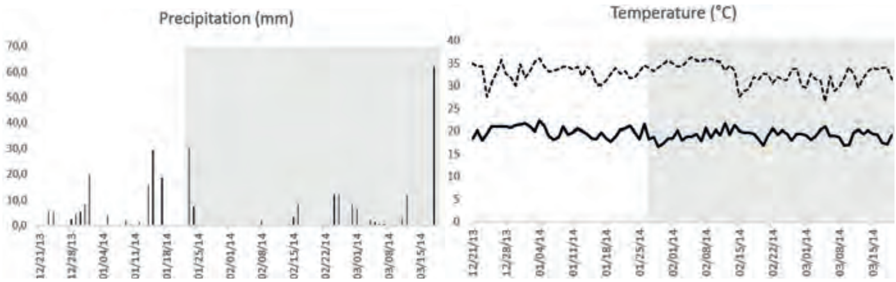

Figure 1. Precipitation, maximum and minimum temperature for the summer in Pirassununga, SP. In gray, the period of the experiment.

In the fertilized pasture, the minimum N_2O emission occurred on February 3, with a rate of 0.007 mg N-N_2O $m^{-2.day}$, after one week without raining, and the maximum, on February 25, with 5.295 mg N-N_2O $m^{-2.day}$, and occurrence of two consecutive days of rain, totalizing 24.4 mm. Not fertilized pasture had the minimum emission of 0.007 mg N-N_2O $m^{-2.day}$, also on February 4, and maximum on March 12, with 0.804 mg N-N_2O $m^{-2.day}$, with 14.4 mm of accumulated rain to the day before and the day of sampling. In the continuous grassland, minimum emission occurred on February 11, with 0.007 mg N-N_2O $m^{-2.day}$, after 14 days without raining, and maximum, on February 25, as observed at the fertilized field, with 4.348 mg N-N_2O $m^{-2.day}$.

Emission pulses of N_2O in the summer season were driven by the raining events, as observed by others authors (XU et al., 2002; SIGNOR et al., 2013; LIU et al., 2014; ROWLINGS et al., 2015). The cumulated emissions for the fertilized pasture were 33.328 mg N-N_2O $m^{-2.day}$, while at not fertilized pasture were 5.863 mg N-N_2O $m^{-2.day}$ and at the continuous management pasture were 19.153 mg N-N_2O $m^{-2.day}$.

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Gaseous fluxes in Oxisol soil surfaces at integrated plant-livestock systems

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Introduction

Greenhouse gas emissions from agriculture, forestry and other land use together are responsible for 10-12 $GtCO_2$-eq/year, which correspond to 24% of anthropogenic global emissions by sector (IPCC, 2014). In agriculture, the most cost-effective mitigation options are cropland management, grazing land management, and restoration of organic soils. This work contributes with information concerning soil gaseous emissions from a managed farm system in the Campanário Settlement at São Gabriel do Oeste (MS). The food production system comprises the integration of swine-forestry-soya/corn (cattle was expected but not effectively implemented) regularly fertilized with standard NPK. The experiment consisted of additionally applying swine effluent of biodigester as an organic fertilizer with known doses (measured, not shown) in sites with arrangements of forestry mixed with agriculture (soya/corn rotation).

Material and Methods

The site description is available elsewhere e.g. Buller et al. (2015). In fieldwork, it was obtained a total of 1105 chamber flux measurements distributed in 36 sites between 26/Sep/2013 and 4/Jun/2014 mostly in the morning (Figures 1 and 2).

Fig 1. Chamber flux measurements at the soil-air interface in integrated livestock-plant system.

The measurements were made on site with a plexiglass closed chamber connected by tubing to a Lumasense Innova 1412 photoacoustic systems with optical filters for measuring carbon dioxide (CO_2), nitrous oxide (N_2O), ammonia (NH_3), Sulfur dioxide (SO_2), and methane (CH_4). It was possible to recalibrate CO_2, N_2O and CH_4 with a GC/SRI-FID/ECD and a Los Gatos Inc. UGGA. Unrecalibrated SO_2 and NH_3 data is presented for insightful interrelationships. Data in Figure 2 represent for each gas species (g) the site-specific medians (med_{sg}) normalized (med_{ng}) by the all sites medians (med_{ag}) and interquartile ranges (ir_{ag}) as $med_{ng} = (med_{sg} - med_{ag})/ir_{ag}$. Figure 3 shows interrelationships among median fluxes per site (n = 36 median values).

Results and Conclusions

In general, gaseous fluxes showed large variability likely due to local and temporal effects (Figure 2).

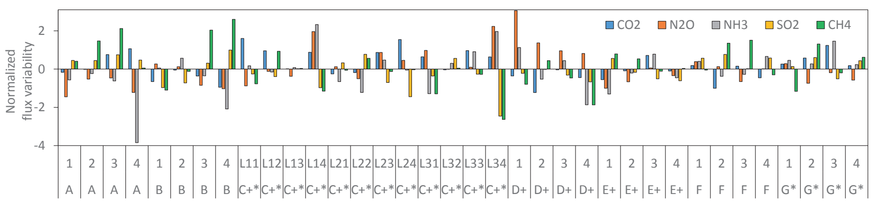

Figure 2. Variability of normalized gas fluxes. Numbers in the x-axis are site replicates, (+) denotes sites that received digested swine effluent, and (*) sites with eucalyptus planted in 2011.

CO_2 fluxes ranged from 7,760 to 10,376 mg/m^2/d, N_2O fluxes ranged from -1.33 to 7.66 mg/m^2/d, and CH_4 fluxes ranged from -0.41 to 0.15 mg/m^2/d. Figure 2 presents normalized flux variability in spatial terms. CO_2 fluxes were higher than overall median particularly in forested sites (C and G), independently of effluent application (Kruskall Wallis test $p = 0.010$, $n = 36$).

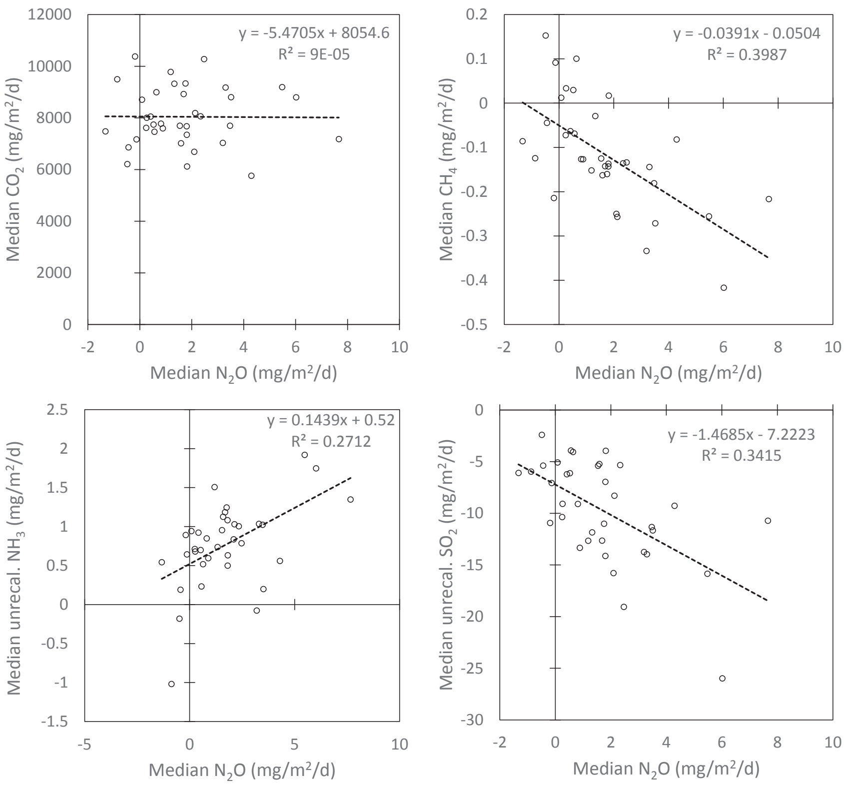

Figure 3. Interrelationships of median N_2O fluxes with median CO_2, NH_3-unrecalibrated, SO_2- unrecalibrated, and CH_4 fluxes.

Unsurprisingly, N_2O fluxes were higher than overall median particularly in sites that received swine effluent (Kruskall Wallis test $p = 0.012$, $n = 36$). NH_3, SO_2 and CH_4 fluxes were not significantly different between sites (Kruskall Wallis test $p = 0.285$, 0.104, 0.167, respectively).

In Figure 3, it is possible to state that:

CO_2 fluxes do not correlate with N_2O fluxes because CO_2 derives from soil and biomass (maize and soya plants left in the ground) respiration independently of N additions;

N_2O and NH_3 fluxes are positively correlated ($p = 0.001$, AIC = 137.732) probably due to an excess of ammonia from fertilizers (NPK and swine effluent) which leads to N_2O formation through nitrification and/or denitrification;

N_2O and SO_2 fluxes are inversely correlated ($p = 0.000$, AIC = 141.217) as SO_2 sink can stimulate NO and N_2O emissions in acidic soils in which nitrification dominates NO and N_2O production (Cai et al., 2012); and

N_2O and CH_4 fluxes are inversely correlated ($p = 0.000$, AIC = 137.629) likely associated to N-stimulation of soil methanotrophic bacteria.

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Enteric Methane Emission of Female Buffaloes Supplemented with Palm Kernel Cake in the Amazon Biome

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Introduction

The relation between environmental impacts caused by different anthropic activities, particularly in the agricultural and livestock sector, have been reported as a source of greenhouse gas emissions, which are strongly related to global climate change. Ruminants, due to enteric fermentation, are known important sources of methane (CH_4) emissions into the atmosphere. The carbohydrate digestion process by these animals generates, physiologically, CH_4 as a metabolic by-product (CUNNINGHAM; KLEIN, 2008).

Several alternatives to reduce methane emissions by ruminant digestion are studied, mainly linked to changes in diet.

The increase in the worldwide demand for palm oil and its application in biodiesel production have generated waste in agro-industries and allowed greater availability of co- products for animal feed (BRINGEL et al., 2011). Palm kernel cake's chemical composition features protein, energy, and fiber contents that may supply ruminants with part of their nutrient needs. In the Brazilian state of Pará, palm kernel cake is available throughout the year at low cost for rural producers compared to other supplements employed in diet (corn, soybean, and wheat). The introduction of cakes with high fat content into ruminant diets may aid in mitigating enteric methane emissions (ABDALLA et al., 2007).

Thus, in face of the concern about global warming and the efficiency of diets, this study aimed to assess the levels of inclusion of palm kernel cake on enteric methane production among female buffaloes in the Amazon.

Material and Methods

The trial was carried out at the animal research unit "Senador Álvaro Adolfo," belonging to Embrapa Eastern Amazon, in the city of Belém-PA, Brazil. The study area features Af_2 climate (MARTORANO et al., 1993) with mean rainfall above 60 mm in the least rainy month and annual rainfall around 2,900 mm. The study was certified by the Animal Ethics Committee - CEUA under protocol 007/2015. 24 crossbred Murrah and Mediterranean female buffaloes with initial age and weight of 34 months and 514 ± 69.88 kg, respectively, belonging to Embrapa Eastern Amazon's experimental herd were used. The female buffaloes were supplemented during September and October 2015. The experimental treatments consisted of supplementing the female buffaloes with palm kernel cake at the following inclusion levels in relation to their body weight (BW): 0% (T_1) (control), 0.25% (T_2), 0.50% (T_3) and 1.00% (T_4). The research adopted a completely randomized design with four treatments and six repetitions considering each animal as an experimental unit. The diets at every inclusion level were added with 0.15% (BW) wheat bran, which acted as a palatability agent. The chemical composition of the ingredients is presented in Table 1. Corn silage (CS) was used as roughage. The animals were managed in confinement in individual pens and underwent 21 days of adaptation to the experimental diets with free access to water and mineral mix. The diet was provided to the animals twice a day (8 AM and 5 PM). The amounts of CS offered were weighed daily and adjusted according to the animals' intake to result in daily leftovers of 10%.

Methane emission was assessed using the sulfur hexafluoride (SF_6) tracing gas technique according to the methodology described by Johnson et al. (1994). Samples were collected every 24 h for five consecutive days. The animals were removed from the pens at 7:30 AM and taken to the management corral, where the samples were collected. The collecting yokes were taken to the laboratory, where the samples were diluted with pure nitrogen gas prior to the analyses. CH_4 and SF_6 concentrations were determined in a 7890A gas chromatograph. The data were analyzed using the statistical package R Core Team (2015) and the means were compared by Tukey's test at 5% significance.

Table 1. Chemical composition of the ingredients at dietary of female buffaloes supplemented with palm kernel cake.

	Ingredients		
Nutrient composition (% dry matter basis)	Palm kernel cake	Wheat bran	Corn silage
Dry matter	90.44	85.85	29.40
Organic matter	95.82	93.51	94.92
Crude protein	14.27	16.77	7.73
Neutral detergent fiber	66.30	49.1	56.07
Acid detergent fiber	41.49	12.8	31.48
Ash	4.18	6.49	5.08
Ether extract	12.53	3.64	3.17

Results and Conclusions

The amounts ingested ($kg.day^{-1}$) of crude protein and Ether extract were higher in the treatment with maximum inclusion of palm kernel cake (T_4) compared to the control group (Table 2).

Daily enteric methane emission was lower in the treatment with palm kernel cake inclusion of 1.00% BW (27.65 $kg.year^{-1}$), showing values lower than those observed in the IPCC (2006), which estimated the emission in buffaloes at 55 $kg.year^{-1}$. The animals that were not fed palm kernel cake emitted greater amounts of CH_4 (214.12 g.day^{-1}).

Including palm kernel cake in the diet of female buffaloes at over 0.50% BW was negatively correlated (r = -0.51; P<0.01) with enteric methane production, i.e., the level of lipid offered in the experiment led to the lowest enteric methane emission.

Table 2. Dietary intake and enteric methane emission of female buffaloes supplemented with palm kernel cake.

	Treatment				
Nutrient intake (kg.day^{-1})	**T_1**	**T_2**	**T_3**	**T_4**	***P***
Dry matter	6.08	6.18	6.64	6.20	0.5892
Organic matter	5.77	5.87	6.32	5.90	0.5674
Crude protein	0.52b	0.59ab	0.68a	0.70a	0.0015
Neutral detergent fiber	3.37	3.53	3.87	3.74	0.2231
Acid detergent fiber	1.80	1.94	2.18	2.16	0.0367
Ether extract	0.19d	0.29c	0.39b	0.47a	<0.0001
Ash	0.31	0.31	0.32	0.29	0.5074
Enteric methane					
CH_4 (g/day)	214.12a	171.11ab	173.12ab	75.75b	0.0151
CH_4 (kg/year)	78.15a	63.19ab	62.45ab	27.65b	0.0151

[a, b] Different letters in the same row differ (p<0.05) by Tukey's test.

Including palm kernel cake at levels above 0.50% BW decreases enteric methane emissions in female buffaloes under the same experimental conditions.

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Quantification of Ammonia Volatilization in Pastures of Integrated and Non-Integrated Beef Cattle Production Systems

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Introduction

Nitrogen (N) is the most limiting nutrient for forages; it has a good cost/benefit ratio and, considering the necessity to increase food production without new deforestation, nitrogen fertilization has become one of the most used techniques to enhance productivity in livestock feed production (BOARETTO et al., 2007). Nonetheless, the characteristics of some N fertilizers and some application methods may cause N losses, reduced profits and environmental problems (VITTI et al., 1999).

Urea is the most used N fertilizer due to its high N content and lower cost compared to other N sources but concerns exist with potentially high losses via ammonia (NH_3) volatilization, which may reach up to 80% of the N applied (ROCHETTE et al., 2009). Some forms of urea application, like incorporation into the soil, may reduce NH_3 volatilization but in no-till farming and in normal pasture management the fertilizer is topdressed, what may result in up to 78% loss of NH_3 (LARA CABEZAS et al., 2000).

This study aimed at evaluating N losses, via NH_3 volatilization, in pastures under different managements to better understand important beef cattle production systems in Brazil and improve the efficiency of N fertilization.

Material and Methods

The study was carried out at Embrapa Pecuária Sudeste, SP (21°57’42”S, 47°50›28» W, 860 m) from 18/01/2014 to 02/09/2015. The climate is classified as Cwa (Köppen), with two well defined seasons: dry season - April to September, with average temperature and precipitation of 19.9ºC and 250 mm, respectively; rainy season - October to March, with average temperature and precipitation of 23.0ºC e 1,100 mm, respectively. The soil in the area is classified as dystrophic red yelow Latosol. Ammonia volatilization was evaluated in pastures belonging to five production systems: 1) Intensive (INT) - dryland rotational grazing system; 2) Integrated Silvopastoral System (SP) - rotational grazing with eucalyptus trees (15 x 2 m spacing); 3) Integrated Crop-livestock System (CL) - rotational grazing system with crop rotation in each paddock in four year cycles (three years with pasture and one year with corn); 4) Integrated Crop-livestock-forestry System (CLF) - the same as CL with eucalyptus trees (15 x 2 m spacing); 5) Extensive (EXT) - continuous grazing system. Soils in EXT and in an adjacent area of Atlantic Forest were used, respectively, as negative and positive controls.

Pastures in INT, SP, CL and CLF were established in 2012 with *Urochloa* (sin. *Brachiaria*) *brizantha* (Hochst ex A. Rich.) Stapf cv. Piatã and were fertilized with 50 kg of N ha^{-1} $year^{-1}$ via urea. Each of these systems had two replicate pasture areas, of 3 ha each, divided in six paddocks in a rotational system with six days of occupation and 30 days rest. The pasture in EXT was established in 2007 with *Urochloa* (sin. *Brachiaria*) *decumbens*

(Stapf) R. Webster and was not fertilized. The EXT system had two pasture areas of 2,85 ha each managed under continuous grazing.

The stocking rate was adjusted in all pastures using the "put and take" technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

Volatilization of ammonia was evaluated following the procedure by Alves et al. (2011). Collectors were composed of 8 × 8 cm foam (density of 0.02 g cm^{-3}) pads soaked with 10 ml of phosphoric acid solution (0.5 N). Each foam pad was placed over a polyvinyl chloride (PVC) plate (10 × 10 × 0.2 cm) and wrapped with one layer of polytetrafluoroethylene tape (PTFE), which is permeable to ammonia and impermeable to

water. The foam pads were placed 1 cm above the soil surface with the PVC plate on the upper side, to restrict the collection of NH_3 to that originated in the soil. Foams were changed every day during five days and, subsequently, in three days intervals until the 23rd day. Ten collections were done during the experimental period. In each collection day, the foams were put in individual plastic bags, sealed and stored in a freezer. For analysis, the foams, the PVC plates and the PTFE tapes were washed with approximately 300 ml of deionized or distilled water inside a Bückner funnel attached to a Kitassato and a vacuum pump. A 50 ml sample was than collected and analyzed by Flow Injection Analysis (FIA).

Results and Conclusions

Accumulated N-NH_3 losses (Figure 1A) were similar ($P>0.05$) in INT, SP, CL and ALF pastures (average of 11.8 kg ha^{-1}), corresponding to 23,6% of the N applied. Ammonia losses were similar in the EXT pasture and in the forest (average of 4.6 kg ha^{-1}) but much lower than in the intensively managed pastures, probably because no N was applied.

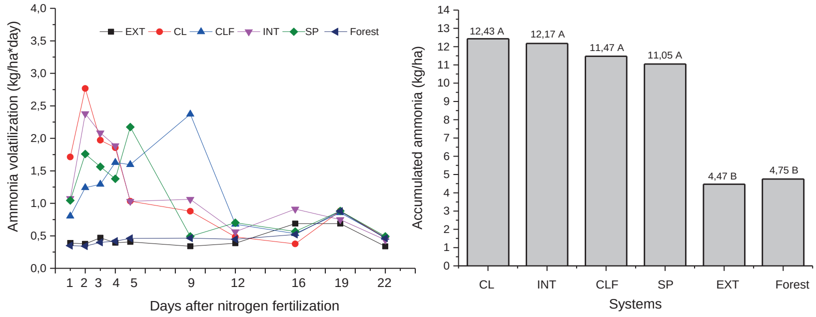

Figure 1 - (A) accumulated N-NH3 losses and (B) - flux of N-NH3 losses (Kg ha^{-1}dia^{-1}), by volatilization in the grazing systems and in the forest. A, B: Means with different letters differ by the Duncan test ($P<0.05$). INT: Intensive; SP: Silvopastoral; CL: Crop-livestock; CLF: Crop-livestock-forestry; EXT: Extensive.

Despite the similarity in accumulated NH_3 losses obtained in INT, SP, CL and CLF, the flux of NH_3 volatilization, after N fertilization, was different among these systems (Figure 1B). The maximum levels of rate volatilization occurred latter in the pastures with trees (SP and CLF) compared to those without trees (INT and CL). Similar results were obtained by Santana et al. (2011) who observed that the length of time it takes to occur 90% of urea hydrolysis is longer in soil under eucalyptus forest than in soils in pastures and in areas of no- till and conventional crop production, what may be related to the amount of organic residues present in the soil.

Conclusions

Total ammonia volatilization from the soil is similar in integrated and non-integrated beef cattle production systems and higher than in extensively managed pastures and forests. The daily rate of volatilization is affected by the presence of trees in the pastures.

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Nitrous Oxide Emission of Fertilizer Nitrogen with Biochar

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Introduction

The Brazilian agriculture, which accounts for more than a third of national GHG emissions, increased its emissions by 44% in the period of 1995-2010 (MCTI, 2013), being the agricultural soils increased their emissions in 55.6 Gg CO_2 eq. The corn crop, according to CONAB (2015), the 2014/15 agricultural year was the second summer crop in terms of higher productivity (5382.0 kg ha^{-1}) and planted area (15743.7 ha).

The N_2O, although in smaller amount in the atmosphere when compared to CO_2, has potential of retention infrared radiation 310 times higher (MCTI, 2013). In the agriculture the emissions of this gas are given by complex microbial processes associated with human management practices on ecosystems (FAO, 2014), nitrification and denitrification reactions, which are the main regulators of the release of N_2O. These processes are highly influenced by mineral or organic nitrogen fertilizer, plants fixing atmospheric N or application of animal waste.

The great current challenge is to reduce the N_2O emissions associated with nitrogen fertilization in cereals. According to the IPCC, 1% of the N applied to the soil via fertilizer ends in the atmosphere as N_2O. In view of this, there are several studies that suggest that biochar can play a positive role in reducing emissions of N_2O. The biochar, organic matter carbonized under poor atmosphere in oxygen (pyrolysis) whose purpose is agricultural use, aimed at the carbon capture in the soil and the improvement of their physical and chemical properties (Sohi, 2012), was considered by Fox & Chapman (2011) one of the nine most viable strategies to mitigate global warming.

Biochar influences N_2O emissions from soil due influence on the dynamics of nitrogen

(N) in the soil, affecting the availability of N to microbial action by the use of soil biochar (Clough et al., 2013), reducing the substrate of nitrification and denitrification reactions. The high ratio of C / N of biochar can favor N microbial immobilization (Cayuela et al., 2013th), in this sense the soil conditioning biochar residue derivative with low C / N ratio generates an increased release of N emanated from biochar (Cayuela et al., 2013b). Also, may occur a decrease in the availability of mineral N as result of an increase in the adsorption of NO_3^- and NH_4^+ (Yang et al., 2015). Another mechanism assists in mitigating N_2O emissions is the increase of reductive activity provided by functional groups of biochar, leading to greater efficiency of denitrification emitting thereby N_2 (Cayuela et al., 2015). Therefore, the aim of this study was to evaluate the potential of the application of biochar in mitigating N_2O emissions associated with nitrogen fertilizer on crops.

Material and Methods

The study was conducted at the Experimental Station of the Federal University of Parana State (UFPR) in Pinhais - PR. The climate is subtropical humid mesothermal (Cfb), according to Koppen (SIMEPAR, 2015). The soil is classified as Cambisol (Sugamosto, 2002).

The experiment was implemented in December 2015 with the corn planting (Zea mays L.) grown under no-tillage in the straw. The nitrogen fertilizer (urea - $CO(NH_2)_2$) was divided into two applications, 30 kg N ha^{-1} at planting and the rest in coverage (170 kg N ha^{-1}). Each plot was 20 m^2 (4.0 x 5.0 m), with 5 rows of planted corn.

The experimental design was randomized blocks, with five replications allocated in an experimental area with 20 plots (20 m2). The experiment consisted of four nitrogen fertilization treatments in coverage of maize (corn V6 stage) and associated with the application of biochar: A) application of nitrogen fertilizer in the open furrow in the planting spacing (NF); B) application of nitrogen fertilizer to haul (NH); C) application of nitrogen fertilizer mixed with biochar, both in the open furrow in the planting spacing (BNF) and D) application of nitrogen fertilizer mixed with biochar, both haul (BNH) .The biochar applied to the soil is from pyrolysis of wood chips eucalyptus (eucalyptus spp.).

Assessments of emissions started in December 2015, the first just before the planting of corn and the others post-planting. In order to characterize the experimental area, there was gas collection just before the planting of corn (12.08.2015) and after 3, 13 and 46 days, totaling 4 collections. After the treatments (21/01/2016) occurred five collections: 2, 4, 7, 9, 11, 14 and 18 days after that date. Samples of gas were collected applying the method of the static closed chamber taken at times 0, 20, 40 and 60 minutes after closing the chamber. Each collection began at 09:00 am. Emitted gas samples were collected from the corn planting line (L) of separately of the emitted gas from of interlineation (I), allowing the performance evaluation of the gases in function of the location of the treatments in the experimental area. The analyzes of the air samples were by gas phase chromatography by GC equipment - Trace 1310.

Results and Conclusions

The largest N_2O emissions occurred 18 days after treatments (AAT) for all treatments when evaluated in the planting spacing (Figure 1). On this date the soil with BNF showed an emission 21.6 % lower than the soil with NF. However, when the treatment was applied to haul the soil with only nitrogen (317.47 ug m^{-2} h^{-1}) had a lower flow than the soil with biochar (317.47 ug m^{-2} h^{-1}).

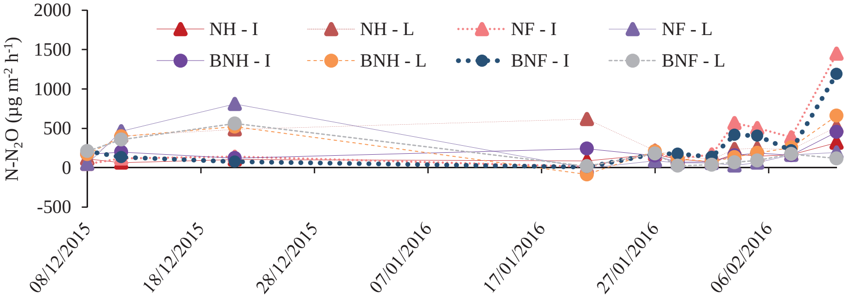

Figure 1. N2O emissions (μg N m^{-2} h^{-1}) on the line (L) and interlineation (I) of planting corn in a Cambisol under application: nitrogen fertilizer in the open furrow in the planting spacing (NF); nitrogen fertilizer to haul (NH); nitrogenous fertilizer mixed with biochar, both in the open furrow in the planting spacing (BNF) and nitrogen fertilizer mixed with biochar, both haul (BNH).

Regarding the evaluations carried out in the row, was observed a peak in emissions of N_2O 13 days after planting (AP) corn (Figure 1). Another rise in flows occurred at 18 days AAT, being the soils with NF and BNF presented a lower emission of this gas. Still, the administration of nitrogenous fertilizer haul associated with biochar resulted in an emission

27.2 % higher in relation to employment just of nitrogen in the soil.

The peak observed only in the evaluations in the planting line to 13 days AP, is due to fertilizer applied at sowing time near the line of planting corn, not influencing emissions in the planting spacing. This effect is commonly observed in post-management period, since it is characterized by an elevation of the mineral nitrogen present in the soil of the previous crop residues and nitrogen fertilization (Zanatta, 2009).

The spatial arrangement of mineral nitrogen in the experimental area was reflected in N_2O fluxes observed. Prior to treatments (topdressing), only in the planting row there was an emission peak in agreement with the absence of fertilizer in the planting spacing. After the treatments, the soil with NS and BNF, had a more significant emission between rows than in the row due to the fact that the treatments were concentrated. As for the NH and BNH treatments the difference between line and line spacing was lower.

The higher spatial proximity of biochar and nitrogen in the soil when applied in the furrow, proved beneficial in helping in mitigating N_2O emissions as a result of their association

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Nellore heifers methane emissions in native and cultivated pastures of the Pantanal at the dry season.

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Introduction

The Pantanal is a plain of alluvial sedimentation, partially and temporarily flooded. With a natural capacity for beef cattle, especially for phase creates. The Pantanal has numerous fields of native grasslands and mixed pastures, represented by a mixture of cultivated pastures in the high parts of the land (*Uroclhoa humidicola* common and Llanero) and native pastures in the low and humid parts. Differences in forage supply and diet quality lead to changes in intake and as a result in the emission of methane. Individual data of methane emission fluxes need to be related to food intake for better interpretation of the systems, and for an appropriate systemic evaluation is necessary to consider the production efficiency, considering this way all of a calf production cycle, as refers to the Pantanal creates systems. This study aimed to compare the individual emissions of heifers in native or mixed pastures of the Pantanal.

Material and Methods

Twelve heifers were divided into two treatments with six replicates, and allocated in paddocks with native or mixed pastures, of the Experimental Farm Nhumirim (Embrapa Pantanal). It was administered orally one capsule containing sulfur hexafluoride gas (SF6) of known and constant release in the rumen of each heifer, to serve as a tracer gas in the methane emissions estimates, according to the technique described by Johnson et al ., 1994. The samples for methane emission measures and intake of dry matter (DM), were carried out between August 24 and September 12, 2014, and the animals were subjected to prior adaptation of 14 days. The fecal output (FO) was estimated by indicator titanium dioxide (20g / animal / day) by a relationship between the daily amount administered and the amount found in the faeces. The degradability data were determined by the method of *in situ* digestibility (Orskov et al., 1980) after incubation for 240 hours. For intake estimates applied to the inverse relationship between the FO and the indigestible forage. Issued methane values were divided by the average intake for estimating the emission per kg feed. It performed preliminary analysis of the distribution of data in order to use the tests, parametric (Student's t test) and nonparametric (Kruskal-Wallis test) averages.

Results and Conclusions

Methane emissions when expressed per animal / day were lower ($P < 0.05$) in native pastures, while emissions per kg feed did not differ ($P > 0.05$) between treatments (Table 1). Fecal excretion of animals was greater in animals on mixed pasture ($P < 0.05$) associated to the greater digestibility of the diet led to increased intake ($P < 0.05$) (Table 2), and consequently the equal ($P > 0.05$) in emission of methane consumed per kg of forage consumed (Table 1).

Table 1. Means of methane emissions per animal/day and per kg of food consumed in mixed and native pastures of the Pantanal.

	Pastures		Difference	P
Methane emissions	Mixed	Native		
Per animal (g/day)	171,85[a]	140,57[b]	31,28	0,0391
Per kg of feed (g/kg de DM)	18,65[a]	21,01[a]	-2,36	0,2351

Means followed by different letters in the same line differ statistically.

Table 2. Means values of fecal excretion, digestibility and intake of dry matter (DM) of heifers in mixed and native pastures of the Pantanal.

	Pastures		Difference	P
	Mixed	Native		
Fecal excretion(kg deDM)	3,771[a]	3,494[b]	0,277	0,0491
Digestibility (%)	59,35	48,44	-	
Intake (kg de DM)	9,277[a]	7,229[b]	2,048	<0,0001
Intake (% Body Weight)	1,932[a]	1,403[b]	0,529	<0,0001

Means followed by different letters in the same line differ statistically.

Observed by Kruskal-Wallis one-way analysis of variance different behaviors ($P < 0.05$), the daily methane emissions between treatments (Figures 1 and 2), which may originate in a widest possible variability in the diet in native grassland probably occasioned by variations in the floristic composition of the grazing sites. This fact demonstrates the need for repeatability of tests, because beyond the climatic effects on pasturage, other factors such as grazing intensity can affect more intensely the native pastures, the result of strong natural selection process of the diet for the animals.

Figure 1. Methane emission distribution curve in mixed pastures in the Pantanal.

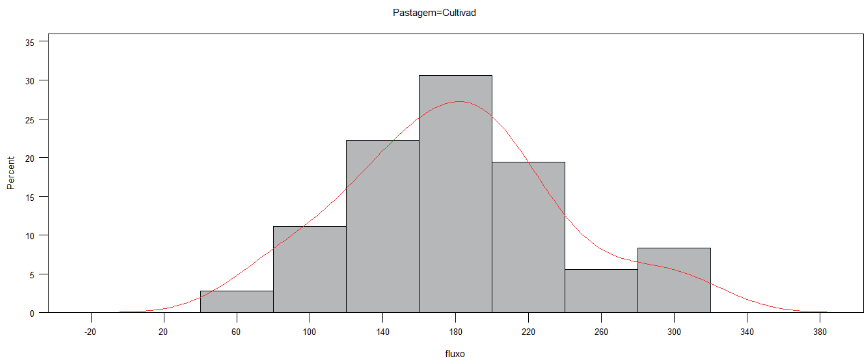
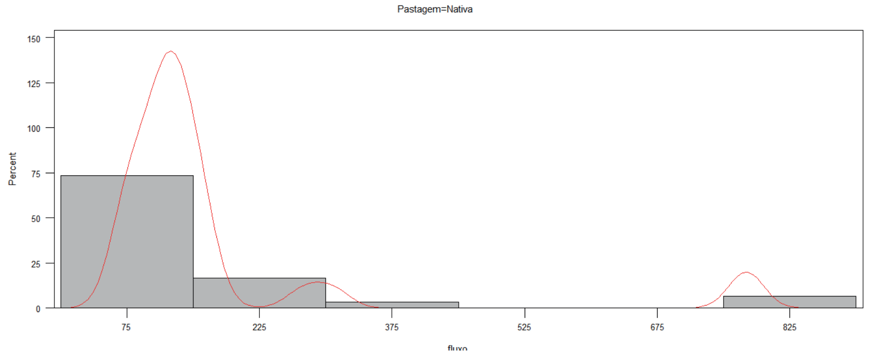


Figure 2. Methane emission distribution curve of native grasslands in the Pantanal.



The data obtained in this study showed no differences in methane emissions between native and cultivated pastures, the result of higher intake observed in the cultivated area. To better understand the systems - as regards the issue of enteric methane; the measurement data is critical in the various seasons. On the other hand, efforts should be concentrated in order to measure methane emissions per kg of calf produced in both systems, as this is the main product of cattle in the Pantanal.

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Comparison of methane emissions by cattle pastures in the Pantanal, between two seasons of the year.

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Introduction

The Pantanal has numerous grazing fields which are subject to annual climatic variations and handling procedures (stocking rate, deferral, etc.). Considering the climate, the largest changes are observed between the dry and rainy seasons of the year. This study was to evaluate the methane emissions in the Pantanal grasslands in the two main climatic periods of the year.

Material and Methods

Twelve Nellore containing rumen sulfur fluoride capsules (SF6) known flow, were used for the collections in two periods of the year (end of the dry and rains seasons) and randomly assigned to two different landscapes - one composed of native pastures and another of a mixture of cultivated and native pastures), of the Experimental Farm Nhumirim (Embrapa Pantanal). Methane emission rates were estimated from the concentration of the tracer gas SF6 according to the technique described by Johnson et al., 1994. The samples were collected from 24 August to 12 September 2014 for the collection of dry season and between March 23 and April 12, 2015, to collect the wet season. Data were subjected to analysis of variance and Student's t test.

Results and Conclusions

Methane emissions between the two seasons were different ($P < 0.01$) both in native pastures as in mixed pastures (Table 1). The changes were more important in native pastures when compared to cultivated pastures, probably caused by changes in the floristic composition and the influence of diet selection processes, more impactful for them.

Table 1. Means of methane emissions in g/animal/day in two seasons in mixed and native _ pastures of the Pantanal.

	Season		Difference		P
Methane emissions	Rainy	Dry	(g/dia)	(%)	
Native pastures	322,09[a]	140,57[b]	181,52	229,13	<0,0001
Mixed pastures	295,83[a]	171,85[b]	123,98	172,14	<0,0001

Means followed by different letters in the same line differ statistically.

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Nitrous oxide emissions from soil of natural grassland under different intensifications in Pampa biome

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Introduction

The Pampa Biome occurs in just 2.07% of Brazilian territory, but in Rio Grande do Sul state occurs in 63% (176,496 km^2) of gaucho territory. Is characterized by predomination of natural grassland with shrubs and tree vegetation in mosaic (Campos). Because of the natural grasslands, livestock production is one of the main economic activities. Despite of the potential of mitigation, the society has paid attention in this livestock production system, mainly in your environmental impact, and greenhouse gas emissions. In addition to the sporadic deferral and stocking rate adjustment, other alternative practice to make more productive this livestock system (in Campos) is fertilizer application, and hibernal forages sowing (Overbeck et al, 2007; Boldrini, 2009; Nabinger et al, 2009). The objective of this work was evaluating the nitrous oxide emissions from soil with natural grassland under different intensifications rates in two seasons (winter and summer).

Material and Methods

The work was conducted at Embrapa Pecuária Sul (Bagé/RS, Brazil), in two seasons (August- September 2014 and February-March 2015). The soil is classified as a sandy clay Luvisol (Soil Taxonomy) or Luvissolo Órtico háplico típico (Brazilian System of Soil Classification – Embrapa, 2006). The experimental area has 61 ha with 3 treatments

(3 repetitions): natural grassland (CN); natural grassland improved by fertilization (CN+A); and natural grassland improved by fertilization and introduction of exotic season species ryegrass (Lolium multiflorum Lam.) and red clover (Trifolium pratense L.) (CN+A+F). The CNT treatment - natural pasture with traditional management without stocking rate adjustment - was conducted in neighboring adjacent area with the same soil. During all experiment time, the area was grazed by Hereford steers with forage offers of 12 kg/ 100 kg of live weight. In the days 25/08/2014 and 23/02/2015, were applied equivalent doses of 300 kg/ha of diammonium phosphate (DAP), at the treatments CN+A and CN+A+F. The N_2O emission rates were measured in situ regularly with static cameras (4 cameras by repetition) and the soil temperature was checked to 5 cm depth. Gas from the chamber was collected with a 20 mL polypropylene syringe (Costa et al, 2008). The gases were measured in Geochemistry Soil Laboratory (UFRGS) with a Gas Chromatography (Shimadzu GC-2014 model Greenhouse) equipped with an electron capture detector (ECD).

Results and Conclusions

The soil temperature at 5 cm depth fluctuated between 10.5 °C and 16 °C in winter (Figure 1a) and between 24.5 °C and 26 °C in summer (Figure 1b). The N_2O flow rates measured at the first and last day of each experimental period were very low and similar to those observed by Godoi et al (2016) under similar conditions (Figure 2). The treatments that received fertilizer application (CN+A and CN+A+F), the largest N_2O emission rates occurred 7 days after application of DAP, independent of temperature differences in the soil (Figure 1) and the season. The highest values of N_2O emission rate were observed in summer (103 $\mu gN_2O\ m^{-2}h^{-1}$ in average between two fertilized treatments), while in winter the highest values were lower (20.5 $\mu gN_2O\ m^{-2}h^{-1}$ in average between two fertilized treatments). The treatments without fertilization (CN and CNT) had very low levels of N_2O emission rate, both in winter and in summer.

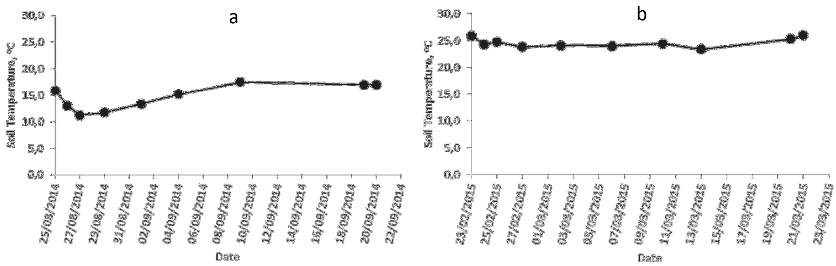

Figure 1. Soil temperature at 5 cm depth in the sampling dates. (a – winter, b – summer).

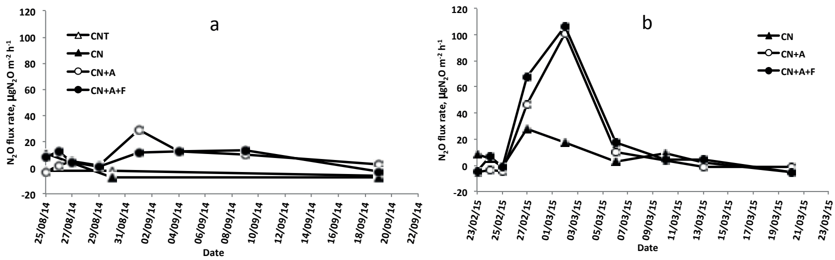

Figure 2. Flux rate of N_2O in a Luvisol under natural grassland in different treatments in two seasons (a- winter, b – summer).

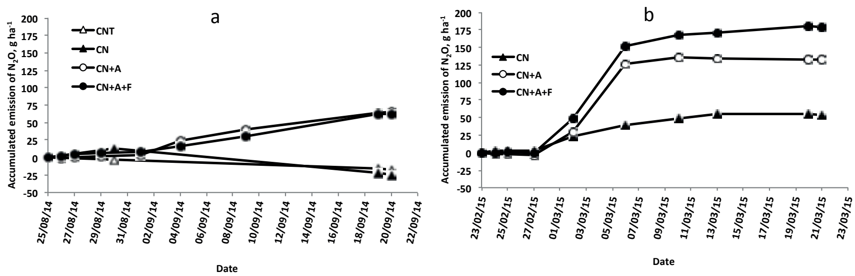

Figure 3. Accumulated emission of N_2O in a Luvisol under natural grassland in different treatments in two seasons (a- winter, b – summer).

Due to the differences in N_2O emission rates, the treatments with fertilization showed higher cumulative emissions than treatments without fertilization (Figure 3). At the end of the evaluation period in the winter had issued, on average, 63 g N_2O ha^{-1} (Figure 3a) and the end of the evaluation period in the summer had issued, on average, 155 g N_2O ha^{-1} (Figure 3b).

We conclude that the application of fertilizer in natural grassland may increases N_2O emissions, with a higher emission in the summer, but de emissions values are low.

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Growth and enteric methane emission evaluation of cattle in livestock- forest integration system in the Amazon biome in the dry period

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Introduction

The dry period is the most challenging time for animal production, especially for beef cattle raised on pasture without irrigation. At this stage usually the animals lose weight, which can compromise their development in the following period. This activity is also aimed to cause great impact on the environment, especially the issue of enteric methane emission and in deforested areas. The objective of this study was to evaluate the weight development and the emission of enteric methane by crossbred steers (Curraleiro Pé-Duro x Nellore).

Material and Methods

The study was performed during the dry season 2015 in the experimental field of the Federal Institute of Maranhão (IFMA), Campus Codó-MA, located in the Amazon biome in 04º 27 '19' 'South and 43º 53' 08 '' West, altitude of 47m. We used two different areas in grazing, the first consisting of grass Mombasa and Babassu palm trees (80 trees per hectare) and the second area only by "Mombaça" grass (*Panicum maximum* Jacq. cv Mombaça), in full sun. Each system consisted of seven paddocks of 4200 m² each, in rotation. The entrance and exit of the animals was determined by the height of the "Mombaça" grass (80 cm at the entrance, and 40 cm at the exit). The present study used twelve contemporaries steers (crossbred steers Curraleiro Pé-Duro x Nellore) supplemented with mineral salt and fresh water. Evaluation of growth was determined by monthly weighing on electronic scales.

The enteric methane was determined with sulfur hexafluoride tracer technique according to Johnson & Johnson (1995) and adapted in Brazil by Primavesi et al. (2004). The eructated and expired gas was collected daily in five consecutive days. The concentrations of CH4 and SF6 were determined at the laboratory of Embrapa Meio Ambiente, located in Jaguariúna , São Paulo state, Brazil, by gas chromatograph (HP6890) equipped with flame ionization detector (FID) and megabore column (0.53 uM, 30 m) HP- Al/M Plot (for CH4) and electron capture detector (μ-ECD) and megabore column HP- MolSiv (for SF6), with two loops 0.5 cm3 coupled to two six-way valves.

Analysis of the available forage was performed according to "Agronomic technique zero cut" (Lopes et al., 2000). We analyzed the percentage of dry matter of leaves (DML), stems (DMS), leaf / stem ratio (L/S), relative living matter / dead matter (LM / DM). The dried material was also chemically analyzed for protein content and fiber fractions. The experimental design was a randomized block. The data were submitted to analysis of variance and compared Tukey test using the program Assistat. Version 7.6 beta (Silva 2011).

Results and Conclusions

In the shaded pastures, the animals showed an average weight gain of 10 kg during this period, while in the pasture in full sun, weight gain was 3 kg on average per animal. The best performance in the integrated system (livestock / forest) could be explained by the higher quantity and quality of forage. Forage availability in the integrated system was 2.041 kg MS and in the traditional system was 1.811 kg MS. The shaded area was also observed higher values of MSLF and MV / MM were 761.4 and 372.7 and 3.12 against 0.85 in grassland in full sun, respectively.

The "Mombaça" grass on integrated system showed higher values of crude protein, 7.33 against 5.66% MS in the traditional system and lower fiber values (ADF and NDF), 35.46 and 64.00% against MS 37.43 and 66.44% DM respectively in pure pasture. The methane production was similar in both systems and were 121,04 g / CH4 / day and 44.18 kg / CH4 / year for the integrated system and 121,53 g / CH4 / day and 44.361 kg / CH4 / year for the system in full sun (Table 01).

Although there are no differences in methane emissions, there was greater productivity in the integrated system which reduces the emission of methane per kilogram of meat produced. Thus it can be concluded that the forest livestock integration system provides better animal performance in the dry season and lower methane emissions per kilogram of meat produced in the period.

Table 1: evaluation systems as the availability and chemical analysis of the forage and methane emissions.

	System	
Variable	Forest livestock integration	Pure pasture
DMTF	2041 kg/ha	1811 kg
DML	761 kg/ha	372kg/ha
LM/DM	3,12	0,85
CP	7,33 % [a]	5,66 % [b]
ADF	35,46 % [a]	37,43 % [b]
NDF	64 % [a]	66,44% [b]
G/CH4/DAY	121,04	121,53
KG/CH4/YEAR	44,18	44,36

Means followed by the different letter in the line differ significantly, Tukey test at 5% probability. DMTF = dry matter total forage. DML = dry matter of leaves. LM/DM = living matter / dead matter. CP = Crude Protein. ADF= acid detergent fiber and NDF = neutral detergent fiber

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Nitrous oxide emission by Pastures in Integrated and Non-Integrated Beef Cattle Production Systems during Spring

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Introduction

Integrated livestock production systems are those in which pastures, crops and trees are, alternately or simultaneously cultivated in the same area. Integrated silvopastoral, crop- livestock and crop-livestock-forestry systems aim at higher levels of productivity as well as environmental, social and economic sustainability (VILELA, et al., 2011). To that end, the most appropriate alternative must maximize the use of available resources, improve soil quality - the base of agricultural production - and reduce the use of inputs, resulting in higher profitability (DORAN & PARKIN, 1994; SINGER & EWING, 2000).

The increasing emission of anthropogenic greenhouse gases (GHG), resultant of farming, energy production, disposal of residues and land use change is one of the greatest environmental problems. It is estimated that agriculture is responsible for 20% of total anthropogenic GHG emissions but it can also function as a carbon sink (JOHNSON et al., 2005). The reduction in GHG emissions, including nitrous oxide (N_2O), besides its importance in climate change, helps to reduce losses in livestock production, improving its efficiency (Oliveira et al., 2015). This study aimed at evaluating N_2O emissions in pastures under different managements, to better understand important beef cattle production systems in Brazil, specially the integrated systems.

Material and Methods

The study was carried out at Embrapa Pecuária Sudeste, SP (21°57'42"S, 47°50'28" W, 860 m) from 29/10/2013 to 19/11/2013. The climate is classified as Cwa (Köppen), with two well defined seasons: dry season - April to September, with average temperature and precipitation of 19.9ºC and 250 mm, respectively; rainy season - October to March, with average temperature and precipitation of 23.0ºC e 1,100 mm, respectively. The soil in the area is classified as Dystrophic Red Latosol. N_2O emission was evaluated in the Atlantic Forest (Forest) and in pastures belonging to five production systems: 1) Intensive (INT) - dryland rotational grazing system; 2) Integrated Silvopastoral System (SP) - rotational grazing with eucalyptus trees (15 x 2 m spacing); 3) Integrated Crop-livestock System (CL) - rotational grazing system with crop rotation in each paddock in four year cycles (three years with pasture and one year with corn); 4) Integrated Crop-livestock-forestry System (CLF) - the same as CL with eucalyptus trees (15 x 2 m spacing); 5) Extensive (EXT) - continuous grazing system. Soils in EXT and in an adjacent area of Atlantic Forest were used, respectively, as negative and positive controls.

Pastures in INT, SP, CL and CLF were established in 2012 with *Urochloa* (sin. *Brachiaria*) *brizantha* (Hochst ex A. Rich.) Stapf cv. Piatã and were fertilized with 50 kg of N ha^{-1} via urea, in each grazing cycle during the rainy season, amounting to 200 kg N ha^{-1} $year^{-1}$. Each of these systems had two replicate pasture areas, of 3 ha each, divided in six paddocks in a rotational system with six days of occupation and 30 days rest. The pasture in EXT was established in 2007 with *Urochloa* (sin. *Brachiaria*) *decumbens* (Stapf) R. Webster and was not fertilized. The EXT system had two pasture areas of 2.85 ha each managed under continuous grazing. The stocking rate was adjusted in all pastures using the "put and take" technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

The experimental design was in blocks with repetitions. It was used two repetitions for each pasture area (blocks). Net flows of N_2O emissions were evaluated using air samples collected from cylindrical PVC "static chambers". The chamber body was 17cm height and 30 cm in diameter and was covered with insulating material. Six chambers were used per treatment (three per block or pasture area). Three chambers were also allocated in an Atlantic Forest area (positive control). A digital thermometer was adapted to each of the chambers for internal temperature measurement. Three collections of air samples were done in each chamber at 30 min intervals, with polypropylene syringes. Samples were taken between 8:00 and 10:00 a.m. Samples were transferred to evacuated vials, provided with rubber septa and aluminum seals, for later chromatography analysis.

Results

The general variation in N_2O emission rate observed indicate there was an influx of N_2O. Accumulated rates during 21 days were small and similar ($P>0.05$) in INT, SP, CL, CLF and EXT pastures (average of -7.26 g ha^{-1}) - Figure 1. The N_2O influx was more intense in the Forest (-39.74 g ha^{-1}) compared to the other systems.

The lack of N_2O emission, resulting in influx, may be explained by the fact that soils in tropical pastures are generally well drained, aerated and N deficient, impairing N_2O emission. Wood e Silver (2012) reported N_2O influx in forest with dry soil. In pastures, Whitehead (1995) observed N_2O consumption by the grass leaves.

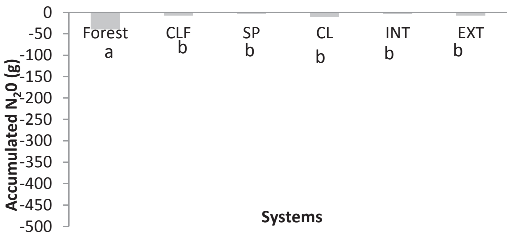

Figure 1. Accumulated N2O (Kg ha^{-1}) in the grazing systems and in the forest.
a, b: Means with different letters differ by the Tukey test ($P<0.05$).
INT: Intensive; SP: Silvopastoral; CL: Crop-livestock; CLF: Crop-livestock-forestry; EXT: Extensive.

Conclusions

Results of one season may not reflect the N_2O emission pattern of a complete production cycle. Evaluations involving all the four annual seasons are necessary to fully characterize emissions in integrated systems, the natural forest and traditional beef cattle grazing systems.

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N_2O emission by pastures in different tropical milk production systems

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Introduction

Global warming, with the contribution of anthropogenic greenhouse gases (GHG) emissions, results in climate changes and potentially catastrophic environmental disorders. The main GHG related to agriculture are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Oliveira et al., 2011). Agriculture is responsible for 38% of the national emissions of nitrous oxide in CO_{eq} (MCTI, 2014). Anthropogenic emissions of N_2O are almost all related to the deposition of livestock excreta and the use of nitrogen fertilizers in agriculture. According to the IPCC (2006), 2% of the N derived from bovine excreta that reaches the soil is lost as N_2O. Animals on pasture are responsible for approximately 41% of the N_2O emitted by agriculture (MCTI, 2014). The aim of the study was to investigate the effect of different milk grazing production systems and seasons on N_2O emissions.

Material and Methods

The study was carried out at an experimental station of the Brazilian Agricultural Research Corporation (EMBRAPA), in São Paulo state, Southeast of Brazil, in 2012. Twelve Holstein and twelve Jersey-Holstein crossbred dairy cows were used in a 2 x 2 factorial arrangement, represented by 2 cattle genotypes (Holstein and Jersey-Holstein) and 2 pasture systems (extensive with low stocking rate - EXT - and intensively managed and irrigated with high stocking rate - IIR). Cows were kept on pastures and received a dietary supplement (concentrate) formulated according to the NRC (2001) in the rate of 1 kg of concentrate per 3 kg of milk produced. The extensive pasture system was composed of two paddocks, 3.0 ha each, containing *Brachiaria spp*. and *Cynodon nlemfuensis* Vanderyst, managed as continuous grazing systems, without fertilization. The intensive managed system was irrigated and cultivated with *Panicum maximum* Jacq cv. Tanzânia and overseeded with *Avena byzantina* cv. São Carlos and *Loliun multifloram* Lan. cv. BRS Ponteio, in autumn. The IIR system

consisted of two similar 1.6 ha rotational systems, divided in 27 padocks with 600 m^2 each, intermittently grazed, with a day of occupation and 26 days of rest. The soil (Red-yelow latosol) of intensive managed pastures were limed and fertilized with superphosphate and potassium chloride to achieve respectively, 20 mg $P.dm^{-3}$ and 4% K in soil CTC - cation

exchange capacity. Nitrogen was applied monthly at the annual rate of 456 kg $ha^{-1}year^{-1}$ (20.05.20 + 6%S).

Three cows (tracers) of each genotype grazed simultaneously in each replicate of area. All grazing systems were submitted to stocking rate adjustments using the "put and take" technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

The experimental design was in blocks with repetitions. It was used two repetitions for each pasture area (blocks). Net flows of N_2O emissions were evaluated using air samples collected from cylindrical PVC "static chambers". The chamber body was 17cm height and 30 cm in diameter and was covered with insulating material. Six chambers were used per treatment (three per block or pasture area). Three chambers were also allocated in an Atlantic Forest area (positive control). A digital thermometer was adapted to each of the chambers for internal temperature measurement. Three collections of air samples were done in each chamber at 30 min intervals, with polypropylene syringes. Samples were taken between 8:00 and 10:00 a.m. Samples were transferred to evacuated vials, provided with rubber septa and aluminum seals, for later chromatography analysis.

Results

Values of nitrous oxide emissions were low, even in the irrigated pastures in which a high dose of N was applied. Accumulated N_2O emissions were effect by the different systems, seasons and it was also observed a system and season interaction ($P<0,0001$) (Table 1 and Figure 1). In all seasons the intensively managed, irrigated with high stocking rate system produced higher N_2O emissions compared to the extensive managed with lower stocking rate and the forest, in which emissions were similar. The higher emissions were verified in summer and autumn compared with winter and spring, except in the forest (Figure 1)

Table 1. Accumulated N_2O emission (g) in different milk production systems and in the Atlantic Forest during the four seasons of 2012.

	Summer	Autumn	Winter	Spring	Mean
Forest	0.5096 Ba	0.8461 Ba	0.0356 Ba	1.1161 Ba	0.6268
Extensive	1.9765 Ba	0.9514 Ba	0.0993 Bb	0.9411 Ba	0.9921
Irrigaded	12.2350 Aa	12.9730 Aa	6.2549 Ab	3.5591 Ac	8.7555
Mean	4.9068	4.9236	2.1299	1.8721	

Means followed by the same letter, lowercase within the line and uppercase within the column, do not differ statistically by Tukey test at 5% probability.

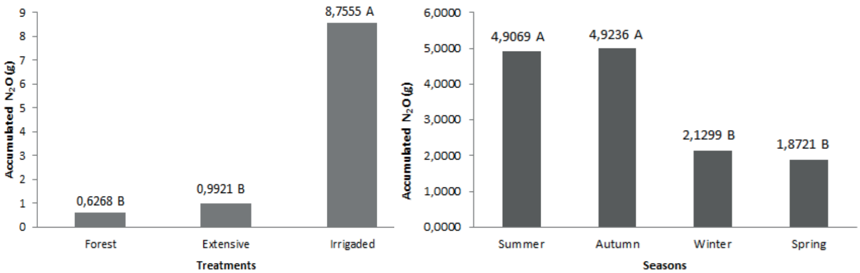

Figure 1. Accumulated N_2O emission (g) in different milk production systems and Atlantic forest, in the seasons of 2012. (Means followed by the same letter, do not differ statistically by Tukey test at 5% probability).

Conclusions

Nitrous oxide emissions were very low in the tropical pastures, independent of the intensification level.

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Nitrous oxide emission by pastures in tropical beef production systems

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Introduction

Brazil has a total of 851.58 million ha and 158.75 million ha occupied by pastures, amounting to 18.6% of its territory and 58.1% of farmland area in the country (IBGE,2010). The Brazilian beef production is based on tropical pastures. The recovery and intensive management of pastures have shown potential for mitigation of greenhouse gases (GHG) due to the high biomass production of tropical grasses (Oliveira, 2015). The main GHG related to agriculture are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Oliveira, 2015). The concentration of N_2O in the atmosphere is much lower compared to the CO_2 concentration but evaluating its emissions is important due to its high greenhouse effect potential, which is 270 to 310 times higher than that of CO_2 (Snyder et al., 2008; MCTI, 2014). The aim of the study was to investigate the effect of different tropical beef production systems and seasons on N_2O emissions by pastures.

Material and Methods

The study was carried out at an experimental station of the Brazilian Agricultural Research Corporation (EMBRAPA), São Paulo state, Southeast of Brazil, in 2014. Treatments consisted of four grazing systems, with two replications each (blocks): 1) IHS: irrigated pasture with high stocking rate (5.9 - animal units - AU/ha; *Panicum maximum*); 2) DHS: dryland pasture with high stocking rate (4.9 AU/ha; *Panicum maximum*), 3) DMS: dryland pasture with moderate stocking rate (3.4 AU/ha; *Brachiaria brizantha*); 4) DP: degraded pasture with low stocking rate (1.1 AU/ha; *Brachiaria decumbens*). Pastures in IHS, DHS and DMS were managed as rotational grazing systems with three days of occupation and 33 days of rest cycles. Each replicate area in IHS and DHS systems had 1.75 ha, divided in 12 paddocks. Pastures in IHS received five applications of 80 kg of N during the rainy season and five applications of 40 kg of N during the dry season and were overseeded with temperate grasses in autumn. Pastures in DHS received five applications of 80 kg of N during the rainy season. Each area in DMS had 3.3 ha, divided in six paddocks managed in a rotational system with 6 x 30 d cycles, and received five applications of 40 kg of N during the rainy season. Urea was used as the N source. Pastures in DP were managed under continuous grazing and were not fertilized. The stocking rate in all systems was adjusted using the “put and take” technique (Mott and Lucas, 1952) and visual evaluation of forage availability. Net flows of N_2O emissions were evaluated using air samples collected from cylindrical PVC “static chambers”. The chamber body was 17cm height and 30 cm in diameter and was covered with insulating material. Six chambers were used per treatment (three per block or pasture area). Three chambers were also allocated in an Atlantic Forest area (positive control). A digital thermometer was adapted to each of the chambers for internal temperature measurement. Three collections of air samples were done in each chamber, at 30 min intervals, with polypropylene syringes. Samples were taken between 8:00 and 10:00 a.m. Samples were transferred to evacuated vials, provided with rubber septa and aluminum seals, for later chromatography analysis.

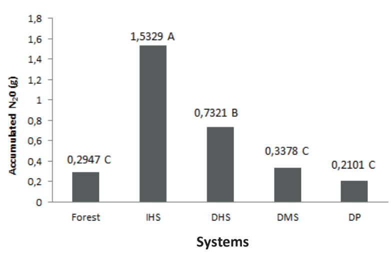
Results

Accumulated N2O emissions were effect by the different systems and by the seasons. It was also observed a system and season interaction (Table 1 and Figure 1). The total emission was higher in IHS, intermediate in DHS and similar and lower in DMS, DP and in the forest (Figure 1). Emissions in IHS were higher in summer compared to other seasons but in DHS emissions were more evenly distribute throughout the year. Emissions did not vary during the year in the dryland pasture with moderate stocking rate, in the degrade pasture and in the forest.

Table 1. Accumulated N_2O emission* (g) in different beef production systems, and forest, during the four seasons of 2014.

	Summer	Autumn	Winter	Spring	Means
Forest	0,3505 Ca	0,6048 Aa	0,0034 Ba	0,2201 Aa	0,2947
IHS	3,9806 Aa	1,2969 Ab	0,6996 Ab	0,1547 Ac	1,5329
DHS	1,3456 Ba	1,0558 Aab	0,4158 Abc	0,1113 Ac	0,7321
DMS	0,3225 Ca	0,266 Aa	0,4567 Aa	0,3060 Aa	0,3378
DP	0,1456 Ca	0,2329 Aa	0,1968 Aa	0,2652 Aa	0,2101
Means	1,2289	0,6913	0,3544	0,2114	

*Means followed by the same letter, lowercase within a line and uppercase within a column, do not differ by the Tukey test at 5% probability.
IHS: irrigated pasture with high stocking rate; DHS: dryland pasture with high stocking rate; DMS: dryland pasture with moderate stocking rate; DP: degraded pasture.



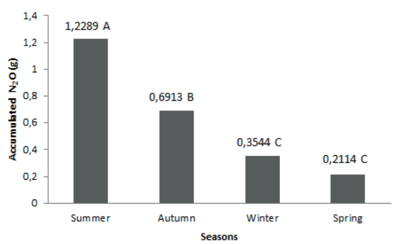


Figure 1. Accumulated N_2O emission* (g) in different beef production systems, and forest, during the four seasons of 2014.
*Means followed by the same letter do not differ by the Tukey test at 5% probability.
IHS: irrigated pasture with high stocking rate; DHS: dryland pasture with high stocking rate; DMS: dryland pasture with moderate stocking rate; DP: degraded pasture.

Conclusions

Nitrous oxide emissions were low in the tropical pastures, independent of the intensification level.

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Study area characterization and preliminary results on GHG emissions in eucalyptus forest, Mato Grosso do Sul

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Introduction

Forestry in the Cerrado Biome have the potential to act as carbon sink and storage and can be used as climate change mitigation option through compensatory planting. The Cerrado occupies about 23% of the national territory, presenting varied physiognomies. The Cerrado *sensu stricto* (herbaceous layer with different densities of tree and shrubs) is the predominant physiognomic type with total extent of about 41.8 million hectares. The Cerrado biome may play a significant role on global carbon balance due to carbon storage and fixation. However, vast areas of Cerrado have been degraded as a result of extensive and frequent fire mainly related with cattle ranching.

Planted forests in Cerrado are predominant comprised of eucalyptus, which are generally established on degraded pasture. Fast growing Eucalyptus boosts absorption of carbon dioxide from the air and therefore Eucalyptus forestry is considered as a greenhouse gas mitigation option. This study presents a preliminary evaluation of greenhouse gases (GHG) emissions from planted forests in the Cerrado of Mato Grosso do Sul, Brazil.

Materials and methods

Initially, a survey was performed to identify the vegetation types associated with Eucalyptus plantation. Then the study area was characterized according to soil type, topography, rainfall and land use. The GHG emissions from soil were measured in a stand inside of the Eucalyptus plantation using a static chamber based technique. Samples for determination of the GHG fluxes at soil-atmosphere interface were collected at monthly intervals.

Each chamber is mounted on a metal base of 0.24 m^2, which was placed approximately 0.07-

0.05 m deep into the soil and stayed installed during the entire field operation. A built-in through 0.09 m height, which holds water, was attached to the metal base to prevent gas leaking. An insulating material was used to cover the water trough to prevent temperature gradients between the interior and exterior of the chambers. First air sample was taken immediately after chamber placement on the base and then after 30 minutes. Samples were collected to evaluate the evolution of the concentration of a gas in the closed chamber with time (linearity test). Concentrations of CO_2 and N_2O in the samples were determined by use of gas chromatography.

Results and Conclusions

Sampling was carried out at the Ribas do Rio Pardo county (20°38′54′′ S and 54°02′10′′ W - 453 meters above sea level), State of Mato Grosso do Sul. The original physiognomic type in this region was cerrado, which was converted into pasture in the 1970s. Due to the inappropriate use occurred degradation. The area was then leased to the planting of eucalyptus clonal called “urograndis”. This is a *Eucalyptus grandis* and *E. urophylla* crossing, planted at 3 x 2.5 m spacing. Its total area is about 1640 hectares, being characterized by undulating topography (8 to 20%) and Quartzsandy Neosoil ortic soil type.

The results indicate that CO_2 emissions in the area of study present seasonal fluctuation. CO_2 emissions were markedly higher from

October to December, which correspond to the rainy season in the Cerrado of Mato Grosso do Sul. Suggesting that CO_2 flux in the interface soil- atmosphere may be affected by soil moisture. Other preliminary results will also be presented.

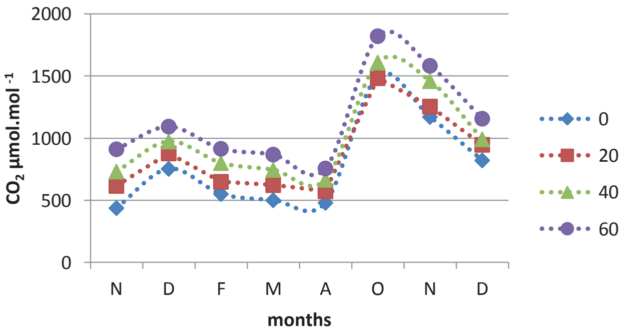

Figure 1: Carbon accumulation in chambers throughout the year, 0 to 60 minutes, in the eucalyptus forest, Mato Grosso do Sul state.

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Enteric methane emission of Nellore cattle in extensive grazing or integrated systems

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Introduction

Brazilian beef cattle production is primarily based in grazing systems which in general present low productivity as a result of extensive monoculture pastures. Integrated systems come up as alternatives to overcome this scenario which in turn may have impacts on agricultural greenhouse gas emission. In 2015, we reported the first results on enteric methane (CH_4) emissions comparing extensive and integrated systems (Gomes et al., 2015). However, it is important to observe how results behave over time, in order to draw robust conclusions. The aim was to evaluate the enteric methane emission of beef cattle grazing extensive pastures (EXT), integrated crop-livestock (ICL) and crop-livestock-forest systems (ICLF) in two seasons, over a two-year study.

Material and Methods

The experiment was carried out at Embrapa Beef Cattle Research Center, in Campo Grande, MS, Brazil (20°24′ S, 54°42′W, 560 m asl) in 2014 and 2015. Nellore heifers were submitted to different grazing systems as follow: EXT – *Brachiaria decumbens,* established in 1992/1993, ICL – 3 years *Brachiaria brizantha* cv. BRS Piatã, following no-till soybean crop and ICLF - 3 years *Brachiaria brizantha* cv. BRS Piatã, following no-till soybean crop, in an area with 227 trees/ha, *Eucalyptus urophylla x E. grandis* planted in 2009. Twelve Nellore heifers were used per year and randomly allotted to one of six paddocks (1 to 1.5 ha), two paddocks per system. The enteric methane was measured throughout two seasons every year (February/Summer and August/Winter). Experimental animals had 442±23 kg live weight (LW) and 30 mo of age in Summer 2014, 501±34 kg LW and 36 mo of age in Winter 2014, 271±14 kg and 18 mo in Summer 2015 and 382±22 kg and 24 mo in Summer 2015. The CH4 was measured using the SF6 tracer gas technique, according to Primavesi et al. (2004) over a minimum 5-day period each season. The effects of year, season, treatment (system) and

interactions were analyzed using a mixed model with repeated measures and means were compared using Tukey-Kramer adjusted test ($p<0.05$).

Results and Conclusions

There was an interaction between year, season and system effects ($p<0.01$), therefore results were presented within years. The CH4 emission was much greater in 2014 than in 2015 (183 vs 118 g head^{-1} d^{-1}, $p<0.0001$). This may be related to differences in age and live weight of the heifers across years, as in 2015 the heifers were younger and lighter than those used in 2014. However, the main explanation for differences in CH4 emission across years may be laid on differences in pasture availability. For instance, considering the summer season, the ICL and ICLF systems presented 4.3 and 3.6 ton forage dry matter per hectare in 2014, respectively (Gamarra et al., 2014), whereas the availability decreased to 2.2 and 1.2 ton in 2015, respectively (unpublished data). Differences in pasture availability may have affected dry matter intake which in turn may have led to differences in CH4 emission between 2014 and 2015.

Enteric methane emissions were greater in the summer compared to winter, irrespective the year (Table 1). In average, the differences between seasons were about 9%. The reasons for this results may be the same those explain the differences for CH4 emissions across years as it is expected a lower forage availability during the winter in the Brazilian Cerrado conditions.

Table 1. Least square means for enteric methane (CH_4) emissions (g head^{-1} day^{-1}) of Nellore heifers in different grazing systems and seasons

Season	System			Mean	Coefficient of variation, %
	Extensive	Integrated Livestock-Crop	Integrated Livestock-Crop-Forest		
		2014			
Summer	196a	189a	189a	191A	5.19
Winter	158c	197ab	170bc	175B	6.73
		2015			
Summer	127a	115a	128a	123A	5.00
Winter	132a	108a	100a	113B	5.76

Different small letters within roll and capital letters within columns differ at 5% probability for Tukey-Kramer adjusted test.

Different small letters within roll and capital letters within columns differ at 5% probability for Tukey-Kramer adjusted test.

In 2014, there were no differences for CH4 emissions during the summer, with an average of 191 g^{-1} d^{-1} head. Conversely, during the winter, ILC system had a greater CH4 emission followed by ICLF and EXT. In turn, in 2015, no differences across systems were observed for both summer and winter. As explained before, forage availability may affect dry matter intake and, in turn, CH4 emission. Therefore, this may explain why the differences across systems

observed in 2014 were not observed in the following year. In conclusion, differences in CH4 emission among grazing systems, including extensive and integrated systems (ILC and ILCF), may exist; however they seem to be mainly driven by the effects of forage availability within systems which, in turn, may vary as a function of climate factors and of pasture management (e.g. stocking rate).

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Nitrous oxide fluxes from different nitrogen sources applied in upland rice in the cerrado goiano

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Introduction

Nitrous oxide (N_2O) is an important greenhouse gas, despite its low concentration in the atmosphere. It stands out due to the persistence of its molecule in the atmosphere and to its high global warming potential. Approximately 7% of the direct N_2O emissions within agricultural land comes from the use of synthetic fertilizers (MCTI, 2013). There is need to spread technologies that reduce the production of this gás. To this end it is necessary to investigate the different marketed nitrogen (N) sources, such as the protected ureias and in combination with other components (such as zeolites) that may contribute to reduce the emission of N_2O, being more efficiently used by the plants.

Material and Methods

The study was conducted at fazenda Capivara, experimental area belonging to Embrapa Rice and Beans, located in the municipality of Santo Antônio de Goiás-GO. The soil is Red Latosol (53% clay). The experimental design was completely randomized blocks ((5 + 1) x 4) corresponding to five N sources and the control (without application of N) and four replicates (total 24 plotes, 32 m^2 each). The test plant was upland rice in integrated crop-livestock system under zero tillage. Gas samples were collected using manual static chambers. Sampling was made 0, 15, 30 minutes after the closing of the chambers. N_2O fluxes were measured by gas chromatography. Were held two fertilization, one soon after planting and another as topdressing, each 60 kg N ha^{-1}, were applied. The N sources used were: common urea (45%), urea + polymer (43%), urea + NBPT (N-45%), urea + inhibitor (44.6%), urea + zeolite (36% N). The emission factor was determined by the amount N lost in the form of N_2O (difference between the total emissions in the treatments with nitrogen fertilization and control) in relation to the total amount of N applied. The emission was expressed per unit of product and evaluated through the relationship between the total N_2O emissions and the amount of grain produced for each source used of N. The evaluations were conducted in the period of November 2, 2014 to November 10, 2015.

Results and Conclusions

Although nitrogenous fertilizers are costly and have potential to cause damage to the environment, these are commonly used in indiscriminated manner by large scale producers causing losses to the atmosphere and groundwater. Among the nitrogenous fertilizers used in Brazil urea is the most required for fertilization of crops because it has lower cost per kg of N. However, the use of urea is not always effective because heavy losses occur after its application. The source of urea + inhibitor presented the highest N_2O emission when compared to control and treatment of urea + polymer. The N sources treatments did not present significant differences for the other evaluated factors (Table 1). The association of the urea + polymer as a mechanism of reduction of uréase in nitrogen fertilization favored reduction of N_2O fluxes and lower emissions in the rice cultivation of uplands. However, the use urea + inhibitor, under the conditions of the study, was not effective in reducing the losses of N in the form of N_2O.

Table 1. Total emission, rice yield, N_2O emission per unit grain and emission factor from the application of different nitrogen sources in upland rice.

Treatments	Total emission ($kg\ N\text{-}N_2O\ ha^{-1}$)	Rice yield ($Kg\ ha^{-1}$)	N_2O emission per unit grain ($g\ N\text{-}N_2O\ kg\ grain^{-1}$)	Emission factor %
Urea + inhibitor	2,59a	6421,59a	0,41a	0,81a
Urea + zeolite	2,09ab	6139,04a	0,34a	0,40a
Common urea	2,09ab	6144,40a	0,34a	0,40a
Urea + NBPT	1,94ab	5832,05a	0,34a	0,31a
Urea + polymer	1,79b	6064,39a	0,30a	0,24a
Control	1,61b	5517,01a	0,30a	-

*Means followed by the same letter in the column do not differ significantly (p-value > 0.05) by the Tukey test.

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Enteric Methane Estimation with TIER 2 Compared to Results Obtained in a Field Experiment with Water Buffaloes Supplemented with Palm Kernel Cake in the Amazon Biome

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Introduction

The increase in greenhouse gases (GHG) concentration in the atmosphere has become steeper, which is attributed to anthropic activities. In Brazil, the productive sector indicated as GHG emitter is related to soil use, agriculture, and livestock. In 2014, the Brazilian agriculture and livestock emission represented about 20% of the overall GHG emission (SEEG, 2016). Particularly in livestock farming, one of the main GHG emission factors pertains to methane (CH_4) coming from ruminants enteric fermentation, which account for 68% of the emissions in the livestock sector (BERCHIELLI et al., 2012).

CH_4 emission by ruminants represents loss of part of the energy ingested by the animals. Some factors impact this emission, such as the quality and amount of food intake, digestive system, and animal age. Different strategies have been planned to reduce GHG emissions by livestock, involving activity, nutritional, and reproductive management (BERNDT, 2012). Nutritional strategies are evaluated to decrease emissions such as supplementing ruminant diets with lipids. It was observed that, for every 1% of fat added to the diet, CH_4 production per kg of dry matter consumed decreases by up to 6% (ABDALLA et al., 2008).

Methodologies are tested to assess GHG emissions, such as employing mathematical equations to estimate enteric methane emissions. The Intergovernmental Panel on Climate Change (IPCC) has developed equations that allow ranking methane production into TIER 1, TIER 2, and TIER 3 depending on information such as animal characteristics and feed.

This study aimed to estimate enteric methane emissions using TIER 2 considering the same diet used in a field trial using sulfur hexafluoride (SF_6) as tracing gas in female buffaloes that consumed different levels of palm kernel cake in the Amazon biome.

Material and Methods

TIER 2 equations were used considering the same diet used in the field trial to quantify enteric methane emission by the SF_6 tracing gas technique according to methodology described by Johnson et al. (1994). These field trial data were obtained by the PECUS Project and belong to the database of the doctorate thesis of one member of the research team. It is worth pointing out that the field data were obtained at the “Senador Álvaro Adolpho” Animal Research Unity, belonging to Embrapa Eastern Amazon, in the city of Belém, Pará, Brazil. The diets were provided to 24 crossbred Murrah and Mediterranean female buffaloes, whose mean weight of 514 ± 69.88 kg, belonging to the Embrapa Eastern Amazon’s experimental herd. The study was approved by the Committee of Animal Ethics – CEUA under protocol 007/2015. The animals were managed in confinement (tie stall) and spent 21 days adapting to the experimental diets with free access to water and mineral mix. The experiment followed a completely randomized design with four treatments and six repetitions: In this study, only three treatments were considered, i.e., palm kernel cake inclusion in relation to body weight (BW) at the levels of 0% (T1), control; 0.5% (T2); and 1.0% (T3). All treatments were added with 0.15% (BW) wheat bran as palatability agent and corn silage was used as roughage. The animals were individually fed twice a day (8 AM and 5 PM). The amounts of silage were weighed daily and adjusted to achieve daily leftovers of up to 10%.

Those diets were used to estimate the emission factor adopting the methodology developed by the IPCC (IPCC, 2006), called TIER 2. Characteristics of the animals and diets were considered such as: animal age, initial weight, mean weight, weight gain, digestible energy, and gross energy.

Results and Conclusions

The results of enteric methane emissions presented in Table 1 show that the means in the control treatment with addition of 0.5% palm kernel cake did not differ according to Tukey's test at 5% probability. TIER 2 can be used as an estimator of enteric methane emissions when the diet's nutritional composition is known. The measurements with SF_6 in the treatment with 1% BW were below the estimates with TIER 2, which confirms that the tracing gas methodology is accurate to assess enteric methane emissions in animals fed the diet with the highest level of palm kernel cake inclusion. These results corroborate that adding fat to the diet reduces CH_4 production per kg of dry matter consumed by ruminants (ABDALLA et al., 2008). The highest emission was identified in animals in the control treatment, i.e., which received no palm kernel cake. The results show that TIER 2 was able to estimate enteric methane emissions for diets with up to 0.5% BW inclusion for female buffaloes since the results did not differ statistically between the two methods analyzed.

Table 1 – Estimated and measured values of enteric methane in beef water buffaloes fed with different levels of palm kernel cake inclusion in relation to body weight.

Evaluation method	Palm kernel cake inclusion levels		
	T1	T2	T3
TIER 2 ($kg.year^{-1}$)	58.08 (±2.85) aA	57.79 (±2.73) aA	57.23 (±4.85) aA
SF_6 ($kg.year^{-1}$)	78.16(±33.13) aA	62.46 (±27.15) aA	27.65 (±3.60) bB

Different letters in the same row differ ($p<0.05$) by Tukey's test.

Enteric methane emission estimated by TIER 2 had values close to those measured with the SF_6 tracing gas technique up to 0.5% BW lipid supplementation, but values were overestimated for lipid supplementation at 1.0% BW. Therefore, TIER 2 can be used to calculate ruminant emissions in the Amazon biome since most of the herd in the region is reared in extensive ranching. Another noteworthy aspect is that the tracing gas methodology requires trained labor, laboratory structure, and a structured research team, such as PECUS Network.

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Evaluation of Vegetation Indices at Pasture-Based Systems for Dairy Cattle using Remote Sensing Data

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Introduction

Milk is among the six most important products of Brazilian agriculture, ahead of processed coffee and rice. Brazilian production of milk tripled between 1970 and 2006 (IBGE, 2016), and the country is currently the sixth largest producer in the world and growing at an annual rate of 4%, which is higher than that of the other top producing countries. The availability of forage, both in quantity and quality, is essential for the animals' production to reach maximum potential, and directly influences animal productivity, area productivity, overall productivity, breeding potential and herd health (Carvalho et. al, 2016). Focusing on this line of reasoning and on gathering economical and environmental sustainability, researchers have been evaluating the introduction of new forage types and management techniques that drive the industry to higher productivity without the need for expanding the areas used. Our objective in this study was to evaluate the effect of two dairy-cattle production systems on the Normalized Difference Vegetation Index (NDVI) of the pasture, obtained from a temporal series of Landsat images. The greenness displayed in the NDVI values may be correlated with plant production to indicate a stronger or weaker production, as well as to act as an indicator for different types of management of livestock systems (Alvarenga et al., 2015). On its turn, the pastures' biomass production may be correlated with potential for carbon storage in the soil (Oliveira, 2015).

Material and Methods

The study area is located within the *Mata Atlântica* biome (Brazilian Atlantic Forest), with average annual precipitation of 1,362 mm, average annual temperature of 21.5 ºC and humid subtropical climate. The experimental design featured the following dairy-cattle production systems: (A) irrigated with intensive management and high stocking rate (INTIRRI_AL) and degraded pasture with continuous grazing and low stocking rate (EXTDEGR_BL) (Figure 1). The two systems are described in Table 1.

Table 1. Description of the pasture-based dairy-cattle production systems.

Production system	Stocking rate	Pasture management	Grass	N dose (kg ha^{-1})
INTIRRI_AL	high	Rotation	*Panicum maximum*	>100
EXTDEGR_BL	low	extensive/continuous	*Brachiaria decumbens*	0

The NDVI values were extracted from OLI/Landsat-8 images using the method described by Conceição et al. (2015). The temporal data consisted of 30 cloud-free images taken from April 2013 to August 2015. The NDVI values of each production system were grouped based on season under 'dry season 2013', 'rainy season 2013/2014', 'dry season 2014', 'rainy season 2014/2015', and 'dry season 2015'. The Kruskal-Wallis ANOVA statistical analysis was applied in order to discriminate each production system for each described period.

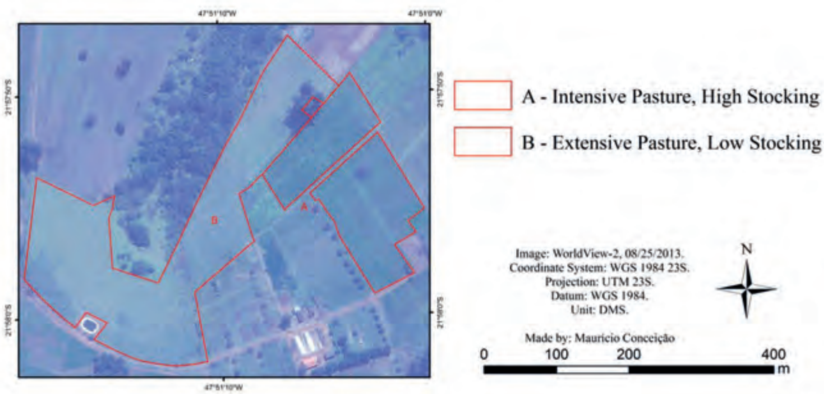

Figure 1. Experimental design with the beef cattle production systems at the study area.

Results and Conclusions

Figure 2 shows average NDVI values in each experimental area for each OLI/Landsat-8 image.

As expected, the intensive management, high stocking rate system showed the highest NDVI values, with a global average of 0.74 (Table 2). The extensive degraded pasture with low stocking rate system showed average NDVI values 8% lower (0.68), reaching up to 12% in the dry season of 2014.

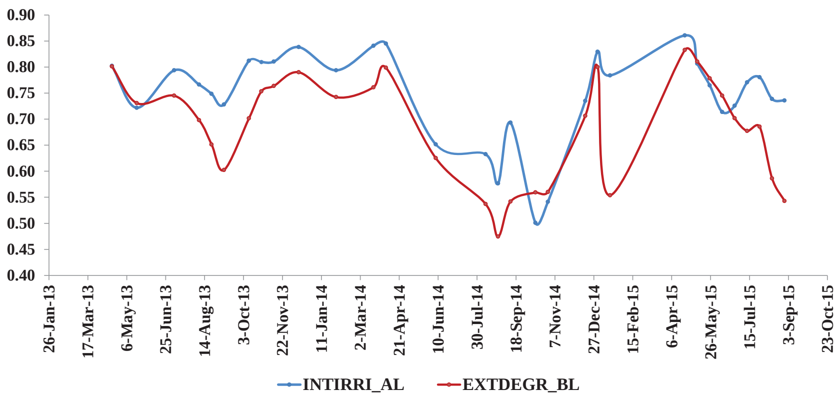

Figure 2. Livestock production systems' NDVI values from April 2013 to August 2015.

Production systems	DRY SEASON 2013 (6)*	RAINY SEASON 2013/2014 (6)*	DRY SEASON 2014 (5)*	DRY SEASON 2014 (5)*	DRY SEASON 2015 (9)*	AVERAGE 2013-2015 (30)*
INTIRRI_AL	0.76[a]	0.82[a]	0.68[a]	0.68[a]	0.76[a]	**0.74**
EXTDEGR_BL	0.70[b]	0.75[b]	0.59[b]	0.64[b]	0.70[b]	**0.68**

*Number of Landsat images. **Averages with different letters showed difference between production systems (p<0.05).

The best performance of the intensive system is due to the grass species chosen, which is more productive under favorable conditions of minimum air temperature and availability of water in the soil (Table 1) despite the higher animal load and the consequent higher biomass consumption (Muller et al., 2002). Vegetation indices show good potential for use in the monitoring of pasture greenness. Well-managed pastures favor carbon accumulation in the soil and contribute to mitigate the concentration of greenhouse gases in the atmosphere.

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Nonlinear Modeling with Sandwich Estimator Approach to Analyze Soil Carbon Profile

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Introduction

Since the 1970s, the city of Paragominas has experienced several changes in land use and become part of the deforestation belt. However, since 2009, integrated production systems have been gaining popularity, grain production has increased, and deforestation has decreased, which makes the city a reference in agriculture and livestock production and awarded it the green city seal in the Amazon. Studying the effects caused by changes in soil use in the Amazon is very important since, in recent years, this region has been an intense agricultural frontier. The implementation of pastures and annual crops led to a significant increase in the removal of natural soil cover as well as high CO_2 emissions in the Amazon region (BRASIL, 2002).

Soil carbon (C) content distribution can be modeled based on measurements over time that assess the chemical kinetics of released carbon. The description of the mineralization process takes into account the simple exponential model with two parameters, namely $\beta 1$ the initial carbon content and $\beta 0$ the mineralization rate (Martines et al., 2006).

In soil carbon mineralization trials, the characteristics inherent to the process may cause issues in data analysis such as non-normal error, variance heterogeneity, and autocorrelation between soil contents along the soil profile. According to Ritz and Streiberg (2008), these issues may be dealt with in two ways. One is based on the use of nonlinear mixed-effects models, which are quite flexible by allowing the variance and covariance matrix structure to be changed. The other approach is based on robust standard error estimates, i.e., sandwich estimators (Zeileis, 2006).

This study aimed to *i*) apply the basis of the nonlinear models theory with least squares method using sandwich estimators to a dataset formed by the C content along the soil profile in the Crop-Livestock-Forest Integration system (ILPF); *ii*) use bootstrap resampling to enhance the precision of the estimates and carbon dynamics along the soil profile.

Material and Methods

The research was carried out at Vitória Farm, located in the city of Paragominas, southeast Pará, Brazil, at the geographic coordinates 2°59'58.37" SE 47°21'21.29" W. This study approaches the agrosilvopastoral system established in 2009 with *Khaya ivorensis* A. Chev. and rotation with *Brachiaria ruziziensis* R. Germ Evrard with *Zea mays* L. (corn). Annual crop rotation remained until 2012, after which the area was managed only with pasture and the forest species. Soil was collected in 2013 by opening five trenches (I, II, III, IV, and V) in the study site, in which samples were collected from three walls in the layers 0-10, 10-20, 20-30, 30-40, 40-60, 60-80, and 80-100 cm deep.
The exponential nonlinear model was used to describe the mean behavior of the carbon content responses in the ILPF system. Overall, the C content in the i^{th} sample (subject) at the j^{th} depth of the u^{th} system can be represented by $y_{iju} = \beta_{0u} x_{ij}^{-\beta_{1u}} + \varepsilon_{iju}$, where x_{ij} is the depth of the i^{th} sample ($i = 1, \ldots, N$) at the j^{th} depth ($j = 1, \ldots, n_i$). The poor specification of distribution assumptions (spatial correlation and variance heterogeneity) led to the estimation of the

robust variance and covariance matrices called sandwich estimator, implemented in the sandwich package (Zeileis, 2006).

Results and Conclusions

The estimates of the model with and without the sandwich estimator are presented, respectively, in Tables 1 and 2. The corresponding standard errors and p-value significance differ between the approaches presented. For instance, the parameter β_1 (initial carbon content) for the third trench was not statistically significant with the use of the sandwich estimator, whereas this parameter was significant when that estimator was not used. Modeling with no validity of the assumptions lead to inadequate standard errors, Student's t-distribution, p-value, and confidence intervals and, consequently, cause mistaken inferences and decision-making (Table 1).

Table 1. Estimate using the nonlinear model with least squares method with no sandwich estimator.

		Least squares method with no sandwich estimator			
Trench	Parameters	Estimate	Std. Error	Student's t-distribution	*p*-value
I	β_1	-1.1254	0.0555	-20.28	$<2\times10^{-16}$ ***
	β_0	35.9524	1.1466	31.36	$<2\times10^{-16}$ ***
II	β_1	-0.8069	0.0723	-11.17	$<2\times10^{-16}$ ***
	β_0	19.7100	1.1216	17.57	$<2\times10^{-16}$ ***
III	β_1	-0.8886	0.0767	-11.58	$<2\times10^{-16}$ ***
	β_0	20.1946	1.1294	17.88	$<2\times10^{-16}$ ***
IV	β_1	-0.7875	0.0608	-12.95	$<2\times10^{-16}$ ***
	β_0	22.9507	1.1196	20.50	$<2\times10^{-16}$ ***
V	β_1	-1.2150	0.0629	-19.33	$<2\times10^{-16}$ ***
	β_0	34.9525	1.1514	30.36	$<2\times10^{-16}$ ***

Table 2. Estimate using the nonlinear model with least squares method with sandwich estimator.

		Least squares method with sandwich estimator			
Trench	Parameters	Estimate	Std. Error	Student' s t-distribution	*p*-value
I	β_1	-1.1254	0.0794	-14.1790	1.475×10^{-11} ***
	β_0	35.9524	3.2059	11.2140	8.059×10^{-10} ***
II	β_1	-0.8069	0.0485	-16.6220	8.927×10^{-13} ***
	β_0	19.7100	0.6594	29.8890	$< 2.2\times10^{-16}$ ***
III	β_1	-0.8886	0.0558	-15.9350	1.89×10^{-12}
	β_0	20.1946	0.4660	43.3360	$< 2.2\times10^{-16}$ ***
IV	β_1	-0.7875	0.0520	-15.1170	4.802×10^{-12} ***
	β_0	22.9507	0.7697	29.8160	$< 2.2\times10^{-16}$ ***
V	β_1	-1.2150	0.0487	-24.9300	5.609×10^{-16} ***
	β_0	34.9525	0.5486	63.7050	$< 2.2\times10^{-16}$ ***

Bootstrap methods were used to obtain the confidence intervals, using the exponential model with sandwich estimators, and significantly improved the precision and accuracy of the inferences with significantly lower amplitude of the intervals (Table 3). Figure 1 shows the fit of the model's curves to the carbon content observed for each sample.

Table 3. Percentile bootstrap using sandwich estimator.

Trench	Parameters	Estimate	Std. Error	Median	IC (LI; LS)
I	β_1	-1.1259	0.0618	-1.1228	(-1.2564; -1.0083)
	β_0	36.0112	1.2476	36.0819	(33.1501; 38.3087)
II	β_1	-0.8099	0.0539	-0.8092	(-0.9198; -0.7066)
	β_0	19.7195	0.8209	19.6945	(18.1812; 21.3417)
III	β_1	-0.8913	0.0620	-0.8895	(-1.0202; -0.7708)
	β_0	20.1946	0.9067	20.3205	(18.1152; 21.6851)
IV	β_1	-0.7903	0.0733	-0.7889	(-0.9303; -0.6475)
	β_0	22.9541	1.3135	22.9725	(20.2676; 25.5094)
V	β_1	-1.2162	0.0513	-1.2135	(-1.3220; -1.1207)
	β_0	34.9470	0.9071	35.1552	(32.9121; 36.2438)

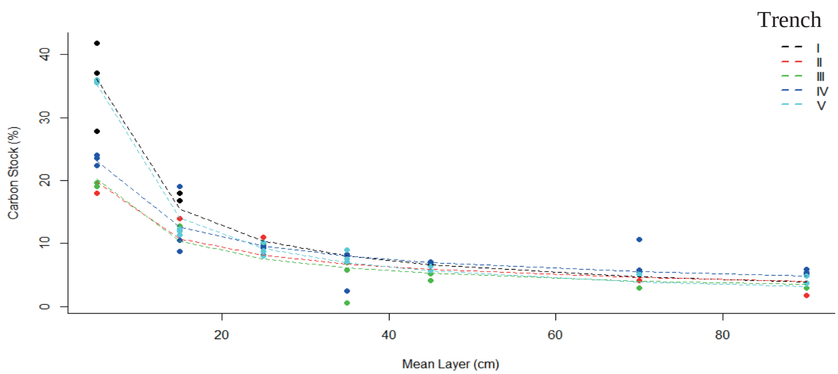

Figure 1. Fit of the nonlinear mixed-effects model using sandwich estimator per trench.

Using bootstrap resamplings in the exponential nonlinear model with the use of sandwich estimators is a viable, more precise and accurate way of spatially estimating soil C content and fits situations such as small samples. Soil organic matter enables high variability in chemical element content in the soil, which impacts the modeling along the profile. Robust methods such as the sandwich estimator have great potential to be applied in this type of study.

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Geostatistical Analysis of NDVI in rotational and continuous grazing pastures

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Introduction

Livestock rearing is an important economical activity in Brazil, and its production is affected by pasture management methods. In this context, the use of geostatistics to analyze the spatial variability of the pastures' vegetation indices is valuable for understanding how management methods influence livestock production. Geostatistics is a tool that considers spatial dependency to interpolate data with no tendency and with minimum variance, which enables the production of precise maps using interpolated values at places that were not sampled (Vieira, 2000). The spatialization of vegetation indices such as the Normalized Difference Vegetation Index (NDVI) helps to evaluate the quality of pastures and to identify areas which may undergo a degradation process. In this study we intended to spatially evaluate two pasture management methods, rotational grazing and continuous grazing, using geostatistics and the NDVI as an indicator obtained from Landsat images of an area located in Pirassununga, São Paulo, Brazil, taken in 2011.

Material and Methods

The study area is located within the campus of Universidade de São Paulo at Pirassununga, São Paulo, Brazil, and features two pasture types with *Brachiaria brizantha*: continuous grazing (no rest and no pasture rotation) and rotational grazing (7 days of grazing and 28 days of rest). The area is located within the *Mata Atlântica* biome (Brazilian Atlantic Forest), and features average annual precipitation of 1,300 mm, average annual temperature of 23 ºC and humid subtropical climate (Cwa according to the Köppen classification). The NDVI was extracted from Landsat-5 satellite images using the method described by Conceição et al. (2015) on a 604-point grid using UTM coordinates and after calculating the Rouse et al. (1973) equation. The data were subjected to descriptive statistical analysis, normality test, and geostatistics. Semivariance was calculated according to Vieira (2000), in order to analyze the existence of spatial variability of the NDVI values in nine dates of 2011: April 28, May 14, May 30, June 15, July 17, August 2, August 18, September 3, and September 19. The semivariograms, which are graphic representations of NDVI's semivariance (with distances in meters) were adjusted according to the best correspondence model. After the adjustments were made, the data were interpolated using ordinary kriging and the semivariogram's adjustment parameters, and the results were displayed as isoline maps created using the ArcGIS 10.3 software.

Results and Conclusions

The results of the descriptive statistical analysis (Table 1) show average NDVI values ranging from 0.065 to 0.763 and with strong variation at each sampled date. As a result, the frequency distribution normality was not significant (5%) according to the Kolmogorov-Smirnov test. This variation is related to the seasonal variation in the average rainfall rate of Pirassununga according to the São Paulo State (*Secretaria de Estado de Saneamento e Recursos Hídricos*) (SÃO PAULO, 2016). The sampling refers to the dry season (sampled), from April to September, and June, July and August show low NDVI averages.

Table 1. Descriptive statistics of the NDVI values for nine dates during 2011.

Date	Average	Variance	Std.Dev.	C.V.	Minimum	Maximum	Skewness	Kurtosis
April 28	0.332	0.004	0.063	19.080	0.204	0.788	3.714	20.700
May 14	0.118	0.001	0.032	27.390	0.067	0.236	1.184	0.968
May 30	0.359	0.005	0.070	19.610	0.196	0.811	2.600	12.260
June 15	0.507	0.005	0.070	13.900	0.300	0.884	0.961	4.822
July 17	0.533	0.005	0.070	13.120	0.334	0.739	-0.596	-0.113
Aug. 02	0.636	0.008	0.087	13.700	0.371	0.807	-0.893	0.046
Aug. 18	0.065	0.000	0.003	4.161	0.057	0.072	-0.071	-0.068
Sept. 03	0.763	0.006	0.077	10.090	0.385	0.905	-1.787	3.137
Sept. 19	0.742	0.006	0.077	10.350	0.413	0.893	-1.954	4.504

Geostatistical analysis enabled the creation of semivariograms, which were adjusted individually, mostly using the exponential model, and tendencies for May 30 and June 15 were removed. All nine dates showed spatial dependency varying from 61 to 650 m. The semivariogram is shown for visualization purposes in Figure 1, scaled according to Vieira et al. (1997) and considering that the vegetation index values are at the same scale.

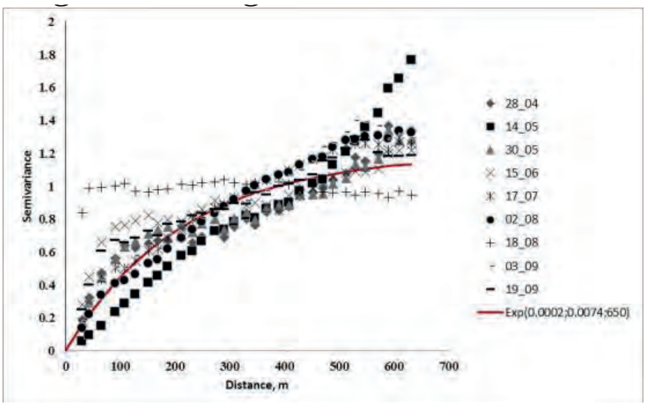

Figure 1. Scaled NDVI semivariogram adjusted using the exponential model for nine dates in 2011.

The maps obtained using ordinary kriging (Figure 2) show the monthly NDVI variation spatially. Places that were not sampled had their values interpolated.

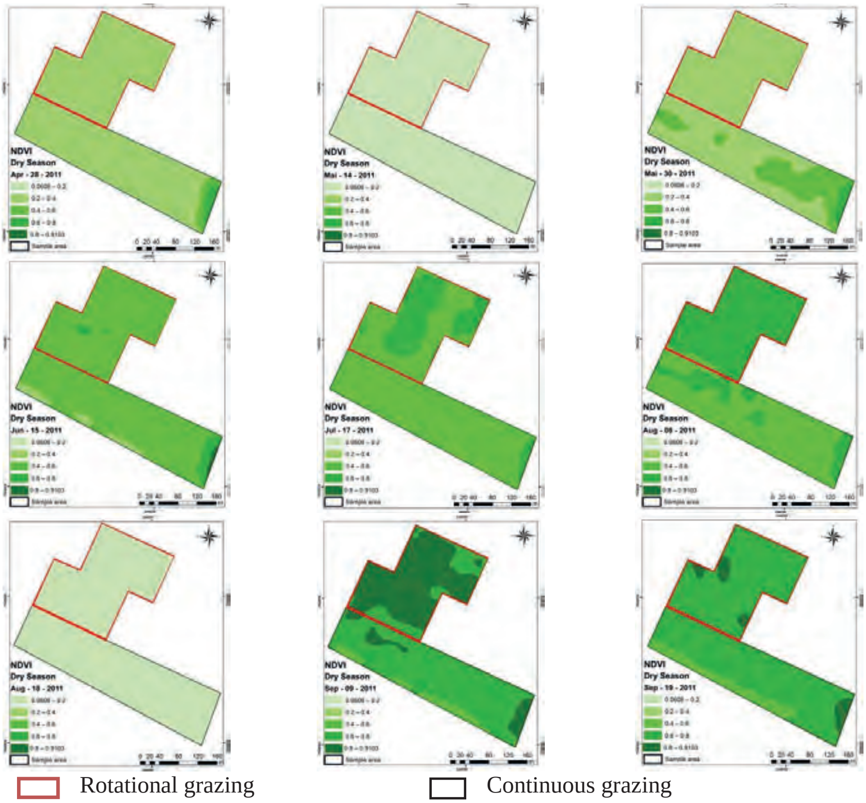

Figure 2. Maps of NDVI values interpolated using ordinary kriging in nine dates along 2011. The rotational grazing system leads to a better recovery of the pasture's vegetation index, even under water stress conditions, especially in July, August and September, except for August 18, when the whole area showed NDVI values lower than 0.2. We therefore conclude that resting the pastures enables restoring their leaf area index, thus leading to a greater soil coverage and hence reaching greater management efficiency.

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Correlation between physiological parameters and thermal infrared emissions from free ranging cattle

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Introduction

Thermally stressful environments may cause physiological and metabolic changes in farm animals, among these, a higher methane production by ruminants. In this context, the main thermoregulatory mechanism in homeothermic animals is an increase in surface temperature, although other physiological parameters such as heart and respiratory rates are also indicative of environmental heat stress (Hahn, 1985; Bouzida et al., 2009).

Infrared thermography, a technique that detects thermal radiation emitted by an object, is a non-invasive alternative to evaluate body temperature of free ranging animals.

Goal of this work was to correlate temperatures obtained by thermal imaging with physiological responses from grazing cattle in Central Brazil.

Material and Methods

The trial was carried out at Fazenda São Carlos, Três Lagoas Municipality, Mato Grosso do Sul State, Brazil (20 º 45’04 ’’ S and 51 º

40’42 ’’ W), in March and August 2015. Local weather pattern is Aw (tropical hot and humid), according to Köppen classification, with local average temperature and rainfall of 26°C and 1400 mm respectively.

54 young heifers from four different genetic groups were used, i.e, 14 Nellore (NEL), 12 ½ Angus x ½ Nellore (ANGNEL), 14 Senepol (SEN) and 14 ¼ x ¼ Brahman Nellore x 2/4 Senepol (TRI) with average initial live weight of 197, 235, 169 and 233 kg, and final weight of 252, 282, 221 and 276 kg, respectively. Average age was between five and seven months. Animals were kept in Brachiaria brizantha cv. Xaraés pasture, with ad libitum water supply and dry feed supplementation with commercial balanced feed on *creep feeding.*

Physiological parameters evaluated were: rectal temperature (TR °C) using digital clinical thermometer (Digi-temp, Kruuse®), introduced into the animal’s rectum with the reading bulb in contact with the mucosa and kept in this position until the read signal was heard. Temperature of skin surface (TSP, °C) and temperature of hair surface (TSPM, °C), read from the animal’s back were obtained using a portable infrared pyrometer (model 890, Instrutherm®). Heart beat rate (FC, beats/minute), was obtained by auscultation of the cardiac movements, for 15 seconds, using a stethoscope placed in the 4th intercostal space of animal’s right hand side.

Respiratory rate (FR, breaths/minute), was obtained through direct observation of animal1s flank movements for 15 seconds. FC and FR values were multiplied by four to estimate values for a one-minute evaluation.

Thermal emissions were measured through thermographic images from animal’s head and the left eye (Figure 1) using infrared imager Testo® (model 875 2i), set to emissivity of 0.95 (animals and biological material) palette for data recording set for hot and cold and 25mm lens (9°x7°). Later, in order to obtain the maximum and minimum values for head (TIC,°C) and eye temperature (TIO, °C), all images were analyzed through IRSoft® (Testo software), with palette for records set for hot and cold and definition for measuring points set for the options free form and circle. Correlations among the variables were obtained through SAS CORR procedure, version 9.4.

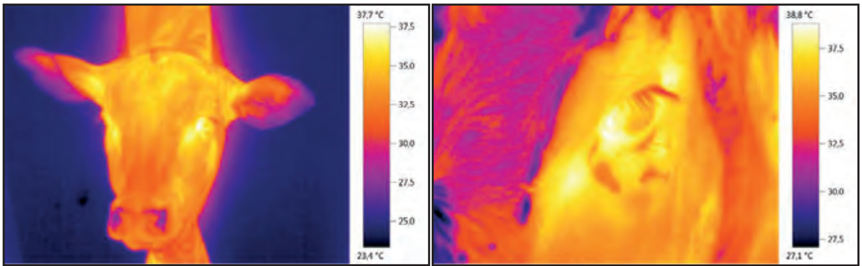

Figure 1: Infrared thermal images of the evaluated spots (head and eye).

Results and Conclusions

The thermoneutral zone in an animal is defined by NÃÃS (1989) as a range limited by the maximum and minimum temperature considered optimal for its husbandry, in which, maintenance of homeothermy occurs with minimal deployment of mechanisms responsible for thermal regulation.

High correlations ($P < 0.05$) were found between infrared eye temperature (TIO) and infrared head temperature (TIC) (0.77), and between temperature of hair surface (TSPM) and temperature of skin surface (TSP) (0.83). Moderate correlation was found between heart beat rate (FC) and respiratory rate (FR) (0.68), and weak correlations were observed between TIO and rectal temperature (TR) (0.41) as well as between TIC and TR (0.45) (Table 1).

In the literature, TR is considered the best indicator for predicting thermoregulation in cattle. Because in this work infrared thermography has shown low/moderate correlation with all other parameters evaluated, it does not hinder its use for inference about thermal regulation processes in cattle, since it is a technology that still needs better-defined protocols for use in free ranging animals.

Table 1. Correlations between thermography and physiological evaluations of different cattle genetic groups

Variable	TIO	TIC	TSPM	TSP	FC	TR	FR
TIO	1	0.77*	0.19	0.09	0.24	0.41*	0.14
TIC		1	0.24	0.23	0.25	0.45*	0.23
TSPM			1	0.83*	-0.17	0.35**	-0.21
TSP				1	-0.22	0.32	-0.17
FC					1	0.18	0.68*
TR						1	0.36**
FR							1

* Significance level with p <0.01; ** Significance level with p <0.05.

TIO: infrared eye temperature; TIC: infrared head temperature; TSPM: temperature of hair surface; TSP: temperature of skin surface; FC: heart beat rate; TR: rectal temperature; FR: respiratory rate

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Modeling Nitrous Oxide emissions in grass and grass-legume pastures in the western Brazilian Amazon

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Introduction

Mineral nitrogen (N) dynamics in soil and the exchange of N gaseous in the interface soil-atmosphere are intimately associated with animal manure in pastures. According to soil inorganic-N pools and the site studied, forest or pasture, and pastures age the soil inorganic-N pools of ammonium and nitrate can be similar in the forest or ammonium dominated in the pasture. Also annual average net nitrification rates at soil surface in forest can be higher than in pasture suggesting a higher potential for nitrate-N losses either through leaching or gaseous emissions from intact forests compared with established pastures (NEILL et al., 1995). To Melillo et al. (2001) nitrous oxide (N_2O) emissions from the newly created pasture (5.0 kg N_2O-N ha^{-1} yr^{-1}) were about two and one half times the forest emissions (9.0 kg N_2O-N ha^{-1} yr^{-1}) during the first 2 years and N_2O fluxes from pastures older than 3 years (1.4 kg N_2O-N ha^{-1} yr^{-1}) were on average about one third lower than fluxes from uncut forest (9.0 kg N_2O-N ha^{-1} yr^{-1}). One of the best predictor of N_2O flux from soil is the magnitude of the nitrate pool in the soil surface (VERCHOT et al., 1999, MELILLO et al., 2001). The N_2O emissions can be measured from samples from the field by gas chromatograph or estimated by process-based models. Denitrification-Decomposition (DNDC) model simulates carbon and nitrogen biogeochemical cycles occurring in agricultural systems (GILTRAP et al., 2010). Here we presented N_2O emissions simulated by DNDC model from grass (> 30 years old) and grass-legume pastures (> 4 years old after grass > 30 years old) and from soil of a native forest in the western Brazilian Amazon.

Material and Methods

The study was conducted to predict the soil N_2O emissions by DNDC in a Ultisol under a pure *Brachiaria humidicola* (Rendle) Scheick pasture (G) and a mixed pasture of *B. humidicola* and *Arachis pintoi* Krapov. & W. C. Greg cv. BRS Mandobi (GL), both without fertilization. A native forest (NF) classified as Bamboo open+dense, on the same soil type, was the reference. The experiment was stablished in 2011 at the Guaxupé farm (68° 05′ W, 9° 57′ S, 200 m a.s.l) in Rio Branco, state of Acre, Brazil. Deforestation of the experimental area occurred in 1981. Soil sampling was carried in G, in the GL, and in the NF, on the same soil type in 2014 Feb-Dec. and 2015 Jan-July in the 0-0.10 and 0.10-0.20 m layers. Soil analyses were according to Pecus network protocols and results and meteorological data were inputs to DNDC to predict N_2O emissions (LI et al., 1994) in the same period 2014 Feb-Dec. and 2015 Jan-July.

Results and Conclusions

Average N_2O emission in 166 days followed the order: pure pasture (35.8 μg N m^{-2} h^{-1}) > native forest (28.2 μg N m^{-2} h^{-1}) > mixed pasture (27.2 μg N m^{-2} h^{-1}). N_2O emissions were lowest in the season's transitions wet-dry and dry-wet and highest in the wet and dry characteristics seasons of the Brazilian Amazon.

N_2O emissions were correlated with water-filled pore space (WFPS 0-0.10 m) and soil temperature (0-0.1. m) in NF, G and GL ($P < 0.05$) and were no correlated with soil nitrate-N contents.

Annual N_2O emission was 3.13 kg N ha^{-1} yr^{-1} in G, 2.47 kg N ha^{-1} yr^{-1} in NF and 2.38 kg N ha^{-1} yr^{-1} in GL. The annual N_2O flux simulated is in the range fluxes tabulated by Verchot et al. (1999) to N_2O

fluxes in the humid tropical forests (0.3 to 6.7 kg N ha^{-1} yr^{-1}) and according to Meurer et al. (2016) to pastures.
Total predicted N_2O flux in the assessed period was 4.6 kg N ha^{-1} in G, 3.0 kg N ha^{-1} in NF and 2.7 kg N ha^{-1} in GL (Figure 1) and are higher than the reported by Melillo et al. (2001) for old pastures but are in the range reported by Meuer et al. (2016).

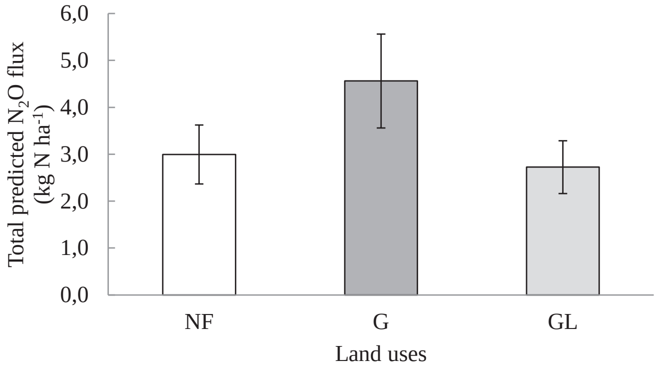

Figure 1. Total predicted N_2O flux at the Guaxupé farm, Acre State, Brazil. NF = native forest. G = single pasture of *Brachiaria humidicola* and GL = mixed pasture of *B. humidicola* with *Arachis pintoi* cv BRS Mandobi. Values are mean of 38 simulations of the soil parameters that were the inputs to DNDC. Bars are standard deviation.

Although in the range of N_2O fluxes measured across the Brazilian Amazon, the N_2O fluxes estimated by DNDC in this study should be treated with caution, as the fields' results to N_2O emissions are not yet available to comparison with simulated fluxes.

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WEB PLATFORM FOR GEOSPATIAL INFORMATION: APLICATIONS FOR GEOPECUS PROJECT

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Introduction

According to the IPCC (2014), livestock is responsible for a large portion of CH_4 emissions, originated mostly from enteric fermentation. However, establishing the dynamics of greenhouse gases (GHG) is very complex, especially for integrated production systems such as silvopastoral, which are seen as alternatives to reduce GHG emissions (BERNDT, 2010). In this context, the PECUS Research Network - Greenhouse Gases Dynamics in Brazilian Livestock Production Systems - was created by Embrapa (Brazilian Agricultural Research Corporation) in order to evaluate GHG dynamics in agricultural systems in six Brazilian biomes (Atlantic Forest, Caatinga, Pantanal, Pampa, Amazon and Cerrado), envolving more than 300 Brazilian and international researchers. The GeoPECUS - Geotechnologies Applied to Dynamics of Greenhouse Gases in Brazilian Agriculture - project has the responsibility to support PECUS with geotechnologies based on remote sensing, generating information which may subsidize the government in the creation of environmental and economically sustainable policies for agriculture.

Geospatial data generation and storage capacity are growing as consequence of increased computational resources available to users from various sectors, including remote sensing (BAYMA-SILVA et al., 2015). Researches in the environmental area apply geoprocessing and WebGIS (GIS system that uses web technologies) as powerful tools for spatial analysis and environmental management. According to Barriguinha (2008), the internet can be considered a privileged environment to make available large amounts of geographic information, expanding its access. A process for geospatial data organization is needed in order to make this type of information accessible and understandable to potential users.

The National Commission of Cartography (CONCAR), through the work of its specialized committees, have set standards and rules to be adopted in the production and publishing of geospatial data and information by public institutions. Considering this, the Brazilian National Spatial Data Infrastructure (INDE) was instituted with the purpose of cataloging, integrating and harmonizing existing geospatial data in Brazilian government institutions. Thus, this data can be easily located, explored and accessed for various uses, by any client with access to the Internet. Geospatial data should be cataloged using their respective metadata, published by the producers/maintainers of such data. The coordination of this infrastructure is responsibility of CONCAR.

The aim of this article is to describe and report how the GeoPECUS project is using the standards and rules established by the Brazilian National SDI to publish and organize the geospatial data produced by the PECUS Research Network.

Material and Methods

For the present project, it was used Embrapa Spatial Data Infrastructure, GeoInfo (Drucker et al. 2015) - Figure 1. One of its tools is Geonode (http://www.geonode.org), which is a web-based application and platform for developing Geospatial Information Systems (GIS) and for deploying spatial data infrastructures (SDI). It is designed to be extended, modified and can be integrated into existing platforms. Considering this, Geonode was adapted in order to present all the fields recommended by CONCAR, especially in metadata information. CONCAR metadata specifications are based on widely adopted OGC standards, specially ISO-19115.

Figure 1. Main interface of GeoInfo: Embrapa Spatial Data Infrastructure

A pattern in the attribute tables of the geospatial data was planned to allow that all experimental areas of the GeoPECUS project, which are the same of PECUS Research Network, have the same variables, so that it would be possible to make comparisons and other analysis. The geospatial data comprises detailed information about the production systems and vector archives of the experimental areas. It also comprises the orbital images of the experimental areas, from different satellites (Geoeye, Ikonos and WorldView), ortoretified and added into GeoInfo as layers.

Maps were elaborated in A0 format and uploaded as image files and attribute tables of the experimental areas were transferred to platform as documents. All metadata information was cataloged and is available in the platform as shown in Figure 2. Furthermore, it shows all tabs available in GeoInfo related to geospatial information.

Figure 2. Visualization of one layer example of geospatial information available in GeoInfo, highlighting the metadata link.

All data previously reported was uploaded in this platform in its respective tabs, for example, “Layers” for the boundaries shapefiles and ortoretified images, “Documents” for the shapefiles’ table of attributes and A0 maps. In the tab “Maps”, maps were elaborated for the

respective experimental areas, highlighting the production systems and ortoretified images that were added as base to these layers. It is important to highlight that the permission to download, visualize, edit a layer or metadata information is given by the platform user, according to the rules established by GeoInfo.

Results and Conclusions

Until now, it was uploaded information of twenty-three experimental areas of GeoPECUS project: files in vector format, table of attributes related to the experimental areas organized in spreadsheet format and also twenty-three maps related to these areas. Among these areas, six correspond to the Amazon Rainforest biome, six to the Cerrado biome, five to the Atlantic Forest biome, three to the Pampa biome, two to the Caatinga biome and one to the Pantanal biome. Thirty-five A0 maps were uploaded as image files, but not all areas were covered by A0 maps and some of them were covered by more than one. The GeoInfo platform contains not only GeoPECUS data but also geospatial data from other projects (e.g. Climatic Risk Zoning), which indicates that this web platform is an efficient tool to organize geoinformation and disseminate this type of data to researches, who may seek references. Furthermore, it is a way to give publicity to the results achieved in the PECUS Research Network for the general population.

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Landsat-based above ground biomass estimation in pasture area in São Paulo, Brazil

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Introduction

Brazilian Cerrado biome occupies 2,039,243 km², of which 29.5% (600,832 km^2) is planted pasture area (MMA, 2015). A considerable portion of these pastures are considered degraded, thus identification and recovery of such areas could result in production gains. In the remote sensing (RS) context, pasturelands have been investigated in order to discriminate intensive and extensive grazing system areas. Intensive systems includes soil and animal management, with pasture fertilization and animal rotation in different paddocks. Extensive grazing systems do not have this management. As RS medium spatial resolution data and field measurements on biomass estimates have strong positive correlation (EDIRISINGHE et al., 2012) future researches points to assess the feasibility on grazing systems discrimination through temporal analysis. Thus, the objective of this work was to assess the Surface Algorithm for Evapotranspiration Retrieving (SAFER) potential, applied in with OLI/Landsat-8 images, to discriminate intensive and extensive grazing system areas through estimates of above ground biomass.

Material and Methods

The study area is an experimental pasture area in the Cerrado biome, located in Pirassununga, São Paulo state. It consists of six rotational (RGS) and three extensive grazing system (EGS) paddocks (Figure 1).

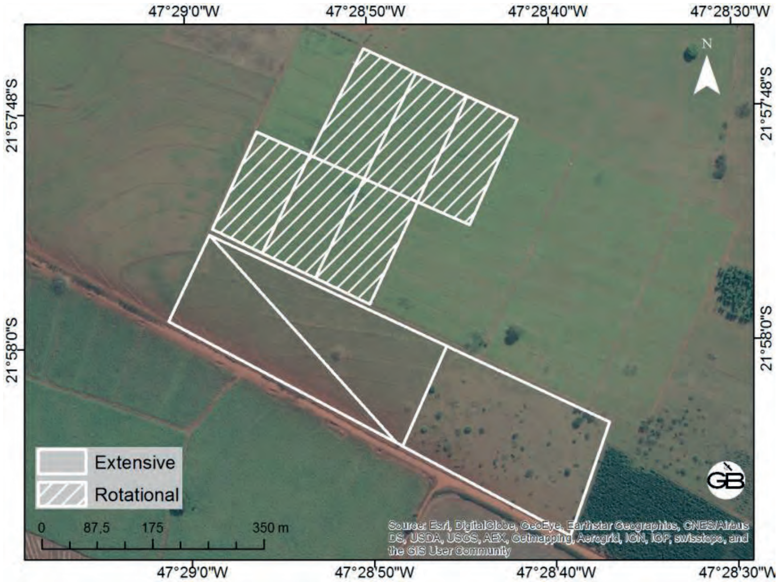

Figure 1. Experimental design from the study area

Landsat-8 images of the dry and rainy seasons from 2013 to 2015 were used, resulting in 29 cloud-free images. Dry period extends from April to September and wet, from October to March. Cumulative precipitation was 1,599.8mm, 1,046mm and 1,612.80m for years 2013, 2014 and 2015, respectively. Bands 1-7 and thermal bands 10 and 11 were used with climatic data from a weather station located inside of experimental area borders. Schematic flowchart of SAFER algorithm, described by Teixeira et al. (2015), can be observed in Figure 2.

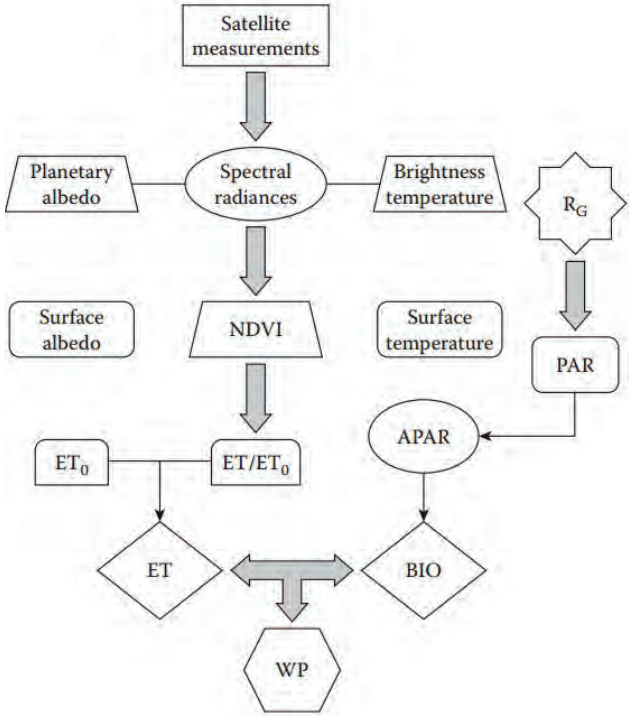

Figure 2. Schematic flowchart of SAFER algorithm. RG is the global solar radiation, PAR is the photosynthetically active radiation, aPAR is the photosynthetically active radiation absorbed, BIO is the biomass, NDVI is the Normalized Difference Vegetation Index, ET is the Evapotranspiration, ET0 is the Reference Evapotranspiration and WP is the Water Productivity. Source: Teixeira et al. (2015).

Results and Conclusions

Figure 3 shows temporal biomass estimates from 2013 to 2015 in kg ha^{-1} day^{-1}, obtained from the SAFER model. Lower accumulate precipitation values influenced vegetation production in 2014. As expected, in 2013 and 2015 biomass was higher on rotational than extensive grazing systems on most of images. In dry period, mean biomass for RGS was 48.5, 31.1 and 55.5 kg ha^{-1} and in extensive grazing system, 26.2, 23.4 and 27.7 kg ha^{-1} in 2013, 2014 and 015, respectively. In wet season, mean biomass for RGS was 54.1 and 82.1 kg ha^{-1} and in extensive grazing system was 25.9 and 45.7 kg ha^{-1} in 2013/2014 and 2014/2015, respectively (Table 1).

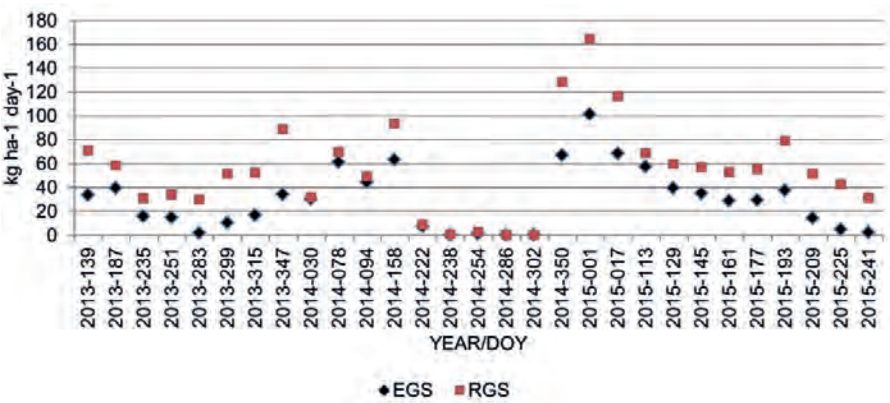

Figure 3. Biomass estimates using SAFER model for extensive grazing system (EGS) and rotational (RGS) paddocks.

Table 1. Mean biomass estimative per period, in kg ha^{-1}.

Production systems	DRY 2013 (4)*	WET 2013/14 (6)*	DRY 2014 (5)*	WET 2014/15 (5)*	DRY 2015 (9)*	2013-2015 MEAN (29)*
Extensive	26.2	25.9	23.4	45.7	27.7	29.8
Rotational	48.5	54.1	31.1	82.1	55.5	54.6

* Landsat images

SAFER algorithm is a feasible tool on biomass estimates. Future works should take into account *in situ* data in order to calibrate SAFER algorithm. Thus, the biomass can be estimated in large areas through upscaling process.

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PECUS Network, Greenhouse gases (GHG) dynamics in Brazilian livestock production systems.

Discrimination of Pastures in Beef Cattle Production Systems with Remote Sensing-Based Vegetation Index

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Introduction

The objective of this study was to discriminate different pastures in beef cattle production systems using Normalized Difference Vegetation Index (NDVI) temporal data, from April 2013 to August 2015, at experimental pasture areas located at Embrapa Pecuária Sudeste - Canchim Farm, São Carlos – SP. Vegetation photosynthetic activity and production are related with NDVI values and this index has been utilized as an indicator on livestock production systems discrimination (Blanco et al., 2008, Alvarenga, 2015). The identification of degraded pasture areas is important as the recovery contributes, in the long term, to the mitigation of greenhouse gases (Oliveira, 2015).

Material and Methods

The study area is located at the Mata Atlântica biome (Brazilian Atlantic Forest with average annual precipitation of 1,362 mm, average annual temperature of 21.5ºC and humid subtropical climate. The experimental design had the following cattle production systems: (A) irrigated with intensive management and high stocking rate (INTIRRI_AL), (B) dryland with intensive management and high stocking rate (INTSEQ_AL) and (C) recovering pasture with medium stocking rate

(REC_ML).all pastures were managed in the rotational system. Descriptions of the three systems are in Table 1.

Table 1. Livestock (cattle) production systems description.

Production system	Grass	N dosage (kg/ha)
INTIRRI_AL	*Panicum maximum*	600
INTSEQ_AL	*Panicum maximum*	400
REC_ML	*Brachiaria decumbens; Brachiaria brizantha*	200

Values of NDVI were extracted from OLI/Landsat-8 images according to the methodology described by Conceição et al. (2015). Temporal data consisted of 30 cloud-free images, from April 2013 to August 2015. Values of NDVI of each production system were clustered in: dry period of 2013, 2013/2014 wet period, dry period of 2014, 2014/2015 wet period and dry period of 2015. Kruskal-Wallis ANOVA statistical analysis was applied in order to discriminate each production system in each described period ($p < 0.05$).

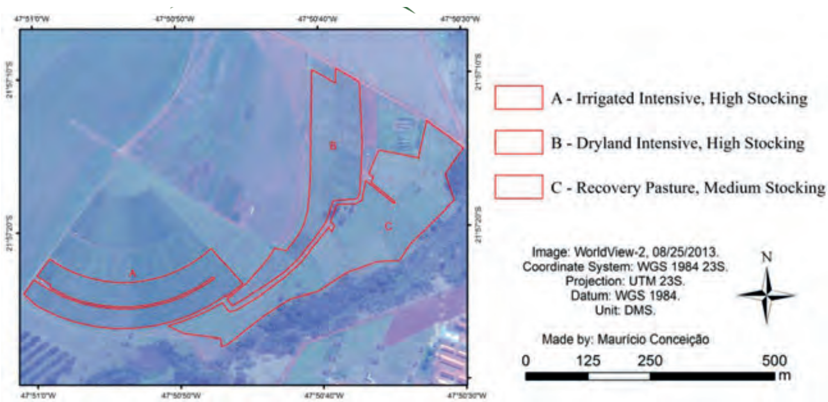

Figure 1. Study area experimental design with the three beef cattle production systems.

Results and Conclusions

Figure 1 shows mean NDVI values in each experimental area for each OLI/Landsat-8 image. In most days of the temporal series, recovering pasture (REC_ML) and dryland intensive pasture (INTSEQ_AL) had the highest and lowest mean NDVI values, respectively. Recovering pasture had also higher mean NDVI value (0.72), than irrigated (0.70) and dryland (0.66) intensive managed pastures, and this can be explained by the cespitose habit of *Panicum maximum* grass cultivated in INTIRRI_AL and INTSEQ_AL, which forms clumps, exposing the soil. Light from soil surface decreases NDVI values due to non photosynthetic activity. (Table 1).

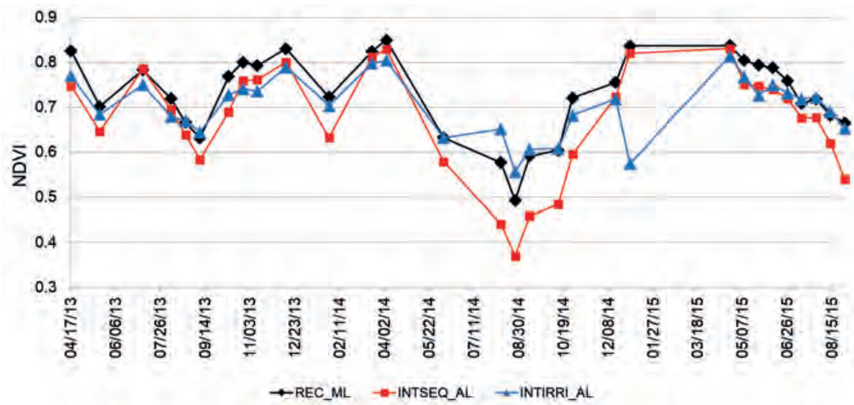

Figure 1. NDVI values for pastures in beef cattle production systems

Table 1. Seazonal NDVI values of pastures in beef cattle production systems.

Production system	DRY 2013 (6)*	WET 2013/14 (6)*	DRY 2014 (5)*	WET 2014/15 (4)*	DRY 2015 (9)*	2013-2015 MEAN (30)*
INTIRRI_AL	0.67ab	0.75a	0.65a	0.64a	0.73ab	0.70
INTSEQ_AL	0.69a	0.74a	0.53b	0.65a	0.70a	0.66
REC_ML	0.73b	0.79b	0.63a	0.73b	0.75b	0.72

* Landsat images

As expected, water availability and higher N dosage resulted in higher mean NDVI in the irrigated and intensively managed pasture (INTIRRI_AL), compared to the intensive managed dryland pasture (INTSEQ_AL), as a result of higher forage mass in the area.

In the dry period of 2013, dryland intensive (INTSEQ_AL) differed from the recovering pasture (INTREC_ML) but neither differentiated from the irrigated intensive (INTIRRI_AL). In 2013/2014 wet period, the recovering pasture differentiated from the *Panicum maximum* experimental areas (INTIRRI_AL and INTSEQ_AL) which had similar NDVI. The irrigated intensive (INTIRRI_AL) and recovering pasture (INTREC_ML) were similar in the dry period of 2014 and different from the dryland intensive (INTSEQ_AL). Results had the same pattern in the wet periods of 2014/2015 and 2013/2014 and dry period of 2013 and 2015. Our findings contribute to monitor different beef cattle production systems. Futures works should consider *in situ* biomass data in order to correlate these data with NDVI values.

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Perspectives and scenarios for carbon balance in forest remnants of the Atlantic Forest using remote sensing time series

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Introduction

Time series of remotely sensed images have been successfully used for the practical monitoring forest and change detection. In the present study, we performed an estimation of Standardized Vegetation Index (SVI) (Park et al., 2008; Leivas et al., 2014) from 16 days MODIS (Moderate Resolution Imaging Spectroradiometer) NDVI (Normalized Difference Vegetation Index) time series of satellite images. The first stage was to identify vegetation anomalies in spring 2012, that means below or above historic NDVI average values in the forest remnants of Zona da Mata region, Atlantic Forest biome, Minas Gerais, Brazil. These anomalies are characterized as variations in vitality of vegetation, classified by NDVI values higher or lower the average values for the analyzed period. The aim of this work was to estimate, classify, and quantify SVI by mapping forest vegetation variation and comparing with remote sensing data about carbon sequestration balance according estimates of net carbon in relation to his proportion in forests, available in literature (Aduan et al., 2004; Amaro et al., 2013; Figueiredo et al., 2015).

Material and Methods

The study area is characterized by semideciduous seasonal forest remnants, and remote sensing-based monitoring allows evaluating the vegetation index variability compared to precipitation records. We analyzed MODIS NDVI series from 2000 to 2012, to derive the SVI. The 16 days NDVI from September 2012 to December 2012 was compared to 2000- 2011 average of same year period. SVI values were classified as below normal, normal, and above normal. The net carbon sequestration was estimated through literature data, considering predominant forest species and forest typology. In this study was classified as predominance of pioneer species for below normal SVI class, with lower potential increase of net carbon (0.5 $ton.ha^{-1}.year^{-1}$), late secondary species for normal class, with stable conditions of increase (1.5 $ton.ha^{-1}.year^{-1}$), and early secondary for above normal SVI class, with higher potential increase (2 $ton.ha^{-1}.year^{-1}$).

Results and Conclusions

The current forest remnants area in the Zona da Mata region (Figure 1) is approximately 400,000 hectares. Based on the methodology proposed in the present study, 5.5% of forest remnant's total area were classified as below normal, 75% as normal, and 19.5% as above normal SVI considering the first half of September 2012. Along the period in the second half of October 2012, 17% were classified as below normal, and 17% above normal SVI.

However, in the second half of December 2012 reached 19% as below and 9% above normal SVI, denoting increase in vegetation anomaly compared to average for the period. We conclude that considering the current forest area of the Atlantic Forest remnants in the Zona da Mata, from predominant forest typologies and carbon balance based on literature data, on average, it is estimated that about 587 thousand tons of net carbon will be sequestered by year, approximately, from spring 2012 (Table 1).

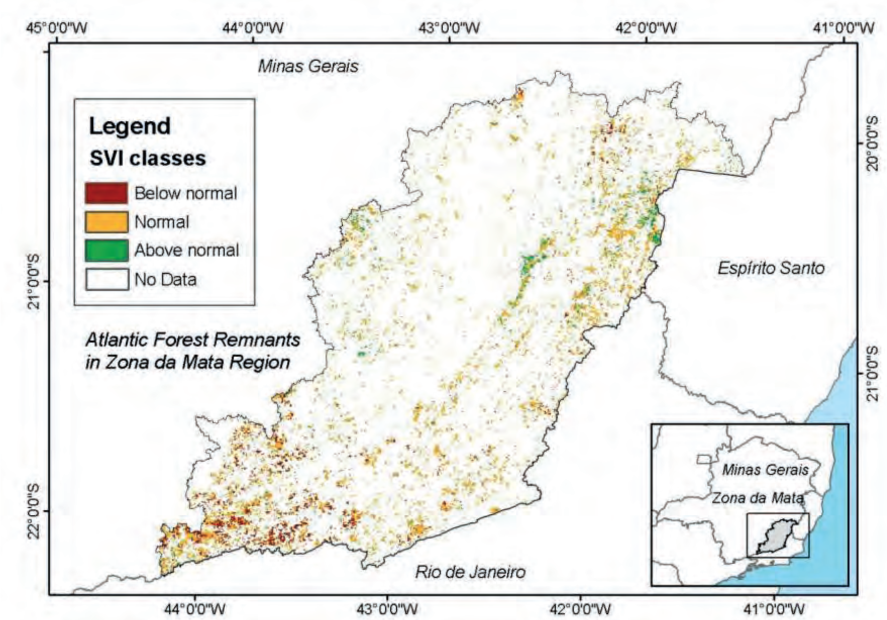

Figure 1 – SVI classes for 16 day period on late December 2012.

Table 1 – Area and net carbon by SVI class, equivalents to forest typologies, from spring 2012.

SVI class	Area (ha)	Net C by typology* ($ton^{-1}.year^{-1}$)
Below normal	47,629.70	23,814.85
Normal	292,810.25	439,215.38
Above normal	62,110.18	124,220.35
Total	402,550.13	587,250.58

* Areas with predominan ce of pioneer (be low normal SVI), late secondary (normal) and early secondary (above normal) species.

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An Optimization Model to Deal with Livestock Production and Emissions While Maximizing the Overall Net Revenue

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Introduction

The Brazil is second world´s largest beef producer (FAO, 2016), with a great variety of climate and natural resources on its Biomas. The grassland area allocated to livestock systems is about 170 Mha, with a great variety of production systems adopted on each one of them (IBGE, 2016). Beef production systems have different input of resources and result on different outputs, as beef, money and greenhouse gases (GEE) emissions. Finding promising solutions dealing with the complexity of the drivers of the trade-offs between profit, production and GEE´s is not trivial. Some authors have evaluated such trade-offs through detailed mathematical models of the technological dynamics in a production system (OLIVEIRA SILVA et al, 2015; 2016).

This work uses an alternative approach where the transition of production systems is modeled. The main objective was to develop a linear programming optimization model with that could represent the dynamics of cattle production system's adoption, maximizing the total net revenue or family revenue profit over the period on different future scenarios. Those considered a beef demand to be met, the amount of capital available, the maximum GEE emission, while complying with constraints considering the producer´s low inclination to adopt new technologies.

Material and Methods

The optimization model is a linear integer programing model that seeks to maximize the Brazilian beef cattle net revenue or family revenue (GUIDUCCI et al, 2012) over a designed horizon of time. The model´s decisions variables include the area allocated to a specific production system, in a specific Bioma on each year; and the area, on a specific Bioma, which changes from a production system (exit system) to another available system on the model (system adopted).

The solution is subject to (I) Meet the annual beef demand projected over the period; (II) Maximum annual greenhouse gases (GEE) emissions (considering soil carbon absorption, emissions by cattle and pasture fertilization) must be lower than a level designated. (III) The demand capital to invest on structure, pasture and animals for land use change, must be lower them the financial resource available.

Other constraints were set to deal with flows among the land use options (the land use on year t is equal to land use on anterior year, plus the amount of land that change from other production systems to this one, minus the land changed from this production system to others). Additionally, a set of constraints was set to allow the model to mimic the fact that, in general, producers are averse to changes. The model then uses three groups of inertia equations: the first one constrains the maximum annual area available for conversion from each production system to all others on the same Bioma (system inertia constraint). The two remaining groups of equations constrains the amount of land available to conversion from other production systems to a specific one (system aversion constraints), the first is based on a percentage of the land already in use on the production system, the second on an absolute value. The model chooses endogenously the equation that allow the greatest land amount available to each production system on each ear. The model also deal with the equilibrium on the supply and demand of calves between the productions systems. The first group of equations balance the supply and demand of male calves between the Amazon´s production systems. The second deal with the balance of female calves between production systems on Cerrado, Mata Atlântica and Pantanal. The last group deal with the male calves between those systems plus a number of male calves supplied by dairy operations, set as an exogenous parameter.

The model was implement on General Algebric Modelling System (GAMS), version 23.7.3, and solved on CPLEX version 12.3.0.

Results and Conclusions

The Picture shows some of the results of the model described herein. On Figure1a it is possible observe an increase in Net Revenue, Family Revenue and beef production, a slightly increase on Soil Carbon, and a greenhouse gases emission´s (GEE´s) over time. The emission intensity stays stable around 30 MgCO2eq/ton until 2015, and then falls to

26.5 at the in 2023. Figure 1b illustrates the corresponding allocation of different types of production systems in the solution for the Cerrado Biome.

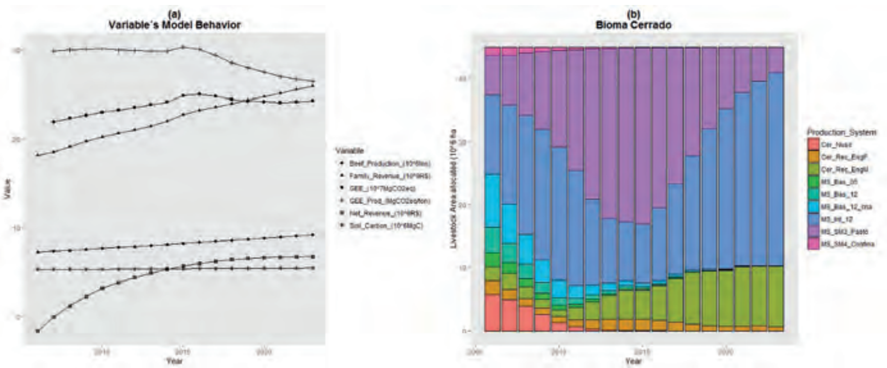

Figure 1 – (a) Dynamics of beef production, total GEE emission, emissions intensity, soil carbon stocks, net revenue and family revenue in preliminary results for one specific scenario for the five Biomes considered. (b) Dynamics of land allocation for different types of production systems for the Brazilian Cerrado.

Those results encourage the model´s use as a tool to analyze public and private policies dealing with livestock revenue, production, investment and emission. The model improvement by the PECUS project´s research team continues, as its validation aiming to analyze possible trade- offs between GEE´s goals and investment, and their impact on net and family revenue on some scenarios. Those will consider the international agreements and perspectives about GEE´s, income and population growth, beef and investment demand behavior and producer´s willing to adopt new technologies.

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IPCC TIER 2 Approach to Estimate Enteric Methane (CH_4) Emissions in the Livestock Sector of the Amazon Biome

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Introduction

The Brazilian state of Pará features a large bovine herd, which amounted to around 20 million heads in 2014, the fifth largest producer in the country (IBGE, 2015). In quantitative terms, this herd's greenhouse gases (GHG) emissions classify it among the five largest enteric methane (CH_4) emitters in Brazil. The countrywide assessments and scenarios forecast by Barioni et al. (2007) indicated that the values obtained in 2007 might decrease by 2025 due to better efficiency in beef cattle farming Brazil. Those authors forecast increases by 7.4% in the country's herd and by 25.4% in meat production in face of enhanced productivity indicators. Meanwhile, methane emissions were estimated to increase by 2.9%, meaning a decrease by 18% per meat unit produced compared to 2007.

According to Berndt (2012), there are different strategies to decrease GHG emissions by livestock farming, particularly concerning the activity, nutritional, and reproductive managements, besides the adoption of integrated production systems. Techniques such as crop-livestock-forest (CLF) integration may be adopted so that Pará meets those nationwide GHG reduction forecasts. Among the cities in the state, Paragominas stands out for its effort in employing production systems that result in lower GHG emission indicators, supported by the obtention of the "Green City" seal in the Amazon. This study aimed to estimate enteric methane emissions by the beef cattle herd in the state of Pará based on TIER 2 of the Intergovernmental Panel on Climate Change (IPCC).

Material and Methods

The data used in the study on the number of cattle heads in the state of Pará refer to the period between 2006 and 2015, obtained from the Agriculture and Livestock Defense Agency of Pará (ADEPARA). The information on the bromatology of the main forage grasses grown in the state, as well as data regarding supplementation, were taken from the technical- scientific literature. In order to calculate emissions, the methodology developed by the IPCC (IPCC, 2006) was employed using the methodological assumptions of TIER 2 (Table 1). This methodology allows estimating emissions for each animal category and is based on the estimated gross energy and digestible energy intakes while taking into account the energy requirements for maintenance, growth, and activity. The weight of each animal category, mean daily weight gain, diet quality, and production system were analyzed.

Table 1. TIER 2 approach

Metabolic functions and other estimates	Equations
Maintenance	$NEm = Cfi.(Weight)^{0.75}$
Activity	$NEa = Ca.NEm$
Growth	$NEg = 22.02\,(BW/C.MW)^{0.75}.WG^{1.097}$
Draft Power	$NEwork = 0.10.NEm.hours$
Ratio of net energy available in diet for maintenance to digestible energy consumed (REM)	$REM = [1.123 - (4.092.10^{-3}.DE\%) + [1.126.10^{-5}.(DE\%)^2] - (25.4/DE\%)$
Ratio of net energy available for growth in diet to digestible energy consumed (REG)	$REG = [1.164 - (5.160.10^{-3}.DE\%) + [1.308.10^{-5}.(DE\%)^2] - (37.4/DE\%)$
Gross Energy	$GE = [(NEm + NEa + NEwork)/REM + (NEg/REG)]/\ DE\%/100$
Emission Factors	$EF = [GE.(Ym/100).365/55.65]$

Results and Conclusions

It was observed that the total enteric methane emissions differed among the mesoregions of Pará. Only the mesoregion comprising the South and Southeast of the state showed an increase in enteric methane emissions between 2006 and 2015 since the state's cattle herd is concentrated in this region. On the other hand, the lowest enteric methane emission values were found in the mesoregion of the Low Amazon and Marajó, where the state's most expressive buffalo herd is found. In 2006, this value was 0.3 times lower than that obtained in the Belém Metropolitan Area and Pará Northeast mesoregion and 0.075 lower than that obtained in the same year for the Southwest and Southeast mesoregion of the state. 2014 and 2015 had the lowest emissions among the nine years analyzed, except in the South and Southeast mesoregion of the state, which had opposite values. Therefore, 2014 had emissions of 302.62 Gg.year^{-1} while the emissions in 2015 were of 308.36 Gg.year^{-1}(Figure 1).

It is concluded that the highest estimated emissions are associated with the mesoregions featuring the largest bovine herd in Pará and that the highest emissions took place in 2015.

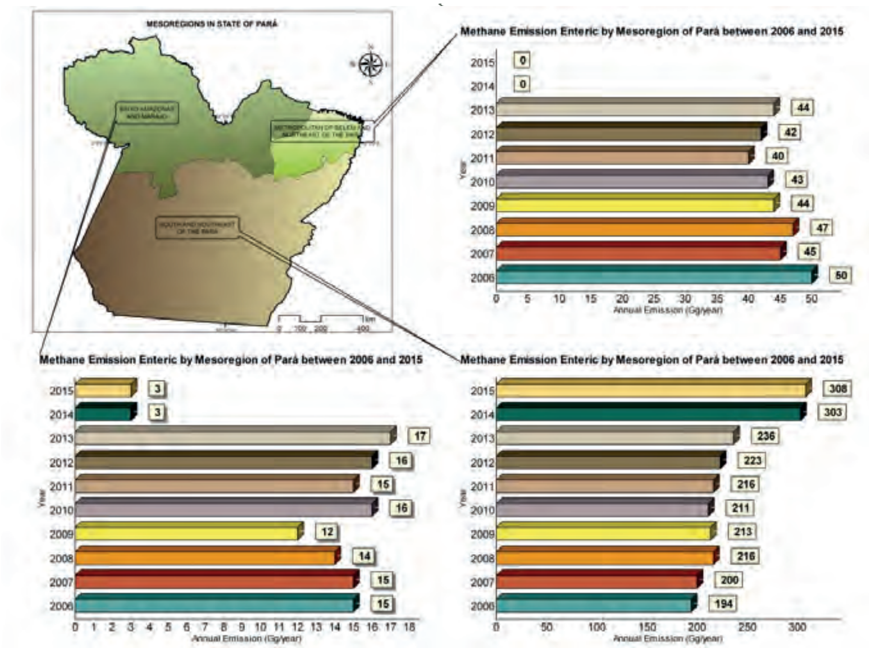

Figure 1. Enteric methane emission in the mesoregions of the state of Pará.

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An equation to determine demand-constrained pasture restoration area

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Introduction

Pasture restoration is a major part of the Brazilian NAMAs (Mozzer 2011) and INDCs (Brazil, 2015) and is operationally encouraged through a government-funded bank credit line for low carbon agriculture (Mozzer 2011). Beef production is the major grassland based activity in Brazil. Therefore, pasture restoration area targets should harmonize with projected demand for beef in order to avoid under and over production and negative impact on prices. Pasture restoration area has been previously estimated by large mathematical programming models (Oliveira Silva et al., 2016) but the development of a single equation model is useful to improve understanding and transparency of the estimates and the interpretation of such large models' results. The objective of this work is to develop an equation to determine pasture restoration area based on beef demand and to use it to analyze the responses of pasture restoration to their conditioning factors in the Brazilian context.

Material and Methods

An equation to estimate pasture restoration area (R, ha) as function of beef demand (D, kg CWE.yr^{-1}) was deduced as follows. Let N be the number of animals (N, heads) in a given pasture area. The variation in animal numbers ($N_f - N_i$) in a given period can be described by equation (1).

$$N_f - N_i = \delta N + N_i - N_{out}, \quad (1)$$

where, Ni and Nf are the number of animals at the beginning and at the end of a period of time, respectively; δN_R is the difference between the number of animals before and after recovering a pasture area (R, ha); N_{in} and N_{out} are the number of animals in areas where grasslands have expanded and contracted, respectively. Stocking rate (S) is defined as ratio between number of animals and grassland area (A, ha), i.e. $= \frac{N}{A}$, therefore $N = A.$. So:

$$\delta N_R = R.(S_r - S_d) = R.\delta S, \text{and,} \tag{2}$$

$$N_{in} - N_{out} = \delta A.S_h \tag{3}$$

Substituting (2) and (3) in (1), and isolating R:

$$R = \frac{\delta N - \delta A.Sh}{\delta S} \tag{4}$$

Hereafter we assume production and demand are in equilibrium. Beef production is the product of the number of animals and production per animal (C, kg CWE.head^{-1}.yr^{-1}), i.e. $D = C.N$. Note that for the analysis herein, C represents the lifecycle average productivity of the herd. The variation in D is due to variations in N and in C as described in equation (5):

$$\delta D = \delta N.C_i + Ni.\delta C + \delta N.\delta C \tag{5}$$

A multiplier P, which is the proportion of production variation due to variation in N is useful to study the pathways of intensification. In a high time resolution, $\delta N.\delta C$ is very small relative to the other two components (lower than 1/50 for Δt = 1yr in the Brazilian conditions). So we can define P as, according to (6).:

$$\delta D.P = \delta N.C_i \therefore \delta N = \frac{\delta D}{C_i}.P \tag{6}$$

Also, let's define the ratios of final over initial, demand (α_D) and animal numbers (α_N), according to equations (7) and (8).

$$\alpha D = \frac{Df}{D_i} \therefore \delta D = Di.(\alpha D - 1) \tag{7}$$

$$\alpha N = \frac{N_f}{N_i} \therefore \delta N = N_i.(\alpha N - 1) \quad (8)$$

Replacing appropriately the definitions in equations (6), (7) and (8) in equation (4), and assuming the average stocking rate for expansion and contraction grassland areas (S_h) is equal to the initial stocking rate, i.e. $S_h = \frac{D_i}{C_i.A_i}$, one can calculate R as in equation (9):

$$R = \frac{D_i}{\delta S.Ci}\left((\alpha_D - 1).P - (\alpha_A - 1)\right) = \frac{D_i}{\delta Yi}\left((\alpha_D - 1).P - (\alpha_A - 1)\right) \quad (9)$$

where $\delta Y_i = \delta S.C_i$ is the difference in productivity between restored and degraded pastures.

Results and Conclusions

According to Equation 9, the main factors defining the area of pasture restoration are the initial demand and its rate of growth, the overall variation in pasture area, the difference in productivity between recovered degraded areas and the rate of expected variation in animal performance.

Results of a sensitivity analysis of the rate of increase of demand to the specified factors, fixing initial demand (D_i) to 10.0 MMT CWE, i.e. approximately the Brazilian current national production. The results highlight the importance of growth in beef demand to achieve the NAMAs target rates of pasture restoration in Brazil and suggest that if a high proportion of production increase is due to animal performance improvement, NAMA restoration targets may turn out to be unattainable (Figure 1). Comparing Figure 1 (a), (b) and (c) it is also possible to evaluate that pasture area expansion may also impair the target achievement.

Applying the expected range of Brazilian beef demand growth rates (1.25 – 2.00 %.yr^{-1}), results presented in Table 1 indicate target rates of pasture restoration in Brazil (1.9 M ha.yr^{-1}) would most likely be achieved in scenarios of pasture area contraction (i.e. $\alpha_A < 1.0$), associated with moderate levels of improvement of animal performance ($\leq$ 50% of total productivity gain) and change in productivity of the recovered areas ($\leq$ 80 kg CWE.ha^{-1}.yr^{-1}).

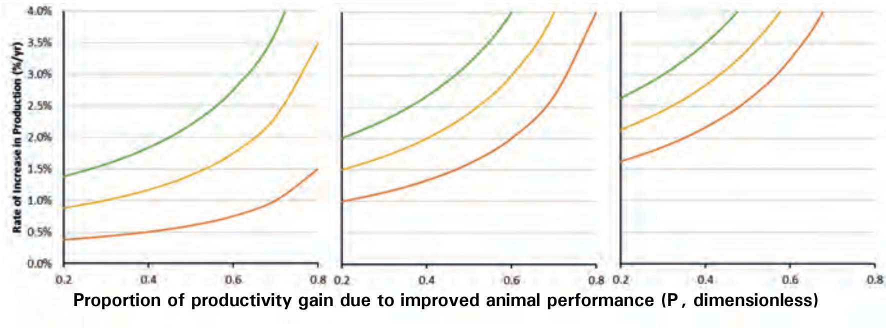

Figure 1. Rate of beef demand growth (αD) required to achieve pasture restoration rates of 1.9 Mha.yr-1 for different rates of variation in area (αA), difference in productivity of recovered – degraded pastures (δY) and proportion of production gain due to improved animal performance (1-P). αA values of 0.995, 1.000 and 1.005 correspond a variation of approx. (-0.79, 0 and +0.79 Mha.yr-1).

Table 1. Intervals of area recovered (M ha.yr-1) for different levels of α, δY and P. Lower and upper limits correspond to annual rates of growth in demand of 1.25% and 2.00 %, respectively. Intervals in red indicate the range is lower than rates for pasture restoration proposed in the Brazilian NAMAs (direct + crop-livestock).

		Proportion of productivity gain due to variation in animal performance (1-P)								
		25%			50%			75%		
		Area variation (α)								
		-0.5%	0	0.5%	-0.5%	0	0.5%	-0.5%	0	0.5%
δY (kg.ha.yr-1)	40	[3.6 , 5.0]	[2.3 , 3.8]	[1.1 , 2.5]	[2.8 , 3.8]	[1.6 , 2.5]	[0.3 , 1.3]	[2.0 , 2.5]	[0.8 , 1.3]	[-0.5 , 0.0]
	60	[2.4 , 3.3]	[1.6 , 2.5]	[0.7 , 1.7]	[1.9 , 2.5]	[1.0 , 1.7]	[0.2 , 0.8]	[1.4 , 1.7]	[0.5 , 0.8]	[-0.3 , 0.0]
	80	[1.8 , 2.5]	[1.2 , 1.9]	[0.5 , 1.3]	[1.4 , 1.9]	[0.8 , 1.3]	[0.2 , 0.6]	[1.0 , 1.3]	[0.4 , 0.6]	[-0.2 , 0.0]
	100	[1.4 , 2.0]	[0.9 , 1.5]	[0.4 , 1.0]	[1.1 , 1.5]	[0.6 , 1.0]	[0.1 , 0.5]	[0.8 , 1.0]	[0.3 , 0.5]	[-0.2 , 0.0]

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Nonlinear mixed model applied to the analysis of longitudinal data in a soil located in Paragominas, PA

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Introduction

The areas conversion with the cutting and burning of natural vegetation, followed by soil cultivation, resulting in changes in the organic matter dynamics of soil (OMS) (SIX et al., 2002). The emission of large amounts of greenhouse gases has as main factor the fire in the Brazilian Amazon, this arises from different processes such as burning of forests in areas that are being cleared for agriculture and livestock, grazing, forests fire, among others. With the fire, we have the release of gases such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) (FEARNSIDE, 2002), and these can influence the average temperature rise and hence to global climate change.

Thus, more and more there is interest in evaluating and to model the content of chemical components such as Nitrogen (N) in the ground, since if they are stored, are not contributing to the greenhouse effect phenomena.

The approach of non-linear models are becoming increasingly common as, for example, in studies by Oliveira et al. (2000) which compares models to describe the growth of female Guzerat, Paz et al. (2004) setting models to study the association between genetic polymorphisms and growth in cattle and Zeviani et al. (2012) using non-linear models to describe the release of nutrients in the soil, among others.

In this context, statistical approaches with non-linear mixed models becomes increasingly important to evaluate and explain the nature phenomena. Thus, this paper proposes to use this modeling and soil data to explain the dynamics of the stock of carbon and nitrogen over space in areas that have changed management over time.

Material and Methods

The research was conducted at Vitória farm, in the municipality of Paragominas in the southeast of Pará state, bounded by geographical coordinates 2º59'58,37 "SW 47º21 '21.29"

W. We studied three different use and land cover patterns: i: pastoral system; ii: agrosilvopastoral system and iii: secondary forest. Soil sampling was done in 2013, on occasion opened a trench in each study area, where the samples were collected on three walls between the layers 0-10, 10-20, 20-30, 30-40, 40-60, 60-80, 80-100, 100-130 and 130-150 cm.

For the evaluation of the nitrogen content (g kg-1), soil samples (TFSA) were sieved through a 0.25mm mesh, macerated and inserted into tin capsules. Subsequently, the samples were analyzed by mass spectrometry in continuous flow on a Carlo Erba CHN 1110 elemental analyzer. These data were used to test non-linear mixed model to describe the average behavior of the nitrogen concentration responses (N) in different production systems, and the area with secondary forest. It was considered as a repeated measure in space (depth) and heterogeneity of variances in this space. In general, the content of N element in the i-th sample (individual), the j-th depth of the u-th system can be represented by $y_{iju} = \beta_{0u} x_{ij}^{-\beta_{1u}} + \varepsilon_{iju}$, where x_{ij} is the i-th sample (i = 1, ..., N), in jth depth (j = 1, ..., n_i). In terms of mixed models, one has to $y_{iju} = \beta_{0u} x_{ij}^{-(\beta_{1u} + b_{1i})} + \varepsilon_{iju}$, where β_{0u} is the average value of the content of study in the system, β_{1u} is the accumulation rate this content, b_{1i} is the random effect associated with β_{1u}, independent and identically distributed as $N(0, \sigma^2_b)$ and σ_{iju} is the random error associated with y_{iju}, independent and identically distributed as $N(0, \sigma^2_\varepsilon)$, and independent of b_{1i}. Thus, the random effect enters as non-linearly in the model.

Results and Conclusions

There was high variability in the upper layers of nitrogen content in the soil. We tested several models, from the likelihood ratio test by modifying structures of intra- individual covariates matrix. After modifications, it could be verified that the model with power function of variances was the best one that suited to the data.

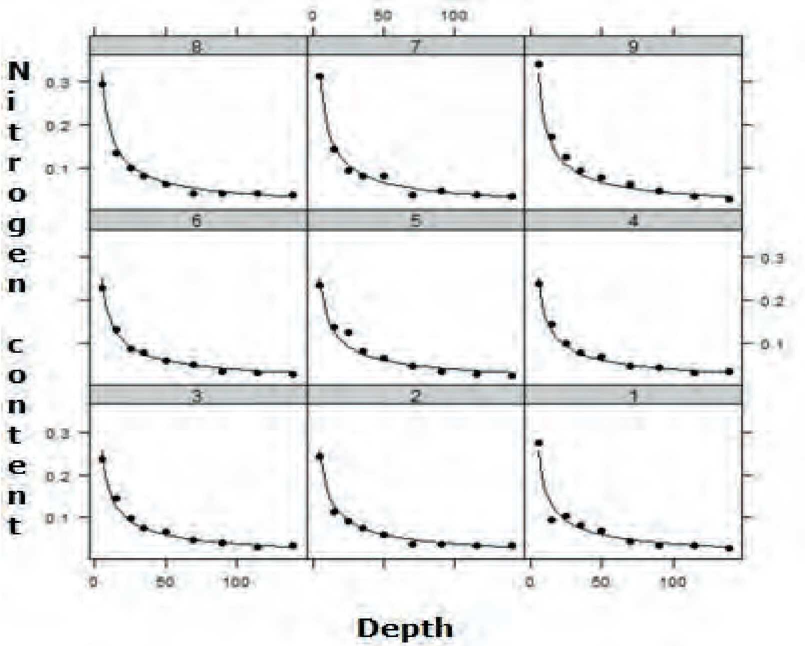

Figure 1: Observed values and fitted model to the nitrogen content of data per depth and sample

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Evaluation of Vegetation Indices at Livestock Integrated Systems using Remote Sensing Data

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Introduction

Livestock systems' economic importance and a growing demand for production efficiency of Brazilian pastures have been fostering researches about the performance of livestock systems under different types of management. Integrated crop-livestock-forestry systems aim at greater sustainability at the farm, and incorporate agricultural, livestock and/or forestry components within the same area under crop rotation, double cropping or sequential cropping (BALBINO et al., 2011). Thus, in this study we evaluated the effect of different livestock production systems on the Normalized Difference Vegetation Index (NDVI). On one side, the greenness represented by NDVI values correlates with plant production to indicate stronger or weaker production, and also to act as an indicator to distinguish the types of management of livestock systems (ALVARENGA et al., 2015). On the other side, biomass production in pastures correlates with potential for carbon storage in the soil (OLIVEIRA, 2015).

Material and Methods

The study area is located in São Carlos, São Paulo State, Brazil, within the *Mata Atlântica* (Atlantic Forest) biome, a region of humid subtropical climate where the average annual rainfall rate is of 1,362 mm, and the average annual temperature rate is of 21.5 °C. The experimental outline featured the following bovine cattle production systems: (A) crop- livestock-forest integration (iLPF), (B) livestock-forest integration (iPF), (C) crop-livestock integration (iLP); (D) intensive (INT) and (E) low-density extensive (EXT_BL) breeding (Figure 1). The ILPF and iPF systems feature *Eucalyptus urograndis* (GG100) in simple rows spaced by 15 m and trees spaced by 2 m. The pastures feature *Urochloa brizantha*. Currently 1/3 of the area is renovated using *Zea mays* double-cropped with *U. brizantha* (Table 1).

Table 1. Description of the experimental areas and livestock production systems.

Production system	Management type	Dominant grass	N dose at the crop (kg ha^{-1})	N dose at the forest (kg ha^{-1})	N dose at the pasture (kg ha^{-1})	Total N dose (kg ha^{-1})
iLPF	rotation	*Brachiaria brizantha*	130	200*		330
iPF	rotation	*Brachiaria brizantha*	0	200*		200
iLP	rotation	*Brachiaria brizantha*	130	0	200	330
INT	rotation	*Brachiaria brizantha*	0	0	200	200
EXT_BL	continuous	*Brachiaria decumbens*	0	0	0	0

*The N dose applied to the total area is of 200 kg ha^{-1} year^{-1}.

The extraction of NDVI values from temporal series of Landsat 8 OLI/TIRS images was performed using the method described by Conceição et al. (2015). We used 31 images taken from April 2013 to August 2015. The NDVI values extracted for each production system were grouped based on season under ‘dry season 2013’, ‘rainy season 2013/2014’, ‘dry season 2014’, ‘rainy season 2014/2015’ and ‘dry season 2015’ and were tested using the Kruskal- Wallis ANOVA method.

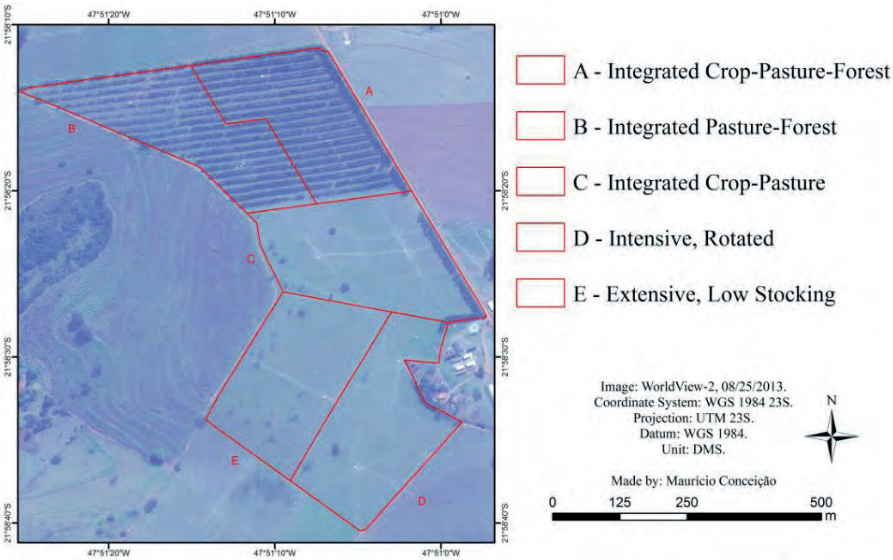

Figure 1. Experimental outline and production systems at the study area.

Results and Conclusions

Figure 2 shows average NDVI values in each experimental area for each OLI/Landsat-8 image. As expected, the iLPF system showed higher vegetation indices along all seasons (Table 2). The permanent presence of the forest conveys stability to the vegetation indices' values and a stronger greenness. Nevertheless, the NDVI values of the iPF system were lower than those of the iLPF system, despite the equal presence of trees in both of them (Table 2). This difference might be associated with the stronger fertilization applied to the iLPF system, since a maize crop was part of the rotation, and the system may have benefited from the residual effect of the nutrients in the soil.

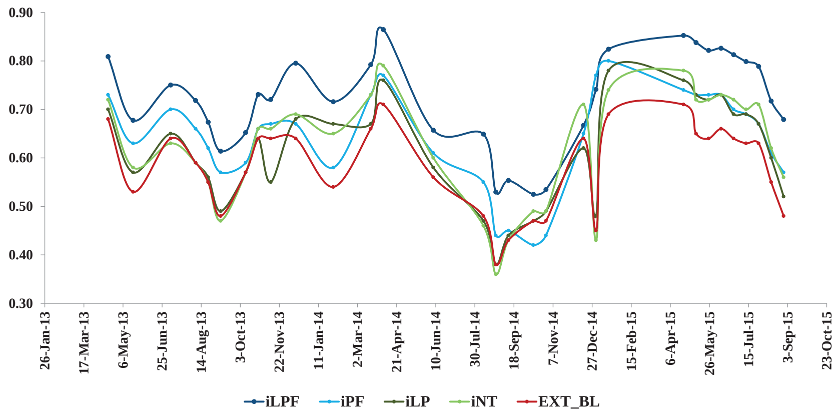

Figure 2. Livestock production systems' NDVI values from April 2013 to August 2015.

During dry periods, the pastures' NDVI values for iLP systems did not differ from those of the iPF and INT systems. The EXT_BL system's NDVI values are equal to those of the iLP system only for the rainy season of 2013/2014, and equal to INT's indices for the dry seasons of 2013 and 2014 (Table 2).

Table 2. Average NDVI values for each production system and season.

Production system	DRY SEASON 2013 (6)*	RAINY SEASON 2013/2014 (6)*	DRY SEASON 2014 (5)*	DRY SEASON 2014 (5)*	DRY SEASON 2015 (9)*	AVERAGE 2013-2015 (30)*
iLPF	0.71^{a**}	0.73^{a}	0.65^{a}	0.66^{a}	0.79^{a}	**0.71**
iPF	0.65^{b}	0.65^{b}	0.56^{b}	0.62^{b}	0.68^{b}	**0.63**
iLP	0.59^{bc}	0.63^{c}	0.52^{b}	0.57^{c}	0.68^{b}	**0.60**
INT	0.59^{cd}	0.66^{b}	0.53^{bc}	0.57^{c}	0.70^{b}	**0.61**
EXT_BL	0.58^{d}	0.61^{c}	0.51^{c}	0.54^{d}	0.62^{c}	**0.57**

*Number of Landsat images. **Averages with the same letters did not differ between production systems ($p<0.05$).

The evaluation of the effect of production systems on the NDVI values along time has potential for discriminating livestock systems according to their intensification level. Although it is not advisable to compare vegetation indices obtained for different types of land cover, as we do here, our results show similar greenness between the iPF integrated system and iLP and INT systems, which signals that other discrimination methods may be coupled for a better understanding of NDVI standards in livestock systems. Under homogeneous land cover situations we were able to separate the most productive (iLP and INT) from the least productive (EXT_BL) systems most of the times. Vegetation indices show good potential for use in the monitoring of pasture greenness. Well-managed pastures favor carbon accumulation in the soil and contribute to mitigate the concentration of greenhouse gases in the atmosphere.

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Estimation biomass of pasture areas using WorldView-2 data

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Introduction

The sustainable use of pastures is of fundamental importance, given that a considerable part of the Brazilian pastures may be in process of degradation or degraded (Andrade et al., 2016). In general, the use of pastures is characterized by extractivism, with few producers who invest in the recovery of the productive potential of pastures and adopting less impactful technologies to the environment. Thus, the intensification of pastoral production systems can be adopted as a viable option to minimize the pressure on opening new areas of agricultural production and reduce the emission of gases causing the greenhouse effect (Barcellos et al., 2008). However, identify areas of pasture that have low production potential can be one of the challenges for large-scale implementation of efficient government policies with the adoption of strategic mitigation measures. In this context, remote sensing data can assist with relevant information for decision making in various scales of time and space. Given the above, aimed to apply data from WorldView-2 sensor and meteorological data to estimate the biomass of pasture areas.

Material and Methods

This study was conducted in the experimental area of GeoPecus project located in the farm of Embrapa Southeast Livestock, São Carlos, Brazil. Therefore, daily meteorological data collected in the weather station of the National Institute of Meteorology (INMET) and World-View-2 image (2013/08/25) were used. Initially, steps radiometric calibration and estimation the surface reflectance with the correction of atmospheric effects by MODTRAN algorithm were carried. Then we calculated the Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1973) and applied the simple linear regression model proposed by Kamble et al. (2013) for estimating crop coefficient (Kc):

$$Kc_{NDVI} = 1.457 \times NDVI - 0{,}1725$$

(3)

To estimate the crop evapotranspiration (ETc, millimeters per day) used the equation:

$$ET_C = Kc_{NDVI} \times ET_o$$

(4)

Where, ET_o is the reference evapotranspiration (millimeters per day), estimated by the Penman-Monteith method, detailed in the bulletin of FAO Nº 56 (Allen et al., 1998).

The vegetation biomass was estimated by the equation:

$$BIO = \sum \left(\varepsilon_{max} \times E_f \times APAR \times 0.864 \right)$$

(5)

Where, BIO is the accumulation of biomass of vegetation (kg ha^{-1}), ε_{max} is the maximum efficiency of the use of radiation, was considered the value of 2.5 g MJ^{-1} (Bastiaanssen e Ali, 2003), E_f is the ratio of the latent heat flux (λE, em W m^{-2}) and net radiation (W m^{-2}) (Teixeira et al., 2012). In this case, λE variable was estimated by the evapotranspiration of culture (ET_c), transforming millimeters per day in watts per square meter. Net radiation was calculated using the daily data collected from the weather station. APAR parameter is the absorbed photosynthetically active radiation (W m^{-2}), estimated by the equation (Teixeira et al., 2009):

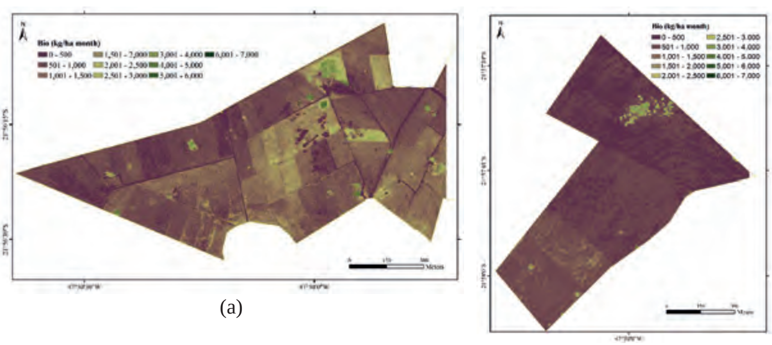
$$APAR = \left(-0.161 + 1.257 \times NDVI \right) \times 0{,}44 \times R_G$$

(6)

Where, R_G is the global solar radiation (W m^{-2}) and 0.44 is the scalar used in the estimation of photosynthetically active radiation (PAR).

Results and Conclusions

We observed that the biomass above soil ranged from 0 to 7000 kg/ha month (Figures 1a and 1b). Biomass values estimated between 500 and 2000 kg/ha month were predominant. However, in some cases, values greater than 4000 kg/ha month (green tones) were mainly observed in representative areas of tree canopy. Biomass values predominantly lower than 1100 kg/ha month (August and September) and greater than 1500 kg/ha month (June and July) were estimated by Andrade et al. (2015) in pastures areas in the municipality of Aquidauana, Mato Grosso do Sul, Brazil. Mean values 2200 kg/ha of total biomass were observed by Zanchi et al. (2009) in pastures of Rondônia State. In this case, the pastures had well-defined seasonal cycle with influence of climatic variations and water availability in the soil. The authors also report that the intensity of grazing can reduce or enhance the growth of forage.



(a) (b)

Figure 1. Biomass estimated for pastures areas located in the experimental farm of Embrapa Southeast Livestock, São Carlos, Brazil.

By analyzing estimates biomass of pastures with indicative of degradation, Andrade et al. (2014) observed that the classes not degraded and low degradation showed values very close, around 1550 kg/ha month. As for the moderate and strong degradation classes were estimated mean values of 1400 and 965 kg/ha month, respectively.

Although estimates of aboveground biomass be supported in the literature, further research is needed to better methodological adjustment. Preliminarily, it can be concluded that the technique has great potential for application in biomass quantification studies of pastures.

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BeefTader (part I): optimal economical endpoint identification using mixed modeling approach decreases greenhouse gases emission and other pollutants for livestock farmers

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Introduction

The database for beef cattle real time individual monitoring assessed by decision support system (DSS) should provide a fast identification of more profitable animals in the future. Animals identification with information about their optimal economical endpoint (OEE; most profitable slaughter date) in commercial beef cattle feedlots owned by farmers could minimize pollutants by kg of meat. This study aimed to identify the OEE in cattle. The hypothesis of the study was: traditional slaughter endpoint (TSE, currently used in commercial feedlots) vs. OEE methods have different marginal net profit (MNV), GHG emission, water intake and manure production per kg of meat produced. The current study is the first from three sequential abstracts based on BeefTrader DSS to maximize profitability of farmers and the meat industry.

Material and Methods

Feedlot data from experimental dataset [DS1; formed by variables: diet chemical composition, intake, daily weight gain and body composition] was used to parameterize a growth model. Based on DS1 a second dataset (DS2) was created using exogenous information (i.e., commercial prices, GHG emission factors, manure and water functions) to predict OEE, MNV, GHG, water intake and manure production. Data was analyzed for the following procedures: i) DS1: after weaning (225 ± 14 days) data from 30 crossbred cattle [10 Red Angus × Nellore (5 male, M; 5 female, F) and 20 ½ Red Angus × ¼ Caracu × Nellore (10 M; 10 F)] evaluated in individual stalls (mixed diet: 2.84 Mcal ME/kg DM, 13.9% CP). Animals were slaughtered when they reached ~ 6 mm of subcutaneous fat in the 12-13th ribs (feedlot maximum period was 147 days); ii) DS2 (exogenous information): the MNV, R$/day (marginal value – marginal cost, MV - MC) from market prices and animal data observed (DS1) was predicted. The daily weight gain (DWG, kg/d) × weight gain value (R$/kg) and DM intake (DMI, kg MS/day) × diet price (R$/kg) + overhead (R$/day) were used to calculate MV and MC, respectively. Manure (kg/day) production from diet indigestibility was estimated. Water intake (kg/day) according to Hicks et al. (1998) was calculated. Enteric methane (kg CH_4/day) and manure (kg N_2O and CH_4) emissions converted in CO_2 equivalent (CO_2-eq) were estimated according to Medeiros et al. (2014) and IPCC Tier 2 methodology, respectively; iii) DS2 (animal growth and body chemical composition modeling): the system of differential equations using Davis Growth Model to represent cattle growth parameterized by Biase et al. (2016) were used to predict daily shrunk BW gain (kg/d) and fat deposition [% fat in the empty body weight (EBW)] during the feedlot. The TSE method was performed considering all the feedlot experimental period, however, OEE period was based on positive MNV values; iv) statistical analysis: using SAS (SAS Inst. Inc., Cary, NC) two linear mixed- effect (LME) model were created: using DS1 variables, the LME1 was created using effects [gender, breed (M; F), gender

× breed interaction and pre-weaning phase (system)] as fixed. The LME2 was created using the same fixed effects structure as LME1, however; method levels (OEE; TSE) and interaction (method × gender) to analyze DS2 was included. The least square means and probabilities were performed by SAS *lsmeans* statement, including gender and method effects for DS1 (by LME1) and DS2 (by LME2). Approximate *t* test was used to test the null hypothesis and the probability between TSE and OEE.

Results and Conclusions

The least square means (± standard error, SE) feedlot period, DM intake, initial and final shrunk BW (SBW), BW gain, slaughter backfat thickness, final fat concentration in the EBW (for F, M, respectively) were: 81, 115 ± 9 days; 7.7, 8.7 ± 0.30 kg DMI/day; 284, 329 ± 8.80kg; 375, 489 ± 10.1 kg; 1.17, 1.45 ± 0.063 kg/day; 8, 5 ± 0.50 mm; 19, 16 ± 0.3% fat EBW. After elimination of negative values for daily MNV based on each animal (Figure 1) to calculate OEE the values for study variables were predicted and analyzed.

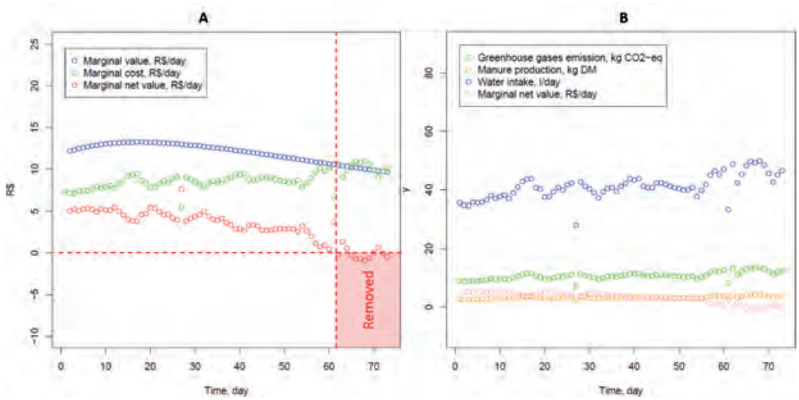

Figure 1. Left side (A): the daily economic performance during feedlot is presented based on marginal value (MV, R$/day), marginal cost (MC, R$/day) and marginal net value (MNV = MV − MC; R$/day) for a Red Angus × Nellore female (ID 941). Dashed red lines intersection indicates (red rectangle) the negative daily MNV removed to calculate the optimal economical endpoint period. Right side (B): greenhouse gases emission (CO_2-eq/day), manure production (kg DM/day); water intake (l/day) and marginal net value (R$/day) for animal ID 941.

The profitability increased (2 to 6 times) based on marginal net value/DWG ratio (R$/kg gain). The GHG emission and the manure production were minimized in 2 to 3 times while water demand 3 to 4 times (Table 1), regardless of the gender in the methods, where OEE was better ($P < 0.05$).

Table 1. Least squares means (± SEM) of performance variables from evaluation of optimal economical endpoint and traditional slaughter endpoint of 30 crossbred cattle (both genders)

Variable (accumulated[1])	Treatment						SEM[4]
	Female			Male			
	OEE[2]	TSE[3]	*P-value*	OEE	TSE	*P-value*	
Daily weight gain, kg	79	110	< 0.01	123	185	< 0.01	8.2
Daily marginal net value, R$	195	44	< 0.01	352	301	0.22	30.9
Marginal net value/DWG[5] ratio, R$/kg gain	99	- 15	< 0.01	110	47	0.07	26.2
GHG[6] emission, kg CO_2-eq	392	806	< 0.01	611	1,282	< 0.01	80.0
GHG/DWG ratio, kg CO_2-eq/kg gain	197	624	< 0.01	341	923	< 0.01	81.6
Manure production, kg DM	116	241	< 0.01	184	388	< 0.01	22.6
Manure/DWG ratio, kg DM/kg gain	58	187	< 0.01	102	279	< 0.01	24.4
Water intake, l	1,528	3,115	< 0.01	2,343	4,848	< 0.01	277.9
Water intake/DWG ratio, l/kg gain	769	2,411	< 0.01	769	3,491	< 0.01	316.1

[1]Accumulated is the sum of observations of the variable in the period according the TSE and OEE metrics.[2]Optimal economical endpoint (OEE, period was calculated after elimination of negative values for marginal net values). [3]Traditional slaughter endpoint (TSE, period defined when animals reached ~ 6 mm of subcutaneous fat in the 12-13th ribs in the experimental feedlot). [4]Least squares means standard error. [5]Daily weight gain, kg/day. [6]Enteric methane (kg CH_4/day) and manure (kg N_2O and CH_4) emissions were converted in CO_2 equivalent (CO_2-eq).

Thus, BeefTrader mathematical and statistical models based on individual growth identification, coupled with optimal economical endpoint decision, improved the profitability and reduced environmental impacts when compared with current experimental dataset. However, what is the influence of BeefTrader metrics over optimal economical endpoint in commercial feedlots of livestock producers in the farm boundary? The answer to this question will be presented in abstract II.

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BeefTrader (part II): optimal economical endpoint identification using nonparametric bootstrapping technique decreases greenhouse gases emission and other pollutants in feedlots

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Introduction

Nowadays there is no decision support system (DSS) that monitor individuals on real time during their growth based on optimal economical endpoint (OEE) in large commercial feedlot operations. This challenge will be overcome by this study based on nonparametric bootstrapping technique to create a large synthetic population to test the following hypothesis: traditional slaughter endpoint (TSE) vs. OEE methods have different marginal profit, greenhouse gases emission (GHG), water intake and manure production by kg of meat produced. This simulation study is relevant not just to test this hypothesis, but to evaluate if environmental and economic benefits from OEE animal identification in an experimental scenario is also observed in a large commercial feedlot. The current study is the second from three sequential abstracts based on BeefTrader DSS to maximize profitability of farmers and the meat industry.

Material and Methods

In the BeefTrader (part I) abstract two datasets (DS) were created. The DS1 was formed by experimental feedlot variables (diet chemical composition, intake, daily weight gain and body chemical composition). The system of differential equations proposed by Oltjen et al. [1986, 2000, named Davis Growth Model (DGM)] reparameterized by Biase et al. (2016) were used to predict the animal growth and body chemical composition. Variables from DGM, exogenous information (i.e., commercial prices, GHG emission factors, manure and water functions) to predict OEE, marginal net value, GHG, water intake and manure production constitute the DS2. Nonparametric bootstrap (NB) resampling was used to create a synthetic population DS3 from DS1 and DS2. The NB performed 100,000 resampling nonparametric for each experimental unit and the confidence of biased corrected percentile bootstrap was determined using the R software (Development Core Team, version 3.1.0, 2014). The mean, median, lower and upper limit were calculated from NB. Biased corrected percentile booststrap interval (95% confidence level) was used to compare the methods from DS3 according to its symmetric and asymmetric distributions probabilities (Efron, 1981).

Results and Conclusions

There was no overlap for confidence intervals for all female variables evaluated (Figure 1). In this situation, there was difference ($P < 0.05$) where OEE was confirmed as the best method bring direct benefits for economic and environmental variables analysed. Similar behavior was identified by males where OEE improved the identification of less impactful environmentally population ($P < 0.05$), however, marginal net value (MNV) was similar between the methods. It is important to highlight that median is considered the best distribution symmetric and asymmetric estimator. Based on median, the accumulated MNV/ daily weight gain ratio was 91 and 27 R$/kg to OEE and TSE (more than 300% of difference, P = 0.07). The feedlot median period for female (F) and male (M) for TSE and OEE methods where, respectively: 80 (F) and 115 (M); 41 (F) and 61 (M) days.

In conclusion, OEE and TSE differ and there was no confidence inter-

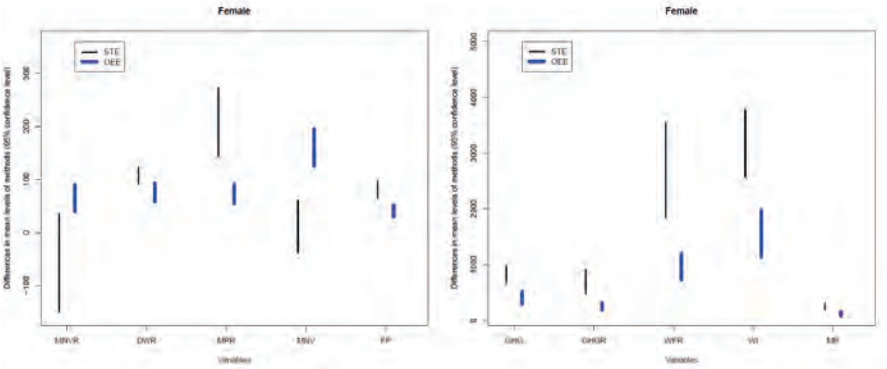

Figure 1. Differences of the mean levels for traditional slaughter endpoint (TSE) and optimal economical endpoint (OEE; 95% confidence level), among variables of female beef cattle synthetic population created using nonparametric bootstrap technique. Variables: marginal net value/DWG ratio (MNVR, R$/kg gain); body weight gain (DWR, kg); manure production/DWG ratio (MPR, kg DM/kg gain); marginal net value (MNV, R$); feedlot period (FP, day); greenhouse gases emission (GHG, kg CO_2-eq); GHG/DWG ratio (GHGR, kg CO_2- eq/kg gain); water intake/DWG ratio (WFR, l/kg gain); water intake (WI, l/kg gain) and manure production (MP, kg DM). The variables were grouped on the left or right side according to its fit in the scale of y-axis.

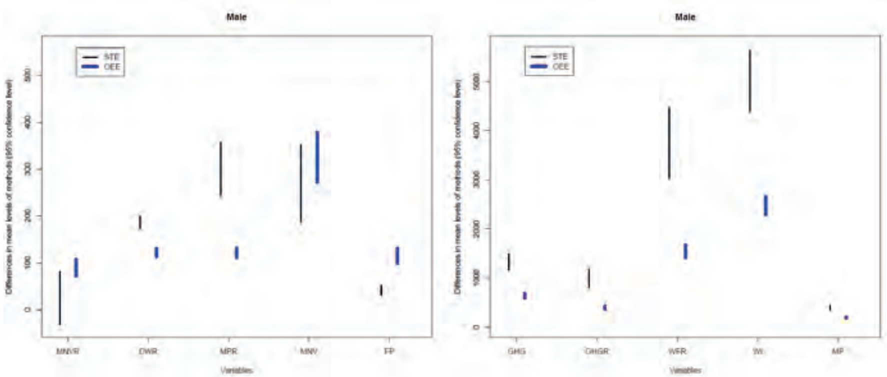

Figure 2. Differences of the mean levels for traditional slaughter endpoint (TSE) and optimal economical endpoint (OEE; 95% confidence level) among variables of male beef cattle synthetic population created using nonparametric bootstrap technique. See Figure 1 for the variables description.

vals overlap from data generated by NB for the most part of variables analyzed between these methods contemplating better precision and accuracy of the inferences. However, what about when the feedlot is owned by the meat packer or is rented? In those situation, does the optimal economical endpoint improve the net economical margins and minimizes the environmental impact? This will be dealt in abstract III.

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BeefTrader (part III): meat industry opportunity to improve its profitability reducing greenhouse gases emission and pollutants based on optimal economical endpoint identification

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Introduction

Feedlots rented or belonging to meat packers are increasing in Brazil and about half million cattle was produced on such feedlots in 2014. On the other side, the meat packers buy a significant quantity of cattle (~ 5 millions animals/year) from other feedlots. Independent if animals have being finished in livestock producers or meat packers feedlot, the individual monitoring based on the optimal economical endpoint (OEE) should improve the profitability decreasing greenhouse gases emission (GEE) and others pollutants for both sides of this market chain. However, the maximization of profitability is central for OEE, and the challenge is to solve it for meat packer, as the marginal value is calculated from carcass and non-carcass tissues deposition over time. Additionally, the marginal cost need to consider operational costs from industry, logistics (from farm-industry-final customer) and maintenance stocks (in or out of industry boundaries). The aim of this study was evaluate the economic and environmental benefits to meat packers based on OEE individual identification. The hypothesis of this study was: traditional slaughter endpoint (TSE) vs. OEE have differences for marginal profit, GHG emission and manure production by kg of meat produced in the meat industry boundary. The current study is the third from three sequential abstracts based on BeefTrader DSS to maximize profitability of farmers and the meat industry.

Material and Methods

In the BeefTrader (part I) abstract two datasets (DS) were created. The DS1 was formed by experimental feedlot variables (diet chemical composition, intake, daily weight gain and body chemical composition). The Davis Growth Model (DGM; Oltjen et al. 1986, 2000) reparametrized by Biase (2016) was used to predict the animal growth and body chemical composition. Variables from DGM, exogenous information to predict OEE, GHG, water intake and manure production performed the DS2. The DS2 was used to simulate the carcass and non- carcass growing during the feedlot than DS3 was created. Main Brazilian meat cuts according MAPA (1988) and non-carcass commercial tissues (skin, liver, heart, kidney, rumen-reticulum, tong and internal fat) were modeled. The meat cuts:carcass and non-carcass:empty body weight ratios simulated in DGM were used to model these tissues deposition over time. The relative cuts and tissues weights were multiplied by prices performed by industry to predict the marginal value daily. Nonparametric bootstrap (NB) resampling was used to create a synthetic population DS4 from DS1, DS2 and DS3. The NB performed 100,000 resampling nonparametric for each experimental unit and the confidence of biased corrected percentile bootstrap was determined using the R software (Development Core Team, version 3.1.0, 2014). The mean, median, lower and upper limit were calculated from NB. Biased corrected percentile booststrap interval (95% confidence level) was used to compare the methods from DS3 according its symmetric and asymmetric distributions probabilities (Efron, 1981).

Results and Conclusions

The OEE economic and environmental benefits for producers can also be observed for meat packers the same way as observed in the situations portrayed in the previous studies (BeefTrader part I and II). However, the simulation of this study shows that the impact on retail prices paid by the meat and internal tissues had a great influence on profitability. Logistics and stocks, national and international customers tendencies, business rules understanding (among farmer-industry--customer) are essential to be implemented in a more realistic model to maximize the profitability.

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Greenhouse gas emissions intensity assessment in beef cattle production systems: a data envelopment analysis (DEA) approach with variable returns to scale

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Introduction

Cattle raising is carried out in around 75% of Brazilian agricultural properties. The importance of beef cattle production in Brazil is evidenced by its share in the Gross Domestic Product (GDP). In 2013, its participation in the agribusiness GDP was 39.94%.

Changes in the demand for beef cattle have been driven by the human population growth rate, income growth, and urbanization. The response of the different livestock systems has been the incorporation of science and technology and the consequent increase of productive indexes. On the other hand, livestock production is likely to be increasingly affected by policies related to the mitigation of greenhouse gases (GHG) emissions, i.e the ‘decarbonization’ of livestock systems, besides the animal welfare legislation and other environmental constraints (Thornton, 2010).

Two types of efficiency may be identified in a production system: technical and economical (Ferreira & Gomes, 2009). One production system may be considered technically efficient if no other system is able to achieve the same level of production by using less quantity of at least one input. Economic efficiency is achieved if there is no other alternative production system that produces the same amount at a lower cost or with a higher profit margin.

This paper aims at evaluating the efficiency of beef cattle productive systems in the Cerrado, Pampa and Pantanal biomes, regarding their emissions intensity (CO2 equivalent per kilogram of carcass weight produced).

Material and Methods

Primary data were collected by means of the panel system, with the definition of representative properties, according to Plaxico and Tweeten (1963). Despite the difficulty to characterize production systems that may be viewed as representative of the biomes studied, the method searches, through the experience of the participating producers, to characterize the ones that are most commonly found in the region, at different levels of technology (Pereira & Costa, 2014; Crespolini, et al., 2015).

Ten beef cattle modal production systems applied in the three biomes (Cerrado, Pampa, Pantanal) were analyzed. The data came from the Pecus Project. Five systems are located in the Cerrado (Cerrado_Básico_05; Cerrado_Básico_12; Cerrado_Intermediário_12; Cerrado melhorado a pasto - SM3; Cerrado melhorado com confinamento -SM4); three in the Pampa (Pampa_Extensivo; Pampa_Semi-Intensivo; Pampa_Intensivo); and two in the Pantanal (Pantanal_tradicional; Pantanal_30).

The emissions were calculated according to the IPCC tier 1 and tier 2 default models implemented in the “PECUS Emissions Model” spreadsheet. The indicator used was the emission intensity (kg CO2-e / kg of carcass for slaughter) in each of the systems analyzed.

We performed data envelopment analysis (DEA) for the efficiency analysis, using Linear Programming. The objective was to determine the efficiency of productive units, called decision making units or DMUs, with information about the levels of resources employed and results achieved. The same method has been previously applied in analyses of beef cattle production systems (Abreu et al., 2008; Gomes, et al., 2015).

In this analysis, the objective was to verify the relative efficiency of the alterative production systems in minimizing the gas emission. We established three input variables: total pasture areas (native and cultivated), number of breeding cows, and number of bulls, and one product variable (output), that is, the emission intensity (kg CO2-e/kg of carcass for slaughter). The inverse of the intensity was defined as output as the objective was to evaluate the product decrease (emissions).

We chose to apply the VRS input-oriented mode, which considers variable returns to scale in order to minimize the resources while keeping the production levels unchanged (Cooper et al., 2006).

Results and Conclusions

Table 1 shows the results of DEA modeling with the variable returns to scale model.

Table 1. DEA index and returns to scale.

DMU	VRS	DRS	IRS	SEff	RTS
Cerrado_Basic_05	91,99	91,99	73,01	79,37	Decreasing
Cerrado_Basic_12	92,05	92,05	74,05	80,44	Decreasing
Cerrado_Intermediate_12	78,35	78,35	76,84	98,07	Decreasing
Cerrado _SM3_Pasture	54,02	54,02	49,20	91,09	Decreasing
Cerrado _SM4_Confinement	53,10	53,10	43,67	82,24	Decreasing
Pampa_Extensive	100	100	74,17	74,17	Decreasing
Pampa_Semi_intensive	100	100	95,61	95,61	Decreasing
Pampa_Intensive	100	100	100	100	Constant
Pantanal_Traditional	71,14	32,44	71,14	45,6	Increasing
Pantanal_30	100	27,29	100	27,29	Increasing

DMU-decision making unit, VRS-variable returns to scale, DRS-decreasing returns to scale, IRS-increasing returns to scale, SEff-scale efficiency, RTS- returns to scale.

The Pampa_Intensivo system was the only one that uses the products without waste and that maximizes the inverse of emission intensity, i.e., it minimizes the emission intensity (kg CO2-e/kg carcass for slaughter). The DMU operates in optimal scale, and the production decrease occurs while keeping the factor use proportion.

The seven systems (five in the Cerrado Biome and two in the Pampa) evaluated operate in descending return and are inefficient in the scale. Therefore, they are operating above the optimal scale and they probably have technical inefficiency. These systems will have to eliminate the excessive use of inputs, which means to produce more with the same inputs. Alternatively, they will have to improve the technology, by increasing the factor productivity. The two systems in the Pantanal Biome operate below the optimal scale. It is necessary to increase production so that the relations between the quantities of inputs used and the production volume may be reduced.

The use of the DEA modeling enables the performance analysis of the DMUs with multidimensional perspective in different situations, by means of the functional relations between inputs and products. The study of the GHG emissions in livestock systems with the use of DEA will lead to evaluating the strategies' technical efficiency, productivity and effectiveness to minimize them.

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Potential of environmental services of eucalyptus on integrated production systems

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Introduction

In order to help solving the serious environmental problems caused by inadequate pasture management, to diversify activities and intensify land use, reducing costs and increasing farm income, Crop-Livestock-Forest integrated systems have been developed (ICLF). In these systems, pasture-crop rotation cultivation between tree alleys, under proper management, promote consistent improvement of aspects like plant production, animal husbandry, environment and society.

Brazil has high potential for implementation of integrated production systems, which demonstrating high efficiency in improving the soil quality, control pests and diseases, control of weeds, in the use of by-products of different crops, in addition to making the cash flow more frequent, creating new jobs and giving greater sustainability in agricultural production.

The adoption of ICLF systems is one of the alternatives to achieve sustainability of production systems, especially with regard to the reduction of greenhouse gases (GHGs). This is due to the high production of tropical grasses and organic matter accumulation in the soil in recovered grazing systems. Another point is the introduction of tree component, which has high potential carbon sequestration and GHG mitigation, which reflecting in higher use efficiency of land and environmental services.

Thus, the objective of this research was evaluated the productivity and the potential environmental services of the tree component in two spatial arrangements.

Material and Methods

The experiment was carried out at the Embrapa Beef Cattle research center in Campo Grande, Mato Grosso do Sul State, Brazil, located between the geographical coordinates: 20º27'02" S and 54º43'07" W.. Soil was a distroferric red latosol (LVdf), Climate under Köppen classification is a transition zone between Cfa and Aw wet tropical. Mean annual rainfall is 1,560 mm, with rainy summer and a dry light cold winter.

A randomized block design was used, with two treatments and four repetitions. Treatments consisted of two spatial arrangements: (1) single rows of eucalyptus trees with 14 meters between rows and 2 meters between trees in the row (14 m × 2 m), totaling 357 trees ha^{-1} and (2) single rows of eucalyptus trees with 22 meters between rows and 2 meters between trees in the row (22 m × 2 m), totaling 227 trees ha^{-1}.

Brachiaria brizantha cv. BRS Piatã was used as cattle pasture between *Eucalyptus urophylla* x *Eucalyptus grandis* trees (clone H13) in the rows. Prior to experiment implementation, there was *Brachiaria* sp. in the area, with low stocking rates. The area was reclaimed in September-October 2008 using crop-livestock-forest integration system (iLPF) with tillage and soybeans farming. Eucalyptus seedlings were transplanted in January 2009 and the Piatã grass was no-till sown over soybeans crop residues in April 2010.

Measurements of total height and diameter at breast height (DBH) were performed at 48 months after planting. From the height and DBH data, the volume of timber per plant was calculated (using the form factor equal to 0.5, and commercial height of 75% total height) as well as was the volume of timber per hectare, using the equation proposed by Porfírio-da- Silva et al. (2009).

The carbon content on stem was determined using CN analyzer (Sumika Chemical Sumigraph CN 900), according to methodology employed by Kanda et al. (2004). CO_2 eq. was estimated using a conversion factor of 3.67. To determine the neutralizing capacity of the GHGs from cattle, it was considered that an animal unit produces 1.88t CO_2 eq per year.

Analysis of variance was carried out and, when there were significant differences up to 5% significance between means, these means were compared by Scott Knott test with 5% probability, using SISVAR software (Ferreira, 2008).

Results and Conclusions

Spacing arrangements did not affect individual production performance of trees until 86 months after planting (Table 1), therefore, there was no significant difference in the silvicultural performance characteristic. In general, increase in diameter is a highly responsive characteristic of spacing (Bernardo, 1995), however, when using broader spacing, as tested in this work, it is expected to detect the influence of these spacing on the DBH in older plants. The same author states that height has no direct correlation with spacing as there are cases where there is increased when larger spacing and others in which the result is the opposite. In this work, there was not detected influence of spacing on height measurements until 86 months after planting s, probably due to large distance between tree rows adopted.

The volume of timber per plant is highly influenced by the height and DBH characteristics, no differences were evident for these two characteristics, so no statistical differences in the volume of timber per plant.

Table 1. Averages of diameter at breast height (DBH), height, volume of timber per tree (Vol./tree) and volume of timber per hectare (Vol./hectare) for different eucalyptus genotypes in Campo Grande-MS, Brazil.

Systems	DBH (cm)	Height (m)	Vol./tree (m^3 $tree^{-1}$)	Vol./hectare (m^3 ha^{-1})
14 m x 2 m	24.00 a	26.98 a	0,43 a	153,50 a
22 m x 2 m	24.50 a	26.21 a	0,41 a	92,37 b
CV (%)	4.69	5.23	10.84	17.51

Means followed by the same letter in the column are not different by Scott Knott test (P> 0.05).

Analyzing the volume of timber per hectare there is influence of tree stand. Timber yield was larger with higher density arrangement (14 m x 2 m).

Among benefits provided by trees in ICLF system, the positive impact on the microclimate variables and carbon sequestration can be mentioned, expanding the possibilities of use in climate change scenarios (Almeida et al., 2011). But a effectively measured benefit is the carbon sequestered by trees and consequently the equivalent CO_2 neutralization potential regarding GHG emissions from cattle (PNEB), as demonstrated by the results shown in Table 2.

Table 2. Averages of carbon (C) fixed on trees, equivalent in CO_2 eq. and neutralization potential for GHG emissions from cattle (PNEB) by eucalyptus tree by integrated Crop-Livestock systems under different tree arrangements in Campo Grande-MS, Brazil.

Sistema	C (t ha^{-1})	CO_2eq. (t ha^{-1})	PNEB (UA ha^{-1})[1]
14 m x 2 m	44,20 a	158,97 a	90,58 a
22 m x 2 m	40,1 b	95,66 b	54,51 b
CV (%)		17.51	

[1] AU = an adult cattle (450 kg)

Means followed by the same letter in the column are not different by Scott Knott (P> 0.05).

Higher tree density provides higher carbon fixation, and therefore, the greater will be the mitigation of the GHGs produced by cattle. In the 14 m x 2 m spatial arrangement, carbon fixed until 86 months was sufficient to neutralize the greenhouse gas emissions from 12.7 animals (weighting 450 kg LW) per hectare per year. For the 22 m x 2 m spatial arrangement, carbon fixed is enough to mitigate the greenhouse gases emission from 7.6 animals (with 450 kg) per hectare per year. In this context, since degraded pastures have average stocking rates under 1.0 animal unit per hectare per year, there will be a carbon surplus set by integrated systems.

Thus it can be concluded that the spatial arrangements used did not influence individual development of eucalyptus trees until 86 months after planting and tree density increased wood productivity per area and consequently the potential for environmental services in agroforestry systems.

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Grazing intensity as a strategy to mitigate methane in native grassland

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Introduction

Ruminants, thank to symbiotic microorganisms, are particularly efficient in transforming vegetal fiber to protein destined to human feeding. In extensive grazing systems where external inputs are absent, grazing intensity (stoking rate/forage biomass) is the main management factor that influence livestock production efficiency. Moderate grazing intensities are generally recognized to optimize livestock productivity while limiting CH_4 emissions (Gerber et al., 2011; Hristov et al., 2013). Native grazing ecosystems are widespread over all continents. They have great economical value through livestock production, particularly in the developing countries of South America (e.g. Argentine, Uruguay, Brazil) that are highly dependent upon this activity (FAO, 2010). When well managed, native grazing ecosystems have the potential to add large amounts of carbon into the soil (>500 kg CO_2 eq yr^{-1} ha^{-1}, Henderson et al. 2016). However, technical information for grazing management in South American native grassland are sparsely. Such information are particularly important to improve productivity, enabling economic development while preserving natural environments. The aim of this work is to discuss the pattern of animal productivity and methane emissions under different grazing intensities in a beef production system in South Brazilian's native grassland.

Material and Methods

The experiment was conducted at the Agronomical Experimental Station of the Federal University of the Rio Grande do Sul, Southern Brazil. This long-term experiment, kept since 1986, involves continuous stocking of heifers on native grassland under different forage allowances (FA, the inverse of grazing intensity). Stoking rate was adjusted monthly to maintain different levels of forage allowances (1, 2, 2-3, 3 and 4 kg of $DM.ha^{-1}$ per kg $LW.ha^{-1}$) in different paddocks. The forage allowance 2-3 kg DM/kg LW was adjusted with 2 kg DM/kg LW during spring and 3 kg DM/kg LW during the rest of the year. The experimental design was a randomized complete block with two repetitions of each FA. We estimated CH_4 emission from six cows per treatment (2.5 years old in average) using the SF_6 marker technique. Methane emissions were collected over periods of 5 days for the summer, autumn, winter and spring of 2012 to represent emissions over all year round.

Results and Conclusions

The forage allowance of 4 kg DM/kg LW represent a very low grazing intensity with few animals per ha and was choose as a reference level here. From this reference level, increasing grazing intensity (or lowering forage allowance) result in direct increase of stoking rate and consequently a quasi-linear increase in CH_4 emissions per ha. The increase in grazing intensity also resulted in a relatively constant decrease in NAPP. On the other hand, moderate grazing intensities (i.e. FA 2-3) optimizes both animal daily gain and animal productivity per ha. Passing this moderate level of grazing intensity, all productive variables decreased while CH_4 emissions continue to increase. Here, moderate grazing intensities represent a simple management technic to mitigate CH_4 emissions while optimizing animal productivity and so being economical viability, with durable effects in time and space.

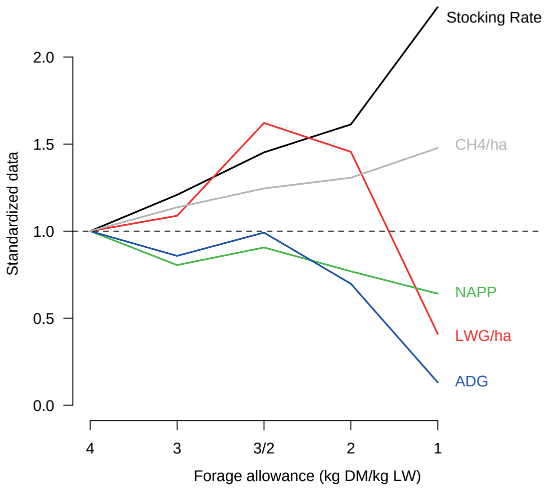

Figure 1: The relative effects of forage allowance on Stocking Rate, Methane Emission (CH_4/ha), Net Aboveground Primary Production (NAPP), Live Weight gain (LWG/ha) and Average Daily Gain (ADG) in a native pasture freely grazed by heifers.

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How are the methane emissions in beef steers grazing natural grassland in southern Brazil?

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Introduction

Natural grasslands are the main feed basis for beef cattle production systems in Southern Brazil. It are the main feed basis for beef cattle production systems in Southern Brazil. It is characterized by a great diversity of species with approximately 3000 rangeland species only in Rio Grande do Sul state (Setubal and Boldrini, 2010). However, one of the most distinct characteristic of this rangeland is the co-existence of C_3 and C_4 species (Overbeck et al., 2007). The data about methane emission in this environment are few. This work aimed evaluating methane emission (CH_4) per animal and live weight gain per area (LWG. ha^{-1}) by finishing beef steers on natural grasslands with different levels of intensification.

Material and Methods

The experiment was carried out at Embrapa Southern Livestock, Bagé, RS, Brazil. Three plots of 7 ha natural grasslands were assigned to each of the three treatments: (i) natural grassland (NG); (ii) NG plus fertilization (NGF): 35 kg ha^{-1} P_2O_5 and 50 kg N ha^{-1}, twice a year;

every year between 2005 to 2014; and (iii) NGF plus overseeded with *Lolium multiflorum* and *Trifolium pratense* (NGFS). Pastures had been under continuous grazing by yearling Hereford steers with constant intensity of 12 kg forage DM per 100 kg live weight. Three "test" animals (nine animals per treatment) were in the paddocks for a whole year and grazing intensity was adjusted with other steers. The "test" animals entered in the area in July of 2014, and had average weight of 230 ± 14 kg in winter and 284 ± 20 kg in spring. Methane emissions (CH_4, g.day^{-1}) were measured using the sulfur hexafluoride (SF_6) technique. Evaluations were made in 2014, in the winter (August, 4-9), and spring (December, 1-6). The animals were weighted each 28 days to determinate live weight gain per hectare (LWG.ha^{-1}). Analysis of variance were performed by JMP (JMP Pro version 12.0.1, 2050). Means were compared using the Tukey test with 5% of significance.

Table 1. Percentage contribution of the main species found in the experimental area based on survey of flora in spring of 2014.

Species	NG	NGF	NGFS
Axonopus affinis	14.14 %	11.59%	17.42%
*Cynodon dactilon**	0.07%	9.22%	0.82%
*Eragrostis plana ness**	30.13%	26.56%	18.78%
Holcus lanatus	0.04%	1.29%	8.37%
*Lolium multiflorum**	0.03%	1.26%	12.89%
Paspalum notatum	4.74%	4.49%	6.59%
Saccharum angustifolium	3.97%	1.09%	6.62%
Sporobulus indicus	2.14%	5.78%	1.77%
*Trifolium pretense**	-	-	0.01%
Others	33.21%	29.97%	25.08%
Dead material	11.53%	8.75%	1.65%

*Exotic species

Results and Conclusions

No interactions was observed for any of the variables. There was effect of season and treatment for methane emission per day and per year. Higher CH_4 emission was observed in spring than in winter (190 ± 8 g and 173 ± 5 g CH_4, respectively). Among treatments, the highest CH_4 emission was in NGFS (Table 2). Faria (2015) also observed higher methane emission in natural grassland overseeded in spring compared to others seasons. This probably occurs due to fast forage growth in this time and its high nutritive value. Cezimbra (2015) evaluating methane emission by heifers on natural grassland in different seasons also observed increased methane emission during the spring, in two consecutive years. The author attributes this result to the difference in dry matter intake by animals and the structural changes that occurs in the pasture at this time. The amount of methane emission per year founded in this paper was higher than that related by Genro et al. (2014) and this may be due to the differences in animal emission or due to differences in the nutritive value of the pasture in different years.

There was effect only for treatment in the average daily gain and live weight gain per area. The highest ADG and LWG was observed in NGF, and the lowest in NG. Faria (2015) related that fertilization improves the nutritional quality of the forages causing animals in that environment had better quality diet, thus being able to meet their daily nutritional requirements and more. This year there was high precipitation, and furthermore, the winter was mild, without presenting very low temperatures for long periods. These conditions along with the nitrogen addition in the soil may have favored the growth of plants in time where little dry matter accumulation occurs, thus resulting in weight gain of the animals (Faria et al., 2016). No difference was observed for methane emitted per kilogram of live weight gain per day, with average of 0.245 kg CH_4 kg LWG^{-1} day^{-1}.

Table 2. Methane emission per animal per day (g d^{-1}) and by year (kg $year^{-1}$), average daily gain (ADG, kg d^{-1}) and live weight gain per area (LWG, kg ha^{-1}) in natural grassland (NG), natural grassland fertilized (NGF) and natural grassland fertilized and overseeded (NGFS).

Treatments	CH_4 Emission (g d^{-1})	Kg CH_4 $animal^{-1}$ $year^{-1}$	ADG (kg d^{-1})	LWG (kg ha^{-1})
NG	170.95±7.99 b	62±3 b	0.298±0.06 b	73±16 b
NGF	176.03±7.57 ab	64±3 ab	0.555±0.06 a	136±15 a
NGFS	201.29±9.37 a	73±3 a	0.488±0.07 ab	117±18 ab

Means that are followed by different letters differ (P<0.05) by Tukey test. Means presented are followed by standard deviation.

The fertilization in natural grasslands had potential to produce more meat without increasing methane emission, proving to be a good alternative to improve productivity without causing greater impact to the environment.

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Use of supplemented pasture during the yearling stage to growth performance of Nelore Angus and Nelore Angus Guzera crossbreed cows contributing to carbon sequestration

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Introduction

The majority of the Brazilian cattle are fed on pastures of grass (LIMA et al., 2004), which contribute to carbon sequestration through the high efficiency in fixing CO_2 of tropical grass, C_4 cicle. Among the cultivated grasses, the genus *Brachiaria*, which occupies approximately 60 million hectares, constitutes the main option for feeding beef cattle in the country (SÁ et al., 2011), especially in the growing stages, however observed a lower performance, in particular when supplementation is not used. The aim of this study was to compare the performance of two genetic groups during the growing stage with supplementation. We evaluated the performance of the genetic groups ½ Nelore ½ Angus and ¼ Nelore ¼ Angus ½ Guzerá, which originate from the rotational crosses of Nelore cows mated with Angus bulls and ½ Nelore ½ Angus cows mated with Guzerá bulls, respectively.

Material and Methods

The average weight during yearling stage of 10 animals were used for each genetic group, ½ Nelore ½ Angus and ¼ Nelore ¼ Angus

½ Guzera. The animals were kept in pastures with *Brachiaria brizantha* cv. Marandu, fertilized with 120 kg ha^{-1} ano^{-1} of N. The experiment site located in Realeza, PR, in the south-west of Paraná, 25º 46 '08" South Latitude and 53º 31' 57" West Longitude and altitude of 520 m, the average environmental temperature was 23 ºC and the average monthly precipitation was above 120 mm. The forage allowance were administered at a rate of 2.5 kg of DM per 100 kg live weight; for this, control cattle was used with the technique 'put and take' and the pasture area was controlled with a mobile fence. The average levels of DM, CP, NDF, and ADF in forage in the growing stage under grazing were 266, 75, 530, and 420 g kg^{-1}, respectively. The animals received protein and energy supplementation *ad libitum* (NDT-750, PB-240, P-5,2, Ca-2,4, and EE-33 g kg^{-1}). During the growing stage in the yearling, the animals were weighed monthly. The results were submitted to analysis of variance, using the Sisvar program (FERREIRA, 2011) and regression analysis, the significance of the regression coefficients of 1 and 5% was determined using a *t*-test.

Results and Conclusions

The average weight function of time obtained monthly during the yearling stage and adjusted to the linear model (Figure 1), considering the significance of the regression coefficients. Lôbo e Martins filho (2002) compared various models, which describe the growth of Nelore beef cattle, and reported that although the nonlinear models de Richards (R^2=0.99) and Brody (R^2=0.99) have a better fit, the quality of the fit of the linear model (R^2=0.97) is similar to that of nonlinear models. The genetic group ¼ Nelore ¼ Angus ½ Guzerá showed greater average weight. However, for the group ½ Nelore ½ Angus had the highest regression coefficient (b), which demonstrates a higher estimated daily gain. It is possible to obtain appropriate weights of the animals maintained in pastures with *Brachiaria brizantha* cv. Marandu with supplementation to animals ½ Nelore ½ Angus and ¼ Nelore ¼ Angus ½ Guzera, contributing to carbon sequestration.

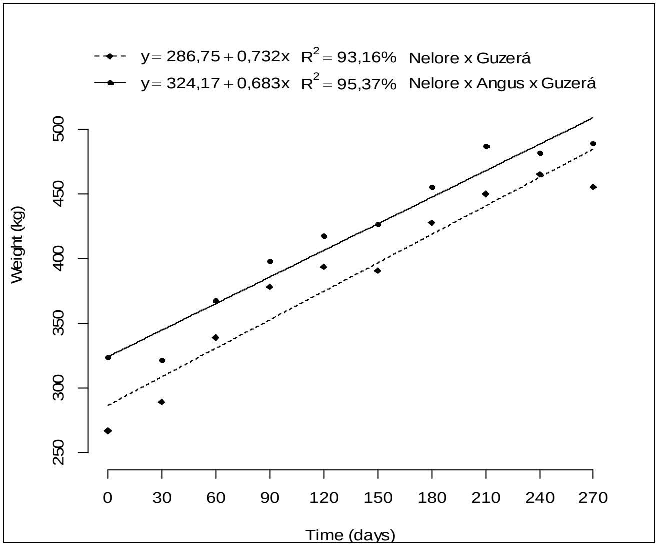

Figure 1.

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Tropical fruits such as mitigation potential of methane in ruminants

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Introduction

Methane is a greenhouse gas (GHG) formed from enteric fermentation of carbohydrate in ruminants. Several factors influence the amount of methane produced per animal such as nutrition, the type of carbohydrate in the diet, the level of feed intake, level of production (annual production of milk, meat and other products), diet passage rate, level of fat saturation in the diet, some environmental factors such as temperature and genetics and feed conversion efficiency (Mcallisteret al., 1996; Nkrumahet al., 2006).

This study aimed to evaluate the kinetic parameters of ruminal fermentation and methane production *in vitro* at different levels of substitution (0, 30, 40 and 50 g/g) of *Brachiaria brizantha* hay by tropical fruits (cocoa, cupuassu, soursop, genipapo and mangosteen).

Material and Methods

Five tropical fruits were evaluated: cupuassu (*Theobroma grandiflorum* Schum, bean and pulp), soursop (*Annona muricata,* whole fruit), genipapo (*Genipa americana*, whole fruit), mangosteen (*Garcinia mangostana,* hulls) and cocoa (*Theobroma cacao*, hulls and beans).Fruits were processed and chemical composition determined according to AOAC (1990) for dry matter (DM), nitrogen compounds

(N), mineral matter (MM), ether extract (EE) and acid detergent fiber (ADF), according to Mertens (1992) for neutral detergent fiber (NDF); and to Licitra et al. (1996) for correction of NDF and ADF according to protein content (NDF_p and ADF_p), insoluble nitrogen in neutral detergent (INND) and in acid detergent (INAD). Analyses of CO_2, CH_4 and short chain fatty acids (SCFAs) were also carried out.

To evaluate *in vitro* dry matter digestibility (IVDMD) and fermentation kinetics parameters, incubations were carried out using a semi-automated *in vitro* gas production technique, according to Mauricio et al. (1999).

A completely randomized design (CRD) was used for each fruit tested in isolation. The data were analyzed by procedures of variance and regression analysis, evaluating levels of substitution of *B. brizantha* hay by tropical fruits at levels of 0, 30, 40 and 50 g/g. The procedures REG and PROC GLM PROC were used. A critical level of 0.05 of probability for error type I was adopted for this study.

Results and Conclusions

In vitro ruminal fermentation kinetics

It was observed that the substitution of *Brachiaria brizantha* hay for all tropical fruits used in this study had a linear negative effect ($P<0.05$) on latency time (LAT) as the level of substitution increased.

Among the tropical fruits used in this study, genipapo resulted in increases ($P<0.05$) in the final volume of NFC (FV_{NFC}) to a maximum of 134.2%, in the degradation rate of NFC (kd_{NFC}) and in the final volume of FC (FV_{FC}) which indicates a positive associated effect. As the final volume of FC (FV_{FC}) was superior to FV_{NFC}regarding the type of fruit used, this was considered the source with the most energy available to microbial populations in the rumen. . Cocoa beans and cupuassu also resulted in an increase ($P<0.05$) in the degradation rate of NFC (kd_{NFC}). Soursop and mangosteen resulted in associated negative effects ($P<0.05$) as the hay was substituted by the fruits

Products of ruminal in vitro fermentation

IVDMD presented similar behavior among the studied fruits: cocoa hulls, soursop and mangosteen, which all affected it negatively ($P<0.05$).
Cocoa beans and genipapo had similar behavior for IVDMD, gas volume, CO_2 and A:P (acetate:propionate) ratio. IVDMD and A:P ratio presented quadratic behavior with maximum digestibilities of 46.4 and 49.4% atrespective substitution levels of 23.1 and 27.1%. The estimated maximum A:P ratios were3.0 and 2.5at respective levels of 22.3 and 18.4%. Cupuassu and soursop presented quadratic behavior ($P<0.05$) for gas volume with maximum gas volume occurring at levels of 28.5 and 30.5%, respectively. Soursop also presented quadratic behavior ($P<0.05$) for CO_2 production, with maximum production at 30.7% of hay substitution by the fruit.

The behavior of hay substitution by genipapo or soursop on SCFA production was similar. Quadratic behavior ($P<0.05$) was observed for acetic acid, butyric acid and A:P ratio; withlinear increasing behavior ($P<0.05$) observed for propionate production. The levels of substitution which most maximize these parameters were estimated to be between 27.4 and 27.9%, 23.6 and 24.0%, 18.4 and 19.6%, respectively. As observed for genipapo and soursop, mangosteen hulls also showed quadratic behavior ($P<0.05$) for acetic acid production.

For the substitution of hay by the cupuassu and mangosteen fruits, a linear decrease ($P<0.05$)was observed for butyric acid production, while for cocoa beans a quadratic effect was observed with the minimal point of production occurring at a32.1% level of substitution. The substitution of hay by cocoa beans and cupuassu showed similar quadratic behavior for A:P ratio with maximum points occurring at 22.3 and 22.8% respectively. For propionic acid concentration however, cocoa beans showed quadratic behavior with a minimal point at 20.4% while cupuassu showed increasing sigmoidal behavior.

Enteric Methane Production

For methane production, the substitution of hay with the processed fruits cocoa hulls, cupuassu, soursop and genipapo, resulted in an observed increase ($P<0.05$) in methane production. The substitution of hay by mangosteen however promoted a reduction in methane production up to 31.5% hay substitution (Figure 1).

Conclusions

Cocoa beans, cupuassu and genipapo improve ruminal fermentation kinetics and can contribute to improve animal performance. *In vivo* studies should be carried out to verify if the increases in animal performance have the potential to mitigate methane per kg of product (meat/milk/wool) produced. Mangosteen reduces methane emissions per g of DDM or incubated DM, and must be studied *in vivo*to verify whetherits methane mitigation occurs in diets without interfering with feeding efficiency.

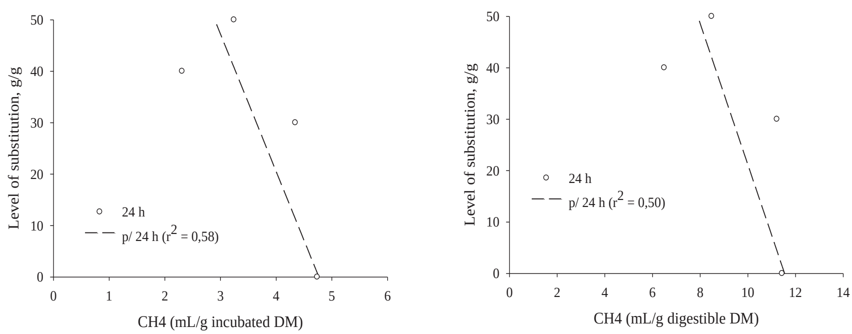

Fig 1.Estimated methane (CH_4) production (mL/g incubated DM or digested DM), as a function of substitution level of hay with Brachiaria brizantha by mangosteen peel at 24 hours of in vitro incubation.

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Chirca Leaves Minimizes Sheep Methane Emissions

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Introduction

A reduction in ruminant animal methane emission is of interest in terms of greenhouse gas production as well as for increase in the efficiency of dietary energy. Methane formation generates losses of 2 to 12% of consumed gross energy (Johnson and Johnson, 1995). Several strategies are being studied to mitigate this emission, and most have focused on the use of additives in the diet. The use of plants containing secondary compounds such as essential oils, tannins and/or saponins are natural alternatives to chemical additives that may be perceived negatively by consumers.

Tannin-containing plants are under study for their anti methanogenic activity, which is attributed mainly to a group of condensed tannins (CT). The CT can act on the methanogenic bacteria and reduce methane output (Martin et al., 2010).

The Pampa biome has a well diversified flora, however, little known as its physical and chemical functions. This area contains chirca, which grows as a weed in fields. It's a native plant that has in its composition secondary compounds. However, there are no studies evaluating the use of this plant because cattle and sheep eat in small quantities. Thus, this study aimed to evaluate the effect of increasing levels of Chirca leaves (*Eupatorium buniifolium*) on the individual intake and methane emission adult sheep.

Material and Methods

The experiment was conducted at Embrapa South Livestock (CPPSUL), Bagé, RS, in two evaluation periods: 09/15/2015 to 09/28/2015 and 10/05/2015 to 10/17/2015. Were used 20 adult sheep barrows, five animals per treatment, with an average initial weight was 43 ± 7 kg. The basic diet for all treatments was composed of chopped alfalfa hay plus 300 grams of a commercial concentrate with 14% crude protein (CP). The amount of feed was calculated to allow 10% of leftovers daily. The treatments consisted of four levels of inclusion of chirca leaves (*Eupatorium buniifolium;* Asteraceae family). It is a shrub native of the Pampa biome. It was included at 0, 50, 100 and 150 grams. The chirca leaves were collected manually in the experimental fields of CPPSUL and subsequently dried in an oven with forced ventilation at 40°C. These were homogenized and milled and offered in different treatments. The feed supply was made in the morning and chirca leaves were mixed with the concentrate. Every day the leftovers were weighed for subsequent calculation of individual intake. The animals were kept in metabolic cages. The adjustment period was eight days followed by five days of collection.

On the ninth day, the animals were prepared with equipment and materials for collection of enteric methane. To measure methane, we used the technique described by Johnson et al., (1994) and adapted by Gere and Gratton (2010) employing sulfur hexafluoride (SF_6) tracer. Stainless steel collection tubes were used for storage of gases, which was sampled for five consecutive days. We used control tubes (n = 3) to control for ambient methane, and all samples were measured with gas chromatography.

The leaves of chirca were analyzed for total phenolic content (TF) and total tannins (TT) expressed as equivalent gram acid tannic.kg of dry matter^{-1} (DM) and condensed tannins (CT) expressed in equivalent gram of leucocyanidin.kg of DM^{-1}.

Daily individual intake and the emission of enteric methane.animals^{-1}.day^{-1} for different periods were subjected to regression analysis by the statistical program JMP (JMP version 9.0.0, 2010). There was no significant interaction effect between the periods, and the data are presented in relation to the treatment.

Results and Conclusions

There was no significant effect for the inclusion levels on the daily individual intake (Figure 1). The literature found divergent results on the influence of condensed tannins on individual intake. This is due mainly to the tannin content in the diet (%) and the different forms of ruminal activities of tannins, which may reduce the digestibility of DM and nitrogen and affect fiber digestion (Batta et al., 2002). When these effects are small, there is no influence on individual intake.

There was a linear significant effect decreasing for the inclusion levels on the reduction in the emission of enteric methane.animals^{-1}.day^{-1}. The performance of condensed tannins on the effect on mitigation of methane emissions, intake and digestibility of food is related to its composition—especially with respect to molecular weight and degree of polymerization in addition to the quantity supplied. A similar result was found by Paengkoum et al. (2015) where it has been tested the effect of five different inclusion levels of peel of the fruits of *Garcinia mangostana.* They found a linear and significant decrease in methane as a function of dose.

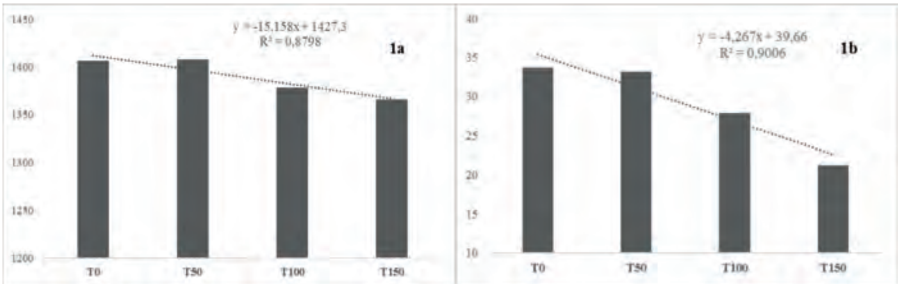

Figure 1. Daily individual intake (grams of the DM) (1a) and emission of enteric methane.animals^{-1}.day^{-1} (1b) from sheep receiving increasing doses of chirca leaves.

The chirca leaves have 95.2 g/kg DM of total tannin (TT), 115.3 g/kg DM of total phenols and 11.4 g/kg DM of condensed tannins (CT). However, the quantities of secondary compounds present in the leaves of chirca used here had no adverse effects on dry matter intake.

The addition of 150 grams of chirca in the diet did not affect daily individual intake, however, there was a possible reduction in the emission of enteric methane.animals^{-1}.day^{-1} for adult sheep.

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Pitangueira Leaves Effects on Enteric Methane Emission in Adult Sheep

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Introduction

On a global scale, the production of methane (CH_4) from ruminant animals is responsible for 8% of total anthropogenic greenhouse gas emissions (Beauchenin et al., 2008). This production is naturally generated in the ruminal digestion of ingested food. The development of feeding strategies to minimize the emission of enteric CH_4 is therefore desirable to mitigate, over time, emissions of greenhouse gases to the atmosphere and the economic benefits in the short term (Berndt and Tomkins, 2013). Currently, the use of foods with secondary compounds or other natural compounds to minimize methane are under study. Tannins may be found in the plant in soluble or insoluble form and can reduce enteric methane emissions when consumed in significant quantities (Saminathan et al., 2015).

The objective was to evaluate the effect of increasing levels of pitangueira leaves on the individual intake and methane emission adult sheep.

Material and Methods

The experiment was conducted at Embrapa South Livestock (CPPSUL), Bagé, RS, in the period from 08/20/2015 to 09/02/2015. Were used 20 adult sheep barrows, five animals per treatment, with an average initial weight of 40 ± 7 kg. The basic diet for all treatments was composed of chopped alfalfa hay plus 300 grams of a commercial concentrate with 14% crude protein (CP). The amount of feed was calculated to allow 10% of leftovers daily. The treatments consisted of four levels of inclusion of pitangueira leaves (*Eugenia uniflora*), which is a native fruit tree of the Pampa biome. It was included at 0, 50, 100 and 150 grams. The pitangueira leaves were collected manually in the experimental fields of CPPSUL and subsequently dried in an oven with forced ventilation at 40 °C, homogenized and milled to be offered in different treatments. Feed supply was made in the morning and pitangueira leaves were mixed with the concentrate. Every day the leftovers were weighed for subsequent calculation of individual intake. The animals were kept in metabolic cages. The adjustment period was eight days followed by five days of collection.

On the ninth day, the animals were prepared for methane studies. To measure methane, we used the technique described by Johnson et al., (1994) and adapted by Gere and Gratton (2010) employing sulfur hexafluoride (SF_6) tracer. It was used stainless steel tubes for storage of gases and remained the same for five consecutive days. We used control tubes (n = 3) to control for ambient methane. Methane and SF_6 was measured with gas chromatography.

The leaves of pitangueira were analyzed for total phenolic content (TF) and total tannins (TT) expressed as equivalent gram acid tannic.kg of dry matter^{-1} (DM) and condensed tannins (CT) expressed in equivalent gram of leucocyanidin.kg of DM^{-1}.

Daily individual intake and the emission of enteric methane.animals^{-1}.day^{-1} was subjected to regression analysis by the statistical program JMP (JMP version 9.0.0, 2010).

Results and Conclusions

There was no significant difference between treatments for daily individual intake. The literature found divergent results on the influence of condensed tannins on individual intake. This is due mainly to the tannin content in the diet (%) and the different forms of ruminal activities of tannins, which may reduce the digestibility of DM and nitrogen and affect fiber digestion (Batta et al., 2002). While these effects are small, there is no influence on individual intake. Here, condensed tannins present in the pitangueira leaves did not affect the digestibility parameters.

There was no significant difference between treatments for the emission of enteric methane.animals^{-1}. day^{-1}. Vázquez et al. (2016) tested the in vitro effect of including leaves of four different trees and three inclusion levels. There were no significant differences in the type of tree or level of inclusion. The leaves of trees with greater presence of CT showed greater reduction in methane emissions.

The action of condensed tannins on the effect on mitigation of methane emissions, intake and digestibility of food is related to its composition—especially with respect to molecular weight and degree of polymerization. In this sense, Saminathan et al. (2015) tested the effect of five different CT molecular weights purified from the *Leucaena leucocephala* and concluded that the fractions TC that had higher molecular weight and higher degree of polymerization showed greater reduction in methane production, but did not affect the digestibility of dry matter.

Table 1. Daily individual intake and emission of enteric methane from sheep receiving increasing doses of pitangueira leaves.

Treatments	Individual intake (grams of the DM)	Grams of the methane.animals^{-1}. day^{-1}
0 grams of pitanga leaves	1296±95	37,3±4
50 grams of pitanga leaves	1209 ±250	31,9 ±12
100 grams of pitanga leaves	1190 ±224	31,5 ±3
150 grams of pitanga leaves	1158 ±380	28,6 ±13

Means presented are followed by standard deviation.

The pitangueira leaves had 135g/kg DM of total tannins (TT), 153.5 g/kg DM of total phenols and 7.8 g/kg DM condensed tannin (CT), however, the amounts of compounds in the leaves of pitangueira offered to animals were not enough to affect methane. These results may have been influenced by the chemical composition and molecular weight.

The inclusion of up to 150 grams of pitangueira leaves in the diet did not affect the daily individual dry matter intake nor the emission of methane in adult sheep.

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Evaluation of the modification of dynamics of rumen fermentation by the addition of tannins on the kikuyu grass on methane emissions in a Rumen Simulation Technique RUSITEC®

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Introduction

Evidence indicates interference (DM digestibility and NDF) of condensed tannins in fermentation processes with tropical forages, but also benefits in mitigating methane, depending on the level of inclusion, the concentration of tannins and activity ruminal microorganisms. The aim of this study was to determine the effect on ruminal fermentation dynamics, including various levels of tannins from *Acacia mearsii* legume tree in the Kikuyu grass (*Cenchrus clandestinus*).

Material and Methods

Ruminal fermentation system in vitro semi-continuous type RUSITEC® described by Czerkawski and Breckenridge (1977) was used. Which it was equipped with eight fermenters capacity of 700 ml, which in turn were adequate under controlled conditions to maintain microbial activity (39 º C, anaerobiosis, and artificial saliva - "McDougall Buffer" continuous motion). At the beginning of the experimental period, in each fermenter 200 ml of artificial saliva was added, preheated to 39°C and 500 ml of ruminal fluid extracted from four cows of the Holstein breed cannulated in rumen, fed kikuyu grass

(*Cenchrus clandestinus*) which it was filtered and mixed under constant gassing of CO_2 to temperature of 39°C.

The procedures described by Giraldo et al, (2007) were followed, each fermenter and randomly, two bags with pore size of 100 μm were incubated, those containing 80 wet grams of ruminal digesta and 12 grams of substrate, respectively. After 24 hours of incubation, the bag ruminal digesta was removed and was replaced with a new containing the substrate, which was removed from each fermenter, upon completion of 48 hours incubation and replaced by a bag substrate, process which it was conducted daily throughout the experimental period. The flow of each fermenter was kept constant by continuous infusion of Buffer pH 8.0 (McDougall, 1948) at a dilution rate of 4.49 ± 0.13%/hour (647 ± 18.40 ml/day). The effluent product from each fermenter was collected in bottles with a capacity of 1 L. The gas fermentation product was collected in aluminum bags with capacity of 5 L, which were subject to the flasks containing the effluent.

Treatments and/or diets included: **T0** = No inclusion (forage only kikuyo); **T1** = Inclusion of 2% of the MS tannin; **T2** = Inclusion 4% by weight of the MS, and **T3** = Inclusion 6% of the MS tannins. The tannins come from leguminous tree *Acacia mearsii* (Weibull Black®), Tanac S.A. (Montenegro-Brazil), with a concentration of 79% of total tannins and 0.725 g of condensate/g MS tannins.

Time evaluation consisted of 20 days, divided into two periods of 10 days each, where each diet or substrate was incubated at random two fermenters, obtaining four replications per diet. For the determination of methane and one VFA Gas Chromatography is used.

Randomized complete block (RCB) design was used with repeated measures over time, the main effects are: experimental period (blocking factor) measurement day, treatment and treatment nested fermenter. When using the ANAVA a significant effect between treatments was detected, the comparison of means from a Tukey test with a significance level of 0.05 was made.

Results and Conclusions

The table 1 summarizes and sample the most outstanding results. The% DMS, NDFD and DFDA was higher (P> 0.05) at **T0** and **T1** vs **T2** and **T3**. PC degradation was higher (P> 0.05) at **T0** (control) and **T1** (2%) vs **T2** (4%) and **T3** (6% tannins) and consequently the ammonia produced behaved the same.

Table 1. Effect of supplementation tannins, on methane and some parameters of degradation and ruminal fermentation in vitro RUSITEC®.

Parámeters	Treatments [1]				*P*=
	TO	T1	T2	T3	
DDM (%)	50.8a	50.7a	46.6b	43.1c	< 0.0001
DNDF (%)	30.46a	30.11a	24.72b	20.97c	< 0.0001
DADF (%)	20.88ab	22.47a	19.27b	15.45c	0.0022
DCP (%)	80.16a	79.18a	73.83b	71.31c	< 0.0001
N-NH_3 (mg/dl)	387.65a	319.02b	234.20c	227.56c	< 0.0001
Gas (L/día)	2.08a	2.13a	1.73a	1.90a	0.2843
pH	7.18b	7.15c	7.19b	7.21a	0.0003
Total VFA (mM)	3358.0a	3382.8a	2668.6b	2304.1b	0.0010
Acetate (mM)	1657.6ab	1509.2a	1393.0bc	1240.4c	0.0074
Propiónate (mM)	1120.40a	1147.50a	899.44b	759.18b	0.0007
Butyrate (mM)	394.89a	378.13a	258.78b	215.89b	< 0.0001
Valérico (mM)	157.708a	125.817b	101.550c	75.433d	< 0.0001
Isovalérico (mM)	29.900a	22.192b	15.775c	13.12c	< 0.0001
Acetate/Propionate	1.48b	1.49b	1.54ab	1.61a	0.0690
Methane (mmol/L)	49.3a	42.6b	40,7b	40,2b	0.0046

[a-c] Means with different letters in the same row differ according Tukey (P<0.05). [1] Diets incubated: Forage kikuyu (TO); Supplementation of the basal diet with 2% DM tannins (T1); Supplementation of the basal diet with 4% DM tannins (T2) and Supplementation of the basal diet with 6% DM tannins (T3) 2Values P by treatment effect.

The volume of gas (L/day) was not different (P<0.05) between treatments, but methane decreased (P>0.05) with increasing tannin% inclusion at the expense of the less DMS, PC, FDN and FDA, in **T3** and **T4**, except in **T2**, coinciding with lower and higher production of acetate and propionate respectively in **T2.**

In conclusion, the results suggest that the use of condensed tannins as a supplement in diets for ruminants can be useful to decrease the total protein degradation ruminal generating protein by pass. The addition of tannins from mearsii Acacia, in ascending levels (2, 4 and 6% of DM) to forage kikuyo, reduces emissions of methane in rumen, but the level most promising is the inclusion of 2% since reduces methane 13.6%, evidenced by the increase fatty acid propionic ruminal fermentation product, although at the expense of DMS, and DADF DNDF.

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Effect of energy sources inclusion in diet on methane production of cattle determined by sulphur hexafluoride (SF6) tracer gas technique

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Introduction

Ruminant animals have a great advantage over simple-stomached animals, as their digestive process is able to release the energy contained in cellulosic material through carbohydrate fermentation by microorganisms enzymes from the rumen environment. However, carbohydrate fermentation results not only in short chain fatty acids (SCFA) but also in less desirable products such as heat, as well as methane (CH_4) and carbon dioxide (CO_2) gases which represents energy loss for the animal estimated in 2 to 12% of gross energy from feed (Johnson and Johnson, 1995). As an adult ruminant can produce up to 17 liters of methane per hour and this gas cannot be metabolized even by rumen microorganisms, most of it is removed from rumen by expiration or eructation (Moss, 1993), and released in the environment.

There are different techniques for methane emissions measurements by ruminants in production conditions; among them there is one that uses an inert gas tracer, sulphur hexafluoride (SF_6). This technique results in a precise estimative of methane production by the animal, besides enabling the evaluation of animals in normal pasture conditions, it consists in placing a permeation tube, which releases SF_6 at a previously known rate in the rumen, where by the contractions of this organ, CH_4 and SF_6 gases are released by eructation and samples are collected close to mouth and nostrils. This method assumes that the standard of SF_6 emission simulates the standard of CH_4 emission. The flow of CH_4 released by the animal is calculated in relation to SF_6 flow (Westberg et al., 1998).

The objective with the present study was to evaluate energy sources inclusion in cattle diets on methane production determined by sulphur hexafluoride (SF_6) tracer gas technique.

Material and Methods

The trial was conducted at the College of Veterinary Medicine and Animal Science, University of São Paulo (USP), Brazil. Six Holstein nonpregnant and nonlactating cows (mean 730 ± 70 kg of BW) fitted with ruminal cannulas were randomly assigned to a replicated 3 x 3 Latin square (n = 18) in three isoenergetic (1.55 Mcal NE/kg of DM) and isoproteic (12% CP) experimental diets: control (CON): diet with low ether extract (3.5% of EE); soybean (SOY): diet with high ether extract (5.30% of EE) with 15% inclusion of whole soybean grain; citrus pulp (CiPu): diet with low ether extract (3.00% of EE) and high participation of pectin with 15% inclusion of citrus pulp. Diets were fed as total mixed rations with a ratio of concentrate to forage of 50:50 (DM basis). Diets were offered twice daily at 0800 and 1600 h throughout the experiment for ad libitum consumption (minimum of 5 - 10% feed refusal). In all diets, the forage source was corn silage and the concentrate consisted of dry-ground corn grain, soybean meal, white salt, dicalcium phosphate, limestone and vitamin and mineral premix. Cows were housed in a barn equipped with individual feed bunks, rubbermatted floors, and automatic water fountains shared by 2 animals. Body weight was measured at the beginning of period 1 (d 1) and at the end of each of the 3 periods (d 21) at the same time each day. Each experimental period had 21 days, where 15 days were destined for diet adaptation and the last 6 days for sampling collection. Dry matter intake (DMI) was daily evaluated at the last six days of each experimental period. Sulphur hexafluoride (SF_6) tracer gas technique for methane measurement was described by Johnson and Johnson (1995) and adapted in Brazil by Primavesi et al. (2004). After the adaptation of animals to the sampling apparatus (PVC canister), the measurement of methane production was performed over six days at 24 h intervals, after morning meal (08:00h). The concentrations of CH_4 and SF_6 were determined by gas chromatograph in EMBRAPA Environment Laboratory Jaguariúna/SP. The quantification of methane released by the animal in the sample was calculated in function of SF_6 concentrations, associating the results to the known rate of the tracer gas in the rumen (Westberg et al., 1998). From the primary data was calculated potential emission of methane in g per day (CH_4, g/d); kg of methane per year (CH_4, kg/yr); g of methane per kg of DM ingested (CH_4, g/kgDMI); % of Gross energy lost as methane (CH_4, %GE) considering the % of gross energy of the diet; Megacalories of methane produced per animal per day (CH_4,Mcal/An.d), considering 13.16 kcal/g of CH_4 and gross energy ingested per animal per day (GEI, Mcal/Ani.d). The data were submitted to variance analysis and the effects of treatment were separated by Tukey test ($P < 0.05$ or $P < 0.10$), using the Statistical Analysis System (Version 9.1, 2002-2003).

Results

There was no difference ($P > 0.05$) between treatments for dry matter intake, when expressed in kilogram per day (kg/d), in relation to body weight (%BW) or in relation to metabolic weight (g/kg $BW^{0.75}$) (Table 1). This was probably, due to the fact that the animals were fed with isoenergetic and isoproteic diets in total mixed rations what may had provided better supply of nutrients along the day, favoring ruminal fermentation, especially the concentration of SCFA.

Table 1. Values of dry matter intake and methane production in cattle fed different energy sources determined by sulphur hexafluoride (SF_6) tracer gas technique.

Variable[1]	Treatment[2] CON	SOY	CiPu	SEM[3]	*P*-value
DMI, kg/d	16.2	14.9	15.8	0.36	0.2559
DMI, % BW	2.12	1.94	2.08	0.06	0.1309
DMI, g/kg $M^{0.75}$	111.4	102.2	109.3	3.00	0.1571
CH_4, g/d	286.2	284.1	344.2	17.7	0.0703
CH_4, kg/yr	110.4	103.7	125.6	6.46	0.0703
CH_4, g/kgDMI	17.4	19.1	22.0	1.20	0.2418
CH_4, %GE	5.17	5.52	6.58	0.36	0.1885
CH_4, Mcal/An.d	3.98	3.74	4.53	0.23	0.0704
GEI, Mcal/An.d	71.7	67.9	69.6	1.55	0.5106

[1]DMI = Dry matter intake; DMI, % BW = Dry matter intake in relation to body weight; DMI, g/kg M0.75 = Dry matter intake in relation to metabolic weight; GEI = Gross energy ingested; [2]CON = Control; SOY = Soybean; CiPu = Citrus pulp; [3]SEM = Standard error of the mean.

Average values of methane production was not affected ($P > 0.05$) by energy source inclusion in the diets when methane was expressed in gram of methane per day (CH_4, g/d); kilogram of methane per year (CH_4, kg/yr); gram of methane per kilogram of ingested dry matter (CH_4, g/kg DMI); percentage of gross energy loss as methane (CH_4, %GE) and megacalories per animal per day (CH_4, Mcal/An.d), as well as the quantity of gross energy ingested per animal per day (GEI, Mcal/Ani.d) (Table 1). When evaluated at 10% probability, it was a significant effect of energy source for the average methane production in g/d; kg/yr and Mcal/An.d, resulting in increased methane emission for the treatment with citrus pulp compared to treatment with soybean and not differing from any of these variables for the control treatment.

In the present experiment, there was no lipid source effect, probably due to the lipid source used, as the shell of soybean does not provide oil directly to the ruminal microbiota, not presenting thus a toxic effect on microorganisms mainly on those who are involved in fiber digestion. On the other hand, the inclusion of a feed source rich in pectin, such as citrus pulp, generates higher CH_4 production, as pectin favors acetate production despite of propionate or lactate (Van Soest, 1994), featuring a fermentative pattern similar to forages. According to ruminal fermentation stoichiometry, changes in ruminal fermentation profile that favor acetate production results in higher

CH_4 (Boadi et al., 2004). However, this fact was not observed in the present study.

Conclusions

The inclusion of a rich source of pectin such as citrus pulp or unsaturated fatty acids such as soybean results in changes in the rumen, although these changes are of small amplitude.

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Effect of supplementation with oils of a forage diet, rumen fermentation and methane emissions in a system of artificial rumen - RUSITEC®

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Introduction

Lipids in ruminant diets affect methanogenesis changing profiles of VFA produced in the rumen and mitigating methane production in these animals by various mechanisms, including, biohydrogenation of unsaturated fatty acids, increased production propionic acid and inhibition of protozoa. The purpose of this work was to study the effect of supplementation with solid soybean, canola and flaxseed, on a diet of Kikuyu grass (*Cenchrus clandestinus*) on the modulation of ruminal fermentation in vitro and methane emissions, using ruminal long term cultures.

Material and Methods

Ruminal fermentation system *in vitro* semi-continuous type RUSITEC® described by Czerkawski and Breckenridge (1977) was used. Which was equipped with eight fermenters capacity of 700 ml, which in turn were adequated under controlled conditions to maintain microbial activity (39 º C, anaerobiosis, and artificial saliva - “McDougall Buffer” continuous motion). At the beginning of the experimental period, in each fermenter 200 ml of artificial saliva was added, preheated to 39 º C and also 500 ml of ruminal fluid extracted from four cows of the Holstein breed who were cannulated in rumen and fed kikuyu grass (*Cenchrus clandestinus*) all of this was filtered and mixed under a constant gassing of CO_2 to temperature of 39 º C.

The procedures described by Giraldo et al, (2007) were followed in each fermenter and randomly, two bags with pore size of 100 μm were incubated, one contained 80 wet grams of ruminal digesta and 12 grams of substrate. After 24 hours of incubation, the bag with ruminal digesta was removed and was replaced with a new containing the substrate, which was removed from each fermenter, upon completion of 48 hours of incubation and replaced by a bag substrate, a process that was conducted daily throughout the experimental period. The flow of each fermenter was kept constant by continuous infusion of Buffer pH 8.0 (McDougall, 1948) at a dilution rate of 4.49 ± 0.13% / hour (647 ± 18.40 ml/day). The effluent product from each fermenter was collected in bottles with a capacity of 1 L. The gas product of the fermentation was collected in aluminum bags with capacity of 5 L, which were attached to the flasks containing the effluent.

Treatments and/or diets included: Control or basal diet: fodder kikuyo 35 days regrowth and a commercial concentrate, in a 70:30 ratio (**D35C**); supplementation of the basal diet with 50 g kg DM of the following oils: Soya (**D35C-S**); Canola (**D35C-Ca**) and Flaxseed (**D35C-Li**). The oils were solid and dry (ALSEC®), which facilitated its mixing with the incubated basal diet. Time evaluation consisted of 20 days, divided into two periods of 10 days each, where each diet or substrate was incubated at random in two fermenters, obtaining four replications per diet. Randomized complete block (RCB) design was used with repeated measures over time, the main effects are: experimental period (blocking factor) measurement day, treatment and treatment nested fermenter. When using the ANAVA a significant effect between treatments was detected, the comparison of means from a Tukey test with a significance level of 0.05 was made.

Results and Conclusions

The table 1 summarizes and samples the most outstanding results. Except degradation PC (DPC), supplementation with 5% soybean oil (**D35C-S**) and linseed (**D35C-Li**), induced an increase in degradation MS, MO and NDF fractions, compared with the control diet and supplementation with canola oil (**D35C-Ca**).

Table 1. Effect of supplementation solid oils, on some parameters of degradation and ruminal fermentation in vitro RUSITEC®

Parameters	Oil Supplementation (50g/kg DM)[1]				Value-*P* [2]
Degradation (%)	**D35C**	**D35C-S**	**D35C-Ca**	**D35C-Li**	
DDM	62.29b	65.80a	62.30b	65.15a	0.04
DOM	60.53b	64.26a	59.97b	63.56a	0.04
DNDF	40.81b	44.99a	44.60a	47.42a	0.03
DCP	70.61	71.22	71.02	69.20	0.63
Fermentation					
pH	6.8	6.7	6.8	6.7	0.10
$N\text{-}NH_3$ (mg/dl)	36.1ab	31.4c	39.7a	32.6bc	<0.0001
Total VFA (mM)	34.9	35.3	36.4	35.4	0.26
Acetate (A)	51.4a	48.8b	50.6a	50.5a	<0.0001
Propionate (P)	29.6b	31.3a	31.2a	30.7a	0.007
Butyrate (B)	10.0ab	10.6a	9.4b	9.8ab	0.0004
A:P (mol:mol)	1.7a	1.5b	1.6ab	1.7ab	0.001
AB:P (mol:mol)	2.1a	1.9ab	1.9ab	2.0ab	0.01
Other VFAs[3]	10.8ab	11.4a	10.6b	10.9b	0.002
Gas Volume (L/day)	2.16	2.10	2.15	2.33	0.19
CH_4 (ml/L gas)	53.9b	50.7b	61.7a	65.5a	0.001
CH_4 (ml/gDMi)	4.5	4.2	5.1	5.5	0.25
CH_4 (ml/gDMd)	7.2	6.3	8.3	8.5	0.20
CH_4 (ml/gOMf)	8.2	7.1	9.5	9.7	0.20
CH_4 (ml/gNDFd)	22.1	19.5	23.1	19.9	0.78

[a-c] Means with different letters in the same row differ according Tukey (P<0.05). [1]Dietas incubated: Forage regrowth Kikuyu 35 days and a commercial concentrate in a ratio of 70:30 (D35C); Supplementation of the basal diet with 50 g/kg DM oils: Soya (D35C-S); Canola (D35C-Ca) and Flaxseed (D35C-Li). [2]Values P by treatment effect. [3]Isovalerate and Isobutyrate suma.

The percentage of the DMS diets and BMD was higher (P<0.05) for soya oil and flaxseed compared with the control and canola. The percentage of NDFD was higher (P<0.05) in all treatments with oils compared with the control.

The proportion of acetate decreased by approximately 4% with the inclusion of 5% soybean oil in the diet when compared to other treatments ($P<0.0001$). Propionate was increased significantly ($P<0.05$) in all treatments with oil.

But the proportion of butyrate in the effluent, with supplementation decreased only 5% with Canola oil and Flaxseed. The ratio A:P, decreased by 12%, when it was supplemented with soybean oil, due to the increase propionate at the expense of acetate. However, pH values and total AGVs, were not affected by any of the treatments compared with the control diet ($P = 0.10$ and 0.26, pH and total VFA, respectively). The concentration of N-ammonia in the effluent decreased by 16% with supplementation of Soya and Linseed oil, compared with the control diet and the supplementation with Canola oil.

The volume of gas produced, was not affected by any of the treatments ($P=0.19$), with an increase of 22% in the production of methane (ml / L gas) with the inclusion of canola oil and flaxseed compared with the control diet supplemented with soybean oil. In general, methane production was higher ($P<0.001$) in Canola oil Flaxseed and smaller in the Control and soybean oil ($P=0.001$).

In conclusion, the inclusion of oils in diets for milk production, modify the modulation of ruminal fermentation, but soybean oil showed potential to mitigate the ruminal methanogenesis in an *in vitro* ruminal fermentation system semi-continuous type RUSITEC ®.

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Greenhouse gas emissions mitigation in more sustainable agroecosystems in Cerrado

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Introduction

The challenge to produce food and fiber in quantity and quality to sustain the population in the next decades is intimately associated to the need for sustainable agroecosystems (Power, 2010; Strassburg, 2014). 'Business as usual' agriculture is the land use dedicated to the production of commodities like grain (soya and corn) and meat that receives government incentives and relies on nonrenewable resources as land, fertilizers, genetically modified and/or certified seeds and fossil resources (Buller, 2016). On the other hand, the core of sustainable agriculture is the ability to recycle materials and to use more efficiently nonrenewable and renewable resources including the provision of ecosystem services as biodiversity, carbon sink and water production (Power, 2010). The transition from business as usual to a more sustainable agriculture is closely adhered to the reestablishment of ecosystem services by integrated crop-livestock-forestry (Buller et al., 2015) and agroforestry systems to produce high-quality food (Buller, 2016). In this work, we show that the transition to more sustainable rural production can mitigate greenhouse gas (GHG) emissions by agroecosystems without compromising revenues, particularly in the Cerrado region.

Material and Methods

GHG fluxes for sinks and sources were derived for enteric CH_4 and excreta livestock N_2O (Dong et al., 2006; World Bank, 2010), median soils CO_2, CH_4, and N_2O fluxes in integrated agroecosystems (Buller et al., 2015), pasture CO_2 fluxes and soil C fixation (Watanabe and Ortega, 2014), and C uptake of Cerrado forest (Meirelles and Henriques, 1992). Data are expressed in Mg CO_2-eq/hectare/year according to GWP values (AR5-IPCC, 2013). Four levels of agricultural development were considered to a small farm with a productive area of 22.4 hectares: 1) agriculture with high technology in integrated swine-crop-pasture- eucalyptus system (ISCPE) in which about 10 heads/hectare is allowed in pasture-forestry fertigated with biodigester effluent (Buller et al. (2015); 2) ISCPE + 10% SA (Sustainable Agroecosystems providing more diversified food as milk, fruits/nuts, honey, and ecosystem services, where native reforestation and nutrient recycling technologies are adopted as shown in Buller (2016); 3) ISCPE + 30% SA; and 4) ISCPE + 50% SA. The ISCPE considers only 5% area of native forest (Buller, 2016), whereas ISCPE + SA scenarios assume 10%, 30% and 50%, respectively, of reforestation area to include the production of honey and fruits/nuts e.g. pequi *(Caryocar brasiliense*), gabiroba (*Campomanesia sp*), jatobá (*Hymenaea L.*) and cumbarú (*Dpterix alata*). The changes in farm economy translated into sale returns, food energetics, net emissions and profitability, all expressed per hectare, are presented in Table 1, considering mature or well-developed agroecosystems ISCPE and ISCPE + SA.

Results and Conclusions

Figure 1 shows the comparison of sinks and sources strength for ISCPE toward to a ISCPE + SA by adding native forest for natural food production. Nutrient recycling technologies and native forestry recovery in SA are responsible for reduced GHG emissions and for a favorable impact in the net emissions. The relative balance for each system indicate an increase in GHG emissions mitigation along the recovery of the native vegetation, and a decrease in net emissions while including more SA (Table 1). Gradual transition from ISCPE to ISCPE + SA 10% or 30% fits the commitment assumed at COP 21 by fixing the mitigation of GHG emissions respectively in 33 or 66%. Moreover, the native tree species are sources of new production outputs (fruits/nuts and honey) that, in a gradual timeframe related to the trees growth and life cycle maintain farmers' incomes and allow the participation in the very volatile commodities markets (Buller, 2016).

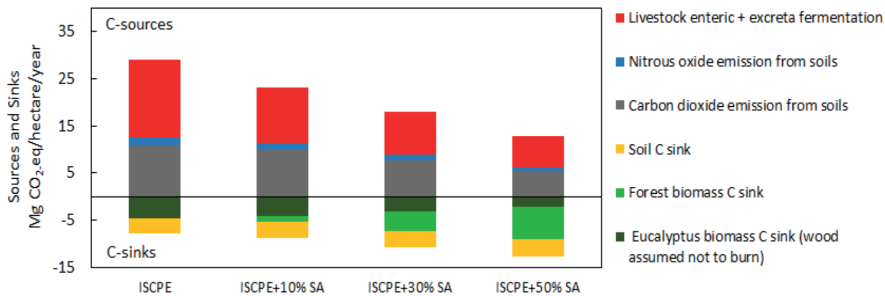

Figure 1. Relative C sources and sinks for different sustainability levels of agroecosystems.

Table 1 presents the calculations of sales, food energetics, net emissions and profitability per hectare for each agroecosystem under analysis. It is clear that the changes from ISCPE to ISCPE + SA do not change significantly farm sales and profitability. Moreover, including SA mitigates net C emissions and recovers vital ecosystem services at the farm level with the production of less energetic but healthier food.

Table 1. Changes in farm sales, food energetics, net emissions and profitability.

	ISCPE	ISCPE+ 10% SA	ISCPE+ 30% SA	ISCPE+ 50% SA
Total sales (USD/hectare)	46962	45856	46682	45365
Food energetics (Gcal/hectare)Net	104.6	99.2	87.0	73.8
emissions (Mg CO_2-eq/hectare)	21.42	14.41	7.20	0.23
Profitability per hectare (%)	51%	54%	61%	67%

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Infrared Thermography to Estimate Thermal Comfort in Meat Sheep

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Introduction

Heat stress is one of the main limiting factors in the performance of sheep in tropical regions, particularly when associated with high humidity and inadequate facilities.

Infrared thermography (IT) is a tool that allows determining the temperature distribution on surfaces and investigating heat transfer processes. Moreover, it is a non- invasive diagnosis technique to measure surface temperature that indicates thermoregulation physiological events as well as assesses the animal's thermal stress (BROWN-BRANDL et al., 2013).

Adverse climate conditions directly impact thermal comfort and animal production. Therefore, this study aimed to verify whether infrared thermography can be used to identify animals experiencing thermal stress due to heat.

Material and Methods

The research was carried out in the sheep farming sector of the Federal Institute of Pará (IFPA) in the city of Castanhal, PA, Brazil. 18 crossbred (Dorper x Santa Inês) sheep whose mean weight was 30 ± 2 kg were used. The animals were confined in a 6 m x 32 m barn oriented in the east-west axis featuring 3.0 m high ceiling and concrete columns 4 m apart that supported wooden trusses. The barn was covered in fiber cement tiles.

To the left of the barn, common bamboo (*B. vulgaris* Vittata) clumps were planted, which were used as a sanitary barrier and decreased the incidence of direct sunlight, thus creating a mild microclimate by the barn's left wall.

The Hobo H8 Onset® data loggers were installed in the barn to monitor the environmental variables of air temperature (AT) and relative humidity (RH) every 15 min. The temperature and humidity index (THI) was determined according to the equation proposed by Thom (1959).

An infrared camera (T650-FLIR®) set to emissivity coefficient of 0.95 was employed to measure the animals' surface temperature at different sites of the body. In all collections, the camera was placed at a standardized distance (4 m from the animal and 1.5m from the ground) to better focus and photograph the animals' right side (axilla, stifle, foreskin, eye, and lip) (Figure 1).

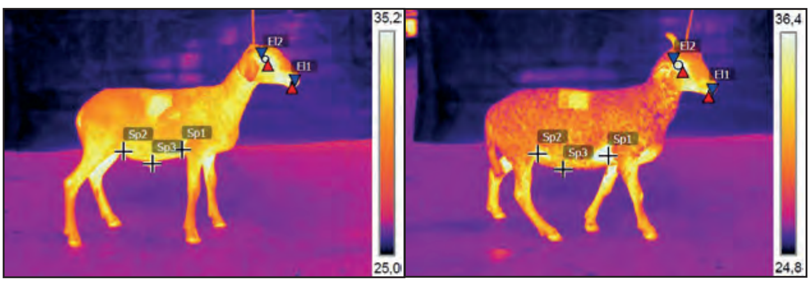

Figure 1: Thermal images highlighting the body sites analyzed.

A completely randomized spli-split-plot experimental design with six treatments and three repetitions was employed with environment (natural shade and no shade) as the plot and period of the day (5-6 AM, 1-2 PM, and 7-8 PM) in the split-plot. The periods were chosen from prior observations of the prevailing climate conditions so that one caused greater thermal discomfort than the others, thus leading to changes in behavioral patterns that could be detected.

Analysis of variance was used for the statistical analysis of the variables and Tukey's test at 5% significance was used to compare the means.

Results and Conclusions

During the experimental period, the values calculated were 24.04 ± 0.17, 29.26 ± 1.36 and 25.46 ± 0.16 for AT; 95.55 ± 0.87, 78.43 ± 4.73 and 90.92 ± 1.66 for RH; 74.84 ± 0.34, 81.40 ± 1.5 and 76.83 ± 0.23 for THI for the periods of 5-6 AM, 1-2 PM, and 7-8 PM, respectively.

The analysis of the temperatures in the periods shows that they were within the thermal comfort range, which is around 30 ºC. However, RH values above the recommended were observed, between 40 and 70%, which indicates difficulties in exchanging heat with the surroundings (BAÊTA AND SOUSA, 1997). In the period between 5 and 6 AM, the animals were under comfort situation, however, the indices between 1 and 2 PM and between 8 and 9 PM indicated alert situation, suggesting thermal stress condition according to the THI (BAÊTA AND SOUSA, 1997).

The analysis of variance showed no significant difference ($P>0.05$) for stifle, eye, and lip between the two environments. Temperature increased around the axilla of the animals in the environment with no shade since part of the process to maintain homeothermy occurs by increasing blood flow to the body surface through vasodilation (SILVA, 2000).

Thus, IT of the axilla and foreskin region enables identifying animals under thermal stress by heat. An effect (P<0.05) was observed for all periods, with the highest means observed between 1 and 2 PM (Table 1).

Table 1. Mean temperature values (°C) of the sheep (axilla, stifle, foreskin, eye, and lip) under different climate conditions measured by thermographic images.

Environment	Periods			Mean
	5-6 AM	1-2 PM	7-8 PM	
Axilla				
No shade	34.98±1.17	36.83±0.80	36.24±0.97	36.57A
Shade	35.00±1.16	37.87±0.62	36.83±0.69	36.02B
Mean	34.99c	37.35a	36.53b	
Stifle				
No shade	35.18±1.21	36.83±0.93	35.91±0.86	35.97A
Shade	35.19±1.18	37.22±0.69	35.05±5.34	35.82A
Mean	35.18b	37.02a	35.49b	
Foreskin				
No shade	33.55±0.87	36.37±0.75	33.72±0.86	35.3A
Shade	34.06±1.01	36.57±0.85	35.27±0.82	34.55B
Mean	33.81c	36.47a	34.5b	
Eye				
No shade	34.35±1.07	37.03±0.34	36.33±0.35	36.10A
Shade	34.25±0.83	37.3±0.44	36.74±0.30	35.91A
Mean	34.30c	37.16a	36.54b	
Lip				
No shade	32.61±1.30	36.29±0.34	34.99±0.90	34.92A
Shade	33.24±0.85	36.55±0.50	34.97±0.49	34.62A
Mean	32.92c	36.42a	34.98b	

Means followed by the same small letters on the same row and by the same capital letters in the same column do not differ according to Tukey's test at 5% probability.

The use of infrared thermography proved sensitive to detect differences in the animals' skin temperature and, thereby, to identify an indicator of thermal stress due to heat. The behavior of body surface temperatures in the axilla and foreskin was shown to be important in sheep homeothermy.

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Eucalyptus and *Urochloa* roots integration system Livestock-Forest

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Introduction

Carbon sequestration (C) atmospheric and storage in the terrestrial biosphere, is one of the options that have been proposed to offset the emission of greenhouse gases, since the soil is the largest reservoir of C in terrestrial environments (Albrecht; Kandji, 2003). The determination of the proportion of the roots of species of photosynthetic pathways C_3 and C_4 has been performed by means of differences in natural isotopic concentrations of stable isotope ^{13}C (Rosolem et al., 2012). The $\delta^{13}C$ values of C_3 plants typically range -30 to -22 ‰ ‰ (mean = -27 ‰), while the C_4 plants values range from -15 to -9 ‰ (mean = -13 ‰) (O'Leary, 1988). It is then possible to calculate the proportion of carbon derived from C_3 and C_4 plants by mass mixture of equation (Balesdent & Mariotti, 1996; Yoneyama et al., 2001). The importance of agroforestry systems with respect to C sequestration is being widely recognized, but there is still lack of quantitative data on the contribution of the root system of the species in the system. The inclusion of eucalyptus in areas of pasture can modify the amount and distribution of MOS intake in depth from the root system of the species. The objective of the study was to investigate the contribution of the eucalypt root system (C_3) and *Urochloa* (C_4) in integrated agricultural production.

Material and Methods

Evaluations were performed in an experiment installed in the Advanced Technology Research Center of Agribusiness and Rubber Agroforestry

Systems, the Agronomic Institute - IAC, located in Votuporanga, SP, Brazil.

The experiment conducted in an area of degraded pasture, with ten years of implementation, the soil classified as Argisol according to Embrapa (2013). The treatments were two- eucalyptus hybrid Grancam 1277 and Urograndis H-13 and four sampling sites in the system: under the canopy of eucalyptus, 2.0 meters of eucalyptus line; 4.0 meters of eucalyptus line and 6.0 meters from the eucalyptus online integrated *Urochloa brizantha* cv. Marandu. Factorial 2 × 4 with a witness, with three replications.

The isotopic ratio of C was analyzed to determine the percentage of contribution of eucalyptus roots and *Urochloa brizantha* in the soil. The roots were ground in cryogenic, weighed and placed mill in tin capsules, then analyzed in a mass spectrometer of isotopic ratio (IRMS) Finnigan MAT Delta Plus.

The results were analyzed using the statistical program Sisvar® (Ferreira, 1999). When differences found, the means were compared by t-test (LSD) at 5% probability.

Results and Conclusions

The $\delta^{13}C$ values of the roots of *Urochloa* (C_4) and eucalyptus (C_3) were -13.25 and -28.86 respectively. The root distribution *Urochloa* and eucalyptus was influenced by the distance of the eucalyptus line 0-0.05 m depth (Figure 1).

The distribution of Eucalyptus roots is higher on the canopy, and decreases with increasing distance from the eucalyptus line at a depth of 0–0.05 m. The contribution of *Urochloa* roots is greater than in full sun integrated with Eucalyptus, with no significant difference in the integrated production system in the layer 0–0.05 m.

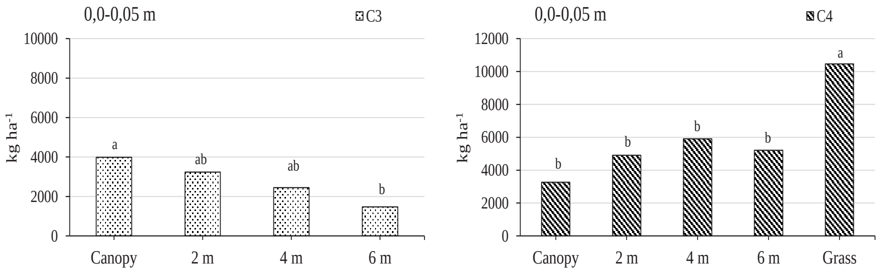

Figure 1. Production dry matter root the Eucalyptus (C3) and *Urochloa (*C4) integrated system

In the integrated crop-Livestock system with eucalyptus and *Urochloa*, the amount of Eucalyptus roots (C3) is higher on the crown, and is reduced to as distances of the line. The contribution of *Urochloa* roots increases with distance from the eucalyptus line.

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Growth in *Urochloa* integrated with Eucalyptus

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Introduction

Carbon sequestration (C) and atmospheric storage in the terrestrial biosphere, is one of the options that have been proposed to offset the emission of greenhouse gases, since the soil is the largest reservoir of C in terrestrial environments. Thus, integrated production systems have received wider recognition not only for agricultural sustainability, but also for issues related to climate change on the planet (Albrecht & Kandji, 2003). Since agroforestry systems tend to sequester greater amounts of carbon than agricultural systems without trees (Neufeldt et al., 2009).

The Livestock-Forest integration is a form of integrated agricultural production, which coexists in the same area trees, pastures and animals. However, knowledge of the behavior of species in competition for factors production becomes of great importance to the successful satisfactory productivity while avoiding the competition existing between species impede cultivation intercropping (Kluthcouski & Yokoyama, 2003). Furthermore, little is known about the effect of trees integrated with pastures. The objective of this study was to investigate the growth of *Urochloa* in integrated with Eucalyptus.

Material and Methods

Evaluations were performed in an experiment installed in the Advanced Technology Research Center of Agribusiness and Rubber Agroforestry Systems, the Agronomic Institute - IAC, located in Votuporanga, SP, Brazil.

The experiment conducted in an area of degraded pasture, with ten years of implementation, the soil classified as Argisol according to Embrapa (2013). The treatments were two- eucalyptus hybrid Grancam 1277 and Urograndis H-13 and four sampling sites in the system: under the canopy of eucalyptus, 2.0 meters of eucalyptus line; 4.0 meters of eucalyptus line and 6.0 meters from the eucalyptus online integrated *Urochloa brizantha* cv. Marandu. Factorial 2 × 4 with a witness, with three replications.

Forage production was evaluated by cutting the forage within a square of 0.5 × 0.5 m (0.25 m^2), launched at random from different points of the floor area of the plot, at the end (April) and early (October) of the rainy season of 2015. After cutting, it was put in paper bags and weighed, obtaining the value of fresh matter. This material pulled out a subsample of approximately 500 g, which was dried in an oven at 60°C/72 hours thus obtaining the dry matter. The results were analyzed using the statistical program Sisvar® (Ferreira, 1999). When differences found, the means were compared by t-test (LSD) at 5% probability.

Results and Conclusions

Eucalyptus hybrids had similar effect on growth of forage. In the dry season of the year, there was no effect of the insertion of eucalyptus the pasture (Figure 1a). In the rainy season, forage production was higher than in full sun, and varied depending on the distance of eucalyptus planting row (Figure 1b).

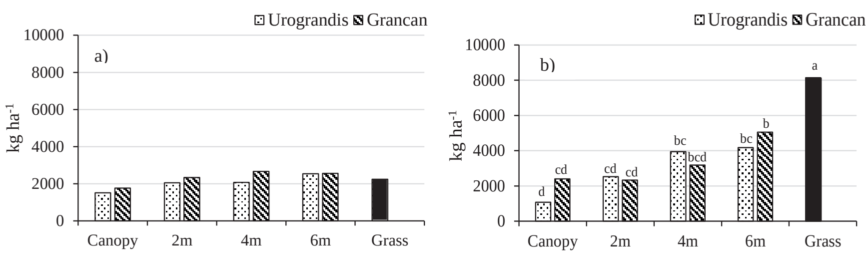

Figure 1. Mass production of dry matter of the aerial part of the forage

The dry matter production of *Urochloa* varies between 1079-8134 kg ha^{-1}, the difference in the magnitude of the results is the rainfall and distance from the eucalyptus line. The lower forage production in Eucalyptus line related to the interaction factors between species. Studies have shown that forage has reduced growth by shading above 35-40% shade (Guenni et al, 2008; Paciullo et al, 2007).

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Co-digestion of swine manure and inclusion levels of waste vegetable oil

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Introduction

Co-digestion is the simultaneous addition of two or more substrates with the aim of improving the economic feasibility of anaerobic digestion process due to increased methane production by their interaction through the balance that is established between the compounds (Mata-Alvarez et al., 2014). Fats, oils and greases have been mentioned as substrates that can increase the biogas production by 30% or more when added directly in an anaerobic digester (Hunter Long et al., 2012).

Thus the addition of lipid residues to animal waste improves anaerobic digestion process, however there are few studies related to this topic.

Lansing et al. (2010) evaluated the additions of 0; 2.5; 5.0 to 10% cooking waste oil in relation to the digesters volume capacity during co-digestion of pig manure and verified the benefits of the combination of these residues, once the largest inclusion of oil doubled the biogas productions and the increment of methane in the biogas composition in comparison to the lowest addition level.

Nonetheless, high amounts of lipids in the substrates may have toxic effects on microorganisms, slowing the degradation process of the material in digestion. According to Mata-Alvarez et al. (2014) proportions of long chain fatty acids and polyphenols inhibit the degradation of the substrate in fermentation by the microorganisms and also have inhibitory action on certain microbial groups. Zhang et al. (2013) reported that the process of toxicity is related to adsorption of long chain fatty acids (oleic and stearic acid) into the membrane of microbial cells hence reducing the transport of nutrients.

Valladão et al. (2011) observed improvement on the production of methane (0.393 L CH_4 / g COD reduced) from digesters supplied with effluent from poultry slaughtering and inclusion of lipolytic enzyme - lipase (1.0% volume).

Thus, the usage of certain inclusion levels of lipase allowed the decomposition of compounds and enhanced the process of co-digestion; however, its excess can cause increased production of long chain fatty acids which are harmful to microorganisms, limiting the degradation process (Mata-Alvarez et al., 2014).

Based on this assumptions, this work aimed to evaluate the performance of digesters supplied with pig manure and increasing levels of waste oil (8, 10 and 12% in relation to the contents of the TS in the substrate) in the presence of lipase enzyme (lipase) through the productions and potential productions of methane and as well as the reductions in the levels of total (TS) and volatile (VS) solids.

Material and Methods

The manure were collected by scraping the animal housing stalls and the waste vegetable oil was obtained through a donation made by a commercial pastry, and already in disposal conditions (after successive frying re-uses). The experiment was carried out in 2014 in the city of Dourados, central-west region of Brazil, latitude 22º 13 ‘16 “S and Longitude 54 48’ 20” W. A completely randomized design was adopted in a factorial scheme 3x5, three inclusion levels of waste vegetable oil (in the proportions of 8, 10 and 12% in relation to the levels of TS in the substrate) and five inclusion levels lipase (0.05, 0.10, 0.15, 0.20 and 0.25% in relation to the levels of TS in the substrate) with two replicates (digesters). The manure used to feed the digesters had the following composition: 28.9% of TS, of which 78.3% were volatile. The inoculum contained 2.77% TS, with 67.4% volatile. Waste vegetable oil presented 98% TS.

The batch digesters used in this study were built with two straight PVC cylinders with diameters of 150 and 100 mm and a container for storing the material to be fermented with 65mm in diameter. The digesters are also described as bench-scale batch digesters with an average capacity of 1.3 liters of substrate in fermentation in each one. The cylinders of 100 and 150 mm diameter are inserted into other so that the space between the outer wall of the inner cylinder and the inner wall of the outer cylinder could hold a volume of water ("water seal"). The cylinder of 100 mm diameter had one end closed and one opening for the release of biogas and was kept submerged onto the water seal to provide anaerobic condition and store the gas produced.

In the influent and effluent, concentrations of TS and VS were determined through the methodology described by APHA (2005).

The biogas volumes produced on a daily basis were determined by measuring the vertical displacement of gasometers and multiplying by their internal cross-sectional area. After each reading, the gasometers were zeroed using the records of biogas discharge.

Specific productions of biogas were calculated by dividing the production values for the quantities of TS and VS added, and the results were expressed in liters of biogas per kg of each of the constituents evaluated. The composition of biogas was assessed using a gas analyzer, GA-21 Plus, Madur Electronics, equipped with sensors for determining CO, CO_2 and CH_4. The potentials of methane production were calculated by the production of methane, dividing the production values by the amount of TS and VS added in the digesters.

The results were subjected to analysis of variance considering as sources of variation the levels of oil and levels of lipase. Orthogonal contrasts were used to determine linear, quadratic and cubic effects of oil and lipase levels. These analyses were performed using the statistical computer package R (version 3.1.0 for Windows).

Results and Conclusions

The potential of methane production, which is the gas of greatest interest (Figure 3), was increased per amount of TS added and the inclusions of enzyme that showed the largest increase for the inclusion levels of 8, 10 and 12% waste oil were 0.13; 0.14 and 0.12% lipase, respectively. The most favorable inclusions of enzyme for VS were 0.12, 0.13 and 0.11% lipase for 8, 10 and 12% waste oil, respectively.

A similar behavior between the two solid constituents was expected since VS is part of the TS, and they reflect even better the quality of digesters, once the integrant part of these constituents is the corresponding fraction degraded by microorganisms, generating biogas production and consequently methane. Thus, the highest production of methane (0.29 L per gram of VS added) might be achieved during co-digestion with addition of 0.11% lipase and 12% waste oil, providing productions of methane 73% higher than with enzyme inclusion of 0.05% with the same level of oil.

A decrease in the potential of methane production indicates a possible toxic effect of the long chain fatty acids that occurred with an average inclusion of lipase about 0.15%. According to Pastor et al. (2013), this behavior can be explained by the adsorption of long chain fatty acids in the microbial cell membrane, which will interfere with the mass transfer and consequently affect the methanogenesis.

Table 1. Regression models, R^2, P (probability), optimal level of inclusion of oil and the best specific productions of methane obtained during co-digestion of substrates prepared with swine manure and increasing doses of waste vegetable oil.

Variables	Level of oil	Regression Model	P	R²	Oil inclusion	Maximum Values
l of methane per g of TS added	8	$y = -3.52x^2 + 0.93x + 0.13$	<0.001	0.89	0.13	0.19
	10	$y = -2.61x^2 + 0.72x + 0.16$	<0.001	0.99	0.14	0.21
	12	$y = -2.36x^2 + 0.57x + 0.20$	<0.001	0.45	0.12	0.23
l of methane per g of VS added	8	y = -3.96x2 + 0.94x + 0.20	<0.001	0.61	0.12	0.26
	10	y = -3.00x2 + 0.76x + 0.22	<0.001	0.93	0.13	0.27
	12	y = -1.01x2 + 0.22x + 0.28	<0.001	0.37	0.11	0.29

CV: coefficient of variation; P: probability; R^2: correlation coefficient; TS: total solids; VS: volatile solids.

In this way, it is concluded the inclusion of lipase at levels up to 0.14% (relative to levels of TS in the substrate) in the composition of substrates in co-digestion with oil at levels up to 12% (relative to levels of TS in the substrate), and swine manure improves the yields of methane.

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Intensive grazing system increases milk productivity of Holstein and Jersey-Holstein crossbred dairy cows

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Introduction

In Brazil, despite the lack of accurate statistics on the contribution of each type of system in total milk production, it is known that pastures represent the main feed source in most production systems (IBGE, 2010). However, a major concern with respect to this factor is related to the potential environmental impact the degradation of thousands of hectares of these pastures may have.

Improvements in pasture management in the last decades have led to a great advance in animal production systems in the country. Among them are the adoption of cultivated pastures and the improvement of native pastures, leading to increased stocking rates and productivity (Oliveira et al., 2015).

Besides the intensification of pasture management, producers must seek dairy cattle genotypes with better production characteristics. Therefore, there is growing interest in Holstein cross breeding to increase fertility and improve milk production and composition (Xue et al., 2011). Combining good genetics with sustainable grazing systems is essential to improve milk production and preserve the environment. This experiment was designed to examine the effect of different grazing systems on the productivity of milk and its components by Holstein and Jersey-Holstein crossbred dairy cows.

Material and Methods

Twelve Holstein and twelve Jersey-Holstein crossbred dairy cows were used in a 2 x 2 factorial arrangement, represented by 2 cattle genotypes (Holstein and Jersey-Holstein) and 2 pasture systems (extensive with low stocking rate - EXT - and intensively managed and irrigated with high stocking rate - IIR). Cows were kept on pastures and received a dietary supplement (concentrate) formulated according to the NRC (2001) in the rate of 1 kg of concentrate per 3 kg of milk produced. The extensive pasture system was composed of two paddocks, 3.0 ha each, containing *Brachiaria spp*. and *Cynodon nlemfuensis* Vanderyst, managed as continuous grazing systems, without fertilization. The intensive managed system was irrigated and cultivated with *Panicum maximum* Jacq cv. Tanzânia and overseeded with *Avena byzantina* cv. São Carlos and *Loliun multifloram* Lan. cv. BRS Ponteio, in autumn. The IIR system consisted of two similar 1.6 ha rotational systems, divided in 27 padocks with 600 m^2 each, intermittently grazed, with a day of occupation and 26 days of rest. The intensive managed pastures were limed and fertilized with superphosphate and potassium chloride to achieve respectively, 20 mg $P.dm^{-3}$ and 4% K in soil CTC - cation exchange capacity. Nitrogen was applied at the rate of 600 kg $ha^{-1}year^{-1}$.

Three cows (tracers) of each genotype grazed simultaneously in each replicate of area. All grazing systems were submitted to stocking rate adjustments using the “put and take” technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

Milk yield (MY), 3.5% fat corrected milk (FCM), fat (F), protein (P), lactose (L), total solids (TS) and dry defatted extract (DDE), per area per year (kg $ha^{-1}year^{-1}$) were evaluated. Data were analyzed by the SAS® (SAS Institute, 2002) program, using Mixed Procedure.

Results

Annual average stocking rates were 1.9 and 2.1 animals ha^{-1} in EXT and 6.6 and 7.9 animals ha^{-1}in IIR, for Holstein and Jersey-Holstein breeds, respectively. Consequently, the type of grazing system influenced ($P<0.0001$) productivity of milk and its components (Table 1). The IIR system increased the productivity of milk and its components, independently of the cow genotype used.

Irrigation and intensive management caused an 258% increase in annual production of milk, when compared to the extensively managed system (63,867 vs.17,839 $ha^{-1}year^{-1}$). The cattle genotypes did not have any influence on productivity of milk and its components, estimated using the average production of each breed (Table 1).

Forage production in irrigated rotational grazing systems tends to be high, and can increase stocking rate and productivity. However, gains in extensive systems, that present low carrying capacity, may be minimal despite the use of better cattle genotypes (Mendonça et al., 2010).

Table1. Effects of two genotypes and grazing systems on the productivity (kg ha^{-1} $year^{-1}$) of milk and its components.

	Genotype		Pasture			*P Level*		
Item[1]	Holstein	Jersey-Holstein	Extensive	Intensive Irrigated	SEM[2]	Pasture	Genotype	Past*Gen
MY	40,095.0	41,611.0	17,839.0	63,867.0	6,461.6	<0.0001	NS	NS
FCM	36,915.5	38,231.0	16,228.5	58,918.0	6,007.7	<0.0001	NS	NS
F	1,207.3	1,248.1	525.1	1,930.3	198.9	<0.0001	NS	NS
P	1,300.1	1,366.4	584.6	2,081.9	207.3	<0.0001	NS	NS
L	1,852.3	1,919.1	823.9	2,947.6	300.3	<0.0001	NS	NS
TS	4,740.2	4,934.4	2,108.1	7,566.6	764.4	<0.0001	NS	NS
DDE	3,544.8	3,690.9	1,579.9	5,655.8	569.9	<0.0001	NS	NS

[1]MY: milk yield; FCM: 3.5% fat corrected milk; F: fat; P: protein; L: lactose; TS: total solids; DDE: dry defatted extract; [2]standard error of the means; NS: non- significant ($P>0.05$);

Conclusions

Intensive management of pastures increases the productivity of milk, collaborating to the sustainability of dairy production, especially in small areas.

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Greenhouse Gasses Emissions and land use in Mato Grosso do Sul (MS) State: an exploratory study to the MS Carbon Neutral Initiative

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Introduction

Climate Change Policy of Mato Grosso do Sul (CCP-MS) was stablished by the State Law 4.555/2014 (Lei 4.555/2014). The state assumed a voluntary reduction in greenhouse gases emissions (GHG) of 20% by 2020 in relation to 2005 emissions. To reach this target, the CCP- MS appointed a number of strategies, including the State Program on Climate Change (PROCLIMA). The program will structure the basis to calculate and monitor the emission inventories of MS, and launch initiatives towards a low carbon emission economy.

The current inventories are based on global and national standards and emission factors that are not completely adapted to particular characteristics of MS. Some emission factors are probably overestimating the net GHG emissions. Complementarily, the final balance of GHG do not consider some important mechanisms that absorbs carbon in conservative land use systems, e.g. no-tillage crop farming, improved sown pastures, zero-burning sugarcane plantations and integrated crop-livestock-forestry (ICLF) systems; as well as soil carbon and aboveground biomass through afforestation and ICLF.

The objective of MS Carbon Neutral Project is to create the methodological basis for a low carbon economy in Mato Grosso do Sul, developing and adapting technologies for GHG emissions reduction and mitigation in the various sectors of the state economy, supporting the achievement of PROCLIMA´s goals.

The first phase of the project was to understand the dynamics of GHG emissions based on available inventories and its relation to changes in land use and agricultural activities in Mato Grosso do Sul State.

Material and Methods

As for GHG emissions attributed to Mato Grosso do Sul, we considered the estimates of the System Study Greenhouse Gas Emissions Estimates (SEEG), a system developed by the Climate Observatory (http://seeg.eco.br/). The estimates follow the guidelines of the Intergovernmental Panel on Climate Change (IPCC). SEEG obtained the basic data from Brazilian Inventories of Anthropogenic Emissions and Removals of Greenhouse Gases, issued by the Brazilian Ministry of Science, Technology and Innovation (MCTI), and from government reports, institutes, research centers, industry organizations and nongovernmental organizations. We analyzed land use changes in Mato Grosso do Sul based on the results of the SIGA-MS Program (SIGA-MS, 2016). Although data are available until 2016, we analyzed data from 2010 to 2014, since emission data are available only until 2014.

Results and Conclusions

Reported GHG estimates to Mato Grosso do Sul showed significant contribution from agriculture and land use change to the total emissions. From the total GHG in 2014 (55 Mt C- CO_{2e} yr^{-1}), 80% came from agriculture and land use change in this State. Energy was the second larger category, accounting for 16% of the GHG emissions (GGE) and showing the largest absolute (3.7 Mt C-CO_{2e} yr^{-1}) and relative (72%) increases on emissions. The final balance of the agricultural sector (land use change + agriculture) was slightly negative, showing a net GGE reduction of -0.1 Mt C-CO_{2e} yr^{-1}. We also verified that the major contribution for the observed net reduction was the enteric fermentation of cattle that showed an absolute decrease of -1.4 Mt C-CO_{2e} yr^{-1}.

Table 1. Greenhouse gasses emissions (1,000 t C-CO_{2e} – GWP) in Mato Grosso do Sul (SEEG, 2016).

Sector	2010	2011	2012	2013	2014	Difference
Agriculture Total	35.395	34.559	34.639	34.331	34.532	-863
Rice	164	175	105	96	94	-69
Enteric Fermentation	23.417	22.592	22.532	22.063	22.018	-1.399
Management of Animal Waste	838	875	847	827	844	7
Residue Burning	395	396	429	481	500	105
Agricultural Soils	10.581	10.520	10.727	10.863	11.075	493
Land Use Change Total	9.162	9.698	9.717	9.870	9.916	754
Soil Use Changes	8.081	8.265	8.077	8.258	8.244	163
Limestone Application	748	817	1.307	1.270	1.331	582
Residue Burning	333	616	332	343	342	9
Removal of Protected Areas	-	-	-	-	-	0
Energy	5.131	5.068	6.450	7.762	8.803	3.672
Industry	359	424	404	555	563	204
Residue Total	1.009	1.160	1.217	1.350	1.403	395
Waste Disposal	418	403	400	427	466	48
Waste Incineration	-	-	-	-	-	0
Treatment of Domestic Effluents	167	173	177	186	190	23
Treatment of Industrial Effluents	424	585	641	738	747	323
Total Emissions	51.055	50.909	52.428	53.869	55.217	4.162

When we analyzed the changes in the agricultural sector in the same period (Table 2), we observed significant changes on land use from 2010 to 2014. There were net increases in areas of grain production (20%), planted forests (107%), sugarcane (52%), and native forests (5%). At the same time, a proportional decrease in cattle grazing areas) indicates expansion of grain and sugarcane farming and commercial afforestation (mainly eucalyptus) over pasture areas, without displacing pristine or regenerating native land cover, which, as a matter of fact, increased 5% in the same period. Decrease in enteric methane emissions from cattle might be strongly related to reductions in the total grazing area. From 2010 to 2014, state's total cattle herd decreased from 22.3 to about 21.0 million head (INFOAGRO, 2015). On the other hand, under the local conditions, land use change through expansion of grain crop farming, sugarcane and afforestation over grazing areas do not lead to increases in GHG emissions. These systems are probably increasing carbon stocks and sequestration in the systems and the net annual emission of 8.2 Mt C-CO_{2e} yr^{-1} should probably be overestimated.

Another important point is that from 2010 to 2014, although pasture area and cattle herd decreased, beef production increased 21% (from 796,000 t to 965,000 t) (INFOAGRO, 2015). We calculated that the emissions per unit of beef yielded decreased from 29.4 to 22.8 kg C- CO_{2e} kg^{-1} of beef. In other words, the same quantity of beef produced in 2014 emitted 22% less greenhouse gases than 2010.

Table 2. Land use change in Mato Grosso do Sul from 2010 to 2014 (SIGA-MS, 2016) in 1,000 hectars.

Land use	2010	2011	2012	2013	2014	Difference 2010 - 2014
Grains	1.840	1.902	2.018	2.069	2.211	370
Sugarcane	593	630	677	827	903	310
Planted Forests	341	373	458	591	706	365
Pastures	21.819	20.832	20.724	20.325	19.935	-1.884
Native Forests	10.581	11.197	11.136	11.144	11.105	525
Others*	537	778	699	756	852	314

* Other agricultural uses, water surfaces, infrastructure and urban areas.

We concluded that GHG emissions from Mato Grosso do Sul are mainly related to the agricultural sector, and especially to cattle enteric fermentation. Patterns of changes on emissions sources are compatible with changes in pasture area and cattle herd, but there are strong evidences that emissions due to land use change are overestimated. MS Carbon Neutral Initiative should focus on improving understanding of carbon balance on local agricultural systems developing site-specific emission factors that are more suitable for regional environmental conditions as well as for local production system's dynamics and peculiarities.

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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 12^{th}-13^{th} 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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Neutralization of enteric methane emissions by carbon sequestration under integrated crop-livestock and crop-livestock-forest systems in Cerrado region.

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Introduction

Brazil holds the biggest commercial cattle herd and is one of the major beef exporters in the world. On the other hand, enteric methane from livestock is responsible for 20% of total greenhouse gases (GHG) emissions in the country (MCTI, 2014). The adoption of positive carbon balance technologies in agriculture is a key factor to Brazil succeed in public policy to reduce its carbon footprint. Thus, estimates on carbon sources and sinks are important to support the adoption of integrated production systems as a GHG mitigation strategy. The objective of this study was to estimate the impact of the adoption of integrated crop-livestock and crop- livestock-forest systems on the mitigation of enteric methane emissions from pasture based beef cattle in Cerrado region.

Material and Methods

Three beef cattle production systems were compared, in a year base, in terms of enteric methane emission and carbon sequestration: a) ICL – integrated crop-livestock system; b) ICLF - integrated crop-livestock-forest system with doube lines of *Eucalyptus urograndis* trees and spacing between rows of 22m (417 trees.ha^{-1}) and c) LPP – low productive pasture. The stocking rates on *Brachiaria sp.* pastures were 3.0, 1.7 and 1 head per hectare, respectively. Beef cattle enteric methane emissions (ECH_4) were based on Mandarino *et al* (2015) and data from Cerrado soil carbon sequestration for ICL and LPP came from a long--term experiment (24 years) according to Jantalia *et al*. (2006) and Sant'anna *et al*. (2015). Findings from Pulronik *et al.* (2015) supported the value of soil carbon sequestration in ICLF 24.5% lower than ICL. Regarding to the annual carbon trunk fixation rate, we estimated the accumulated mass of each tree being 0.0306 (density of 0.51 x volume of 0.06 m^3) considering 46% of carbon content. All these studies were carried out in the central plateau of the Cerrado region at Embrapa Cerrados research Center, Brazil (15°36'41.51"S 47°42'08.92"O), on *Brachiaria sp.* pastures under Oxisols.

Results and Conclusions

The highest pasture carrying capacity and stocking rates resulted in the highest enteric methane emissions for ICL and ICLF when compared to LPP (Table 1.). Nevertheless, the soil carbon sequestration in ICL and the additional carbon sequestration by the trunk carbon fixation in ICLF systems can mitigate 100% of all ECH_4 emitted. Moreover, ICL and ICLF presented a positive annual carbon balance of 1.3 and 23.0 Mg CO_2eq.ha^{-1}, respectively. The opposite occurred with LPP, which presented a negative carbon balance of 0.4 Mg CO_2eq.ha^{-1}. The carbon surplus stock in integrated systems could neutralize the ECH_4 of more 1 head in ICL and 20 heads in ICLF systems. These results support the statements that integrated systems in fact can contribute as a mitigating strategy of greenhouse gases. Besides that, it can be highlighted the necessity to recover pasture yields as an opportunity to reduce the environmental impact of livestock systems. It can be concluded that the adoption of integrated crop-livestock or crop-livestock-forest systems can mitigate the ECH_4 from pasture based beef cattle in Cerrado region.

Table 1. Enteric methane emissions, soil carbon sequestration, trunk carbon fixation and annual carbon balance under different beef cattle pasture based systems in Cerrado

System	ECH_4[1] Mg CO_2eq.ha^{-1}.$year^{-1}$	Soil Carbon Sequestration[2] (100 cm depth) Mg CO_2eq.ha^{-1}.$year^{-1}$	Trunk Carbon fixation[3] Mg CO_2eq.ha^{-1}.$year^{-1}$	Annual Carbon balance Mg CO_2eq.ha^{-1}
ICL	3.4	4.7	0	+ 1.3
ICLF	2.0	3.5	21.5	+ 23.0
LPP	1.1	0.7	0	- 0.4

[1]CH_4 Global Warming Potential – GWP (100-year time horizon) relative to CO_2 = 25; [2]Average soil carbon sequestration rate per year: ICL = 1.273 Mg ha^{-1}.$year^{-1}$; ICLF = 0.961 Mg ha^{-1}.$year^{-1}$; LPP = 0.182 Mg ha^{-1}.$year^{-1}$; [3]ILPF Trunk carbon fixation = 5.869 Mg ha^{-1}.$year^{-1}$.

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Beef cattle productivity in grazing systems with different levels of intensification

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Introduction

The intensification of livestock production in tropical grazing areas should be based on the best use of the potential of pasture growth with a sustainability focus.

Livestock production is growing worldwide due to increased demand for animal protein. Beef cattle production worldwide has increased almost 40% in the last three decades , Americas being one of the regions which led this development (FAO, 2013). At the same time, the need to reduce the sector's greenhouse gas emissions and its overall environmental footprint has become a top priority for industry and policy makers (Gerber et al., 2013). Therefore, the objective of this research was to assess beef cattle productivity in grazing systems with different levels of intensification.

Material and Methods

The grazing experiment was conducted from march 2012 to august 2013 with 24 Nelore steers (292.8 ± 1.28 kg of live weight - LW;15 months old). Animals were allotted to four grazing systems with two area replications (blocks), at an experimental station of the Brazilian Agricultural Research Corporation (EMBRAPA), Southeast of Brazil 1) DP: degraded pasture (1.1 animal units - AU/ha; *Brachiaria decumbens*); 2) IHS: irrigated pasture with high stocking rate (5.9 AU/ha; *Panicum maximum*); 3) DHS: dryland pasture with high stocking rate (4.9 AU/ha; *Panicum maximum*), 4) DMS: dryland pasture with moderate stocking rate (3.4 AU/ha; *Brachiaria brizantha*),. Pasture in IHS DHS and DMS systems were fertilized with 600, 400 and 200 kg N year^{-1}, respectively. The irragated pastures were overseeded with *Avena byzantina* cv. São Carlos (60kg/ha) and *Loliun multifloram* Lan. cv. BRS Ponteio (30 kg/ha), in 06/01/2012 and 04/22/2013. With exception of the degrade pasture, all pastures were manage in a rotational grazing system. Three steers were used to evaluate performance in each system (testers) and regulating animals were used to adjust the stocking rate using the “put and take” technique (Mott and Lucas, 1952) and visual evaluation of forage availability. . Animals were slaughtered with approximately 450 kg of LW. Data were analyzed as completely randomized block design using PROC MIXED.

Results and Conclusions

As expected, IHS system presented higher socking rate (6.9 AU/ha) and higher animal productivity (Table 1) due to higher amount of N applied, irrigation and the overseeding with winter grasses, resulting in higher availability of forage in the pasture. Systems DHS and DMS presented similar and intermediary stocking rates and productivity. The DP system resulte in the lower stocking rate and productivity when compared to all others. Overall, animal productivity increased as the intensification of the systems increased. Similarly, Barcellos et al. (1999) verified lower carcass yield (51 kg/ha/year) for animals grazing degraded pasture when compared to those kept in pasture under recovery (310.5 kg/ha/year).
Besides the very low productivity observed in the degraded pasture, there is a strong relation between GHG emissions by plants and soil, especially CO_2, and the degradation process of pastures (Oliveira, 2015). According to Primavesi (2007), degradation of farmland causes soil compaction, reducing aeration and water infiltration, with higher potential for GHG emission; the exposed soil allows greater thermal amplitude which accelerates the degradation process.

Table 1. Nelore steers productivity in grazing systems with different levels of intensification (least square means ± -).

Item*	DP†	IHS†	DHS†	DMS†	SEM	*P* level
Stocking rate (AU/ha)	1.7[c]	6.9[a]	5.2[b]	4.0[b]	0.79	0.0008
Live BW (kg/ha/year)	231.6[c]	993.3[a]	697.0[b]	533.0[b]	60.40	0.0079
Carcass (kg/ha/year)	124.6[c]	570.6[a]	395.4[b]	301.7[b]	32.48	0.0057
CEP (kg/ha/year)	112.0[c]	531.0[a]	374.2[b]	280.5[b]	32.46	0.0076

[a,b] Means within a row with unlike letters differ at P≤0.05; SEM: standard error of the mean.

*BW: body weight; CEP: carcass edible portion.

† DP: degraded pasture; IAL: irrigated pasture with high stocking rate; DHS: dryland pasturewith high stocking rate; DMS: dryland pasture with moderate stocking rate.

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Infrared Thermography in the Assessment of Thermal Comfort of Confined Water Buffaloes in the Amazon Biome

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Introduction

In tropical regions, thermal stress is one of the major issues for animal farming since it compromises productivity and, consequently, milk and meat production and animal husbandry (ABLAS et al., 2007). Being homeothermic, buffaloes subjected to high temperatures and relative air humidity may experience thermal stress (MORAES JÚNIOR et al., 2010), which is able to set off physiological processes. The ability to monitor and identify animals experiencing thermal stress becomes important since these initial analyses are able to define beforehand the best management for the herd. When it comes to physiological variables, data collection must be as reliable as possible, however, not always are the data properly collected. That entails the need to develop more precise methods to analyze animal response to environmental conditions.

The use of infrared thermography is quite broad and the technique may be employed in the animal production system as a non-invasive method to replace traditional ones (SCHAEEFER et al., 2012) in order to measure skin temperature without interfering in the animal's behavioral reactions.

This study aimed to assess thermal responses in water buffaloes using infrared thermography associated with environmental variables and thermal comfort indices.

Material and Methods

The trial was carried out at the animal research unit "Senador Álvaro Adolfo," belonging to Embrapa Eastern Amazon, in the city of Belém-PA, Brazil. The study area features Af2 climate (MARTORANO et al., 1993) with mean rainfall above 60 mm in the least rainy month and annual rainfall around 2,900 mm. The data were collected in a field trial on 24 crossbred Murrah and Mediterranean female buffaloes whose initial age and mean weight were 34 months and 514±69.88 kg, respectively. The animals belong to Embrapa Eastern Amazon's experimental herd and the procedures were approved by the Committee of Animal Ethics (protocol nº 007/2015). The measurements were performed in November 2015 while the animals were managed in tie-stall facilities featuring individual feed and drinking troughs.

The thermographic images were captured 1.5 m away from the animals three times a day (4 AM, 2 PM, and 8 PM) and framed the cranial and tail sections. The left ileum (A), left ischium (B), right ischium (B1), right ileum (A1), sacrum (C), nose (D), upper lip (E), eyeball (F), thigh (G), forehead (H), and region around the tail (I) were tagged in the images (Figure 1 and 2). The infrared camera used (T650-FLIR®) set to emissivity coefficient 0.95 emissivity was employed to measure the animals' surface temperature at different sites of the body.

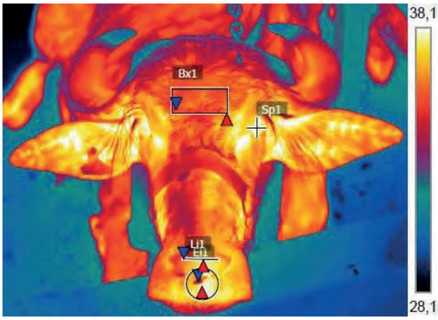

Figure 1. Cranial thermal image with the respective collection sites.

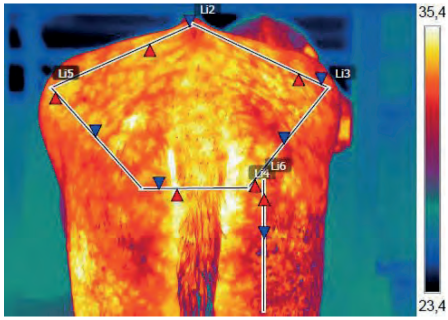

Figure 2. Tail thermal image with the respective collection sites.

Three data loggers (U12-HOBO®) were used to characterize the agrometeorological conditions inside the barn regarding temperature and relative air humidity. The data loggers were installed in agrometeorological cases at the height of the animals' muzzle along the stalls hallway. The data were recorded every 15 min and were downloaded only at the end of the experimental period. The temperature and humidity index (THI) inside the barn was calculated every 15 min and four values were obtained per period of the day assessed based on the model proposed by Thom (1959) according to the following equation: THI = [(0.8 AT) + (RH/100) x (AT-14.4) 46.4], where AT is air temperature (°C) and RH is relative humidity (%).

Results and Conclusions

The mean THI values were 76.5, 84.0, and 80.0, at 4 AM, 2 PM, and 8 PM, respectively. The values observed at 4 AM and 8 PM were below those proposed by Somparn et al. (2004), who stated the animals were under risk at THI $\geq$ 84, i.e., the animals experienced thermal discomfort at 2 PM.

Buffaloes have a less efficient evaporative thermoregulation system than bovines given their limited sweating capacity, which makes them more prone to thermoregulatory issues. One way of dissipating heat is by redirecting blood flow to the body surface, thus increasing skin temperature, which facilitates heat dissipation through non-evaporative mechanisms. It was observed that, as air temperature increases, the animals' body surface temperature also increases, leading to a significant correlation between AT and most anatomical sites, particularly between the forehead and AT (0.94) and THI (0.94) ($p<0.01$) (Table 1).

Table 1. Pearson correlation analyses among the environmental variables and thermal comfort indices with thermographic images of confined water buffaloes.

Variable	A	B	B1	A1	C	D	E	F	G	H	I
AT	0.82	0.81	0.82	0.87	0.85	0.16	0.01	0.55	0.83	0.94	0.77
p-v	**	**	**	**	**	*	ns	**	**	**	**
RH	-0.78	-0.75	-0.75	-0.81	-0.80	-0.12	0.10	-0.55	-0.89	-0.69	-0.78
p-v	**	**	**	**	**	ns	ns	**	**	**	**
THI	0.80	0.81	0.84	0.87	0.84	0.18	0.09	0.53	0.83	0.94	0.79
p-v	**	**	**	**	**	ns	ns	**	**	**	**

Left ileum (A), left ischium (B), right ischium (B1), right ileum (A1), sacrum (C), nose (D), upper lip (E), eyeball (F), thigh (G), forehead (H), around the tail (I), mean air temperature (AT), mean relative humidity (RH), temperature and humidity index (THI).

*significant ($p<0.05$); **significant ($p<0.01$); ns=non-significant ($p>0.05$).

The use of infrared thermography proved sensitive to detect differences in the animals' skin temperature in association with index THI, indicating thermal stress due to heat at 2 PM of confined water buffaloes.

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Managing Pantanal rangelands for optimizing carbon flow: effects of growing season and pasture type on dry mass accumulation

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Introduction

Pantanal is a marginal agriculture area, suitable for low inputs livestock systems. Pantanal rangelands include different habitats, which presenting a temporal and spatial variation in productivity and processes, according flooding gradient. The main grazing areas are wetland and open grassland on which cattle select grazing sites with better quality forage. In general, total average dry matter of theses areas is low with low animal carrying capacity. Thus, ranchers have been substituting natural pasture of lower quality of the higher areas by exotic pasture cultivation (mixed pasture), increasing the carrying capacity of the management units (Santos et al., 2011). This work aimed to assess the forage mass accumulation in the main grazing sites in two pastures systems to identify resting decisions to maximize the carbon flow in the system.

Material and Methods

The study was carried out at Nhumirim ranch, Pantanal Nhecolândia sub-region in two management units (MU): 1 - mixed pastures (natural + cultivated) and 2- disturbed natural pastures. In each MU two main feeding sites were identified. In both of them seven exclusion from grazing cages ($1m^2$) were allocated in order to estimate forage and no forage mass accumulation rate, according to triple pairing methodology from September 2014 to March 2015. Aboveground plants were clipped in $0.25m^2$ plots inside and outside of the exclusion cage in October 2014 (late dry season), December (early rainy season) and March 2015 (late rainy season). The dry mass accumulation (kg $DM.ha^{-1}$) was obtained by the difference between the forage mass from inside the cage and from the outside of the cage. All plant were separated into fodder and non-fodder species.

Results and Conclusions

The values of dry mass accumulation were higher in mixed pasture during the early season and were negative in the late rainy season (Figure 1), indicating high grazing pressure on these feeding sites. December was the more productive month because November was a rainy month. These results suggest that fencing the pastures in the months of the early rainy season (October to November) in function of the rainfall distribution could be a strategic management practice to maximize the carbon flow in the system and the forage accumulation.

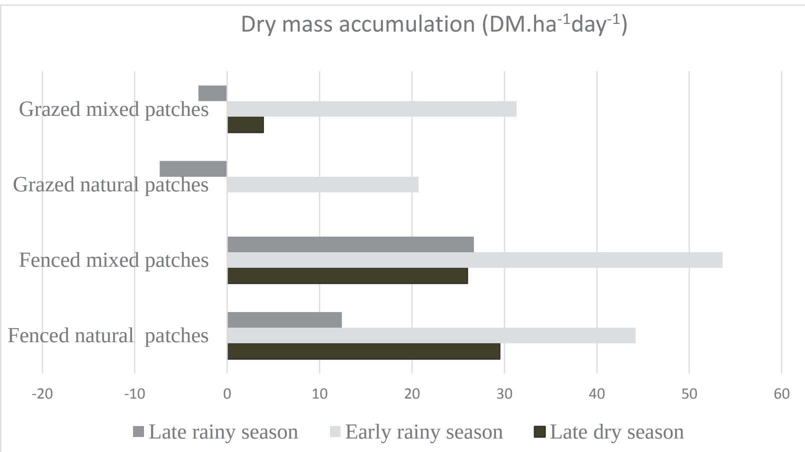

Figure 1. Aboveground dry mass accumulation rate (kg $DM.ha^{-1}day^{-1}$) in two pasture types (fenced vs grazed) during seasons of the hydrological year, from September 2014 to October 2015.

In these areas occurred dominance of several invasive species, many of which non-fodder species. In Figure 2 highlights dry mass accumulation rate of fodder and non-fodder species in two type of pastures.

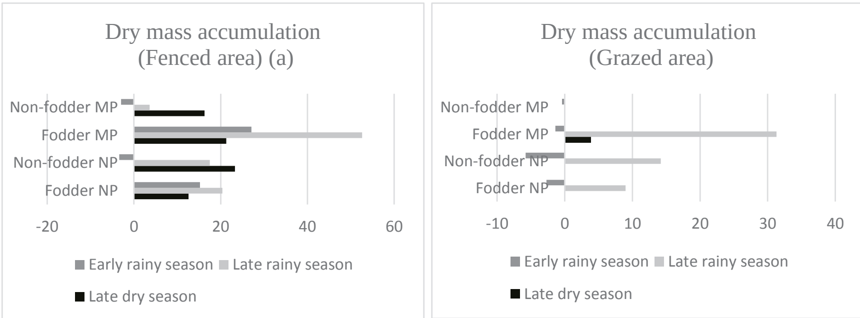

Figure 1. Aboveground dry mass accumulation rate (kg DM.ha^{-1}day^{-1}) in natural disturbed pasture (NP) and mixture pasture (MP), fenced (a) and grazed (b), during seasons of the hydrological year, from September 2014 to October 2015.

Higher proportion of non-fodder species can be seen in disturbed natural pasture. It also observes that the dry matter accumulation rate was reduced during late rainy season, as consequence of pasture cleaning. It notes that fenced patches of disturbed natural pasture presented higher proportion of non-fodder species. Thus, deferred grazing can be used during strategic season but more investigation are necessary to define the adequate length of the deferment. The cultivation of exotic forage species in open grassland can reduce the proportion of non-fodder species and invasive natural species. However, due to spatial and temporal variation of natural pastures, adaptive management strategies are necessary to mitigate and reduce greenhouse gas emissions and optimizing carbon flow.

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Production of maize and biomass of massai grass in the establishment of a consortium with forage legumes

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Introduction

The Brazilian agriculture has shown a good technological development and production, expanding its exports and the producer's income. However, the biggest problem Cerrado remains being the degradation, which affects more than half of the pasture areas. Thus, the implementation of new production systems as the consortium of grasses and legumes or the combined crop-livestock system has been appointed as alternatives to this problem.

An important aspect in systems of consortia between crops and forages is that these show slow accumulation of dry matter in the early stage and therefore compete less with annual crops, and studies on the use of woody legumes intercropped with maize are infrequent. However, the alternative is considered feasible in view of the potential of these plants in fixing atmospheric nitrogen through Rhizobium bacteria and association with mycorrhizal fungi, which are able to increase the absorption area of nutrients and water by plants.

Therefore, the objective of this study was to evaluate the use of legumes in association with Panicum maximum cv. Massai, deployed with the maize crop through the maize yield and herbage accumulation.

Material and Methods

The experiment was carried out at the Research Center of the Agency for Agricultural Development and Rural Extension in Campo Grande, MS. The experiment was conducted in split plot in time, having allocated the plots and subplots the cutting times in a randomized complete block design with four replications.

Five woody legumes were evaluated: Albizia lebbeck, Cratylia argentea, Dipteryx alatta, Leucaena hybrid and Leucaena leucocephala cv. Cunningham and a herbaceous (Arachis pintoi cv Belmonte) in consortium with Panicum maximum cv. Massai and maize, and maize monoculture, cv. Massai in monoculture and intercropping maize with cv. Massai. The soil of the experimental area is classified as Oxisol textural class of sandy-clay.

The woody legumes were sown before the grasses on December 5, 2007. A line of woody legume was seeded at every three maize lines, so that the spacing of these was 3.0 m. The mechanized sowing of maize (BRS 2020) in monoculture occurred on December 14, 2007, at a spacing of 0.75 m.

The maize grain yield (kg ha-1) was evaluated in 4 m of six axis of each plot. In threshing of corn cobs to tread grain, straw cobs and cobs were separated and weighed. Withdrew two subsamples of 500 g of each material for estimates of dry biomass of straw and cob. The stubble was evaluated in the same area harvested for determination of maize yield, weighted in the field, and soon after two subsamples of 1.0 kg each were taken and also pre- dried to estimate the stubble dry biomass.

After the harvest of maize cobs the height of woody legumes were measured, measuring five plants at random per plot at the center line with a ruler graduated in millimeters, the height from the ground to the curvature of the leaf blade. The evaluation of the accumulation of dry biomass of massai grass occurred with plant height of 45 cm, leaving a residue of 10 cm.

The two samples of material obtained from each plot were homogenized and separated into two subsamples of 0.5 kg each. One of the subsamples was made by weighing the material in nature, and after that weighting its again for the estimave of the dry biomass accumulation. In another subsample the forage species were separated in the case of samples grass and herbaceous legume and in the massai grass morphological components were separated. These subsamples were also processed to estimate the contribution of each morphological component in total biomass. The consortia were also analyzed in order to compare the accumulation of total biomass between the experimental arrangements.

The dependent variables were subjected to variance analysis in split plots in time and the means compared by the Soctt-Knott test at 5% probability, using the application SAEG (Ribeiro Junior, 2001).

Results and Conclusions

The maize grain yield obtained with consortia (grass and / or legumes) was 32% lower than that obtained with the maize monocrop. Cobucci et al. (2007) found that the recovery of nitrogen intercropped with maize was the best alternative with the restriction that the productivity of maize grain is around 3600 kg ha^{-1}, this production lower than that achieved in this work, which average was 5193 kg ha^{-1}.

All consortia studied interfered negatively in grain yield compared to maize monocrop. However, according to the National Supply Company (Conab), the average Brazilian maize crop for 2010 was

4412 kg ha^{-1}, this productivity lower than that obtained in this study. Severino et al. (2005) also observed reductions in corn yield of 7130 kg ha^{-1} in monocrop to 4000 kg ha^{-1} in consortium with *P.maximum* cv. Colonião, *U. decumbens* and *U. brizantha.*

Several studies conducted with intercropping maize and forage show that on the average, the presence of reduced forage productivity of grain in 5% (Cobucci et al., 2007; Severino et al. 2005), and this reduction lower than that found in this study (32%). However, the different findings may be related to a combination of several factors such as the population of the forage, the time of its deployment, the planting arrangements, the presence of weeds, pests and predators, the application or not of herbicides, fertility of soil and water conditions.

The dry biomass of green accumulation massai grass monocrop was higher by 41.8% and 74.6% respectively to that observed in consortium with arachis and with the woody legumes, as did not suffer competition with maize and, also received nitrogen fertilization. Therefore, the consortium with maize harmed more the cv. Massai than otherwise, indicating that the maize is more competitive compared to grass.

For the evaluation of the arrangements, after the harvest of maize, the results represent the sum of two cuts for accumulation of dry biomass of green massai grass, and only one cut for legumes (Table 1). The highest concentrations of DBG occurred during the wet season after the maize harvests were observed in massai grass monocrop and in consortia with albizia and baru woody legumes.

There was not great participation in this legume establishment phase, when compared to the accumulation of the massai grass. The only woody legumes that had already cutting height during the harvest season of the maize, were Leucaena cv. Cuningham and Leucaena hybrid, the others were only assessed in the period after the maize harvest.

Table 1. Dry biomass of green accumulation (DBG) of massai grass, biomas accumulation (DBLeg) and height (HLeg) of legumes and total dry biomass accumulation (TDB), in the period after harvest of maize

Arrangements	DBG ($kg.ha^{-1}$)	DBLeg ($kg.ha^{-1}$)	HLeg (m)	TDB ($kg.ha^{-1}$)
Massai monocrop	8.122 a			8.122 a
Massai + Araquis	3.585 c	-	-	3.585 c
Maize + Massai	5.629 b			5.629 b
Maize + Massai + Araquis	6.182 b	-	-	6.182 b
Maize + Massai + Baru	7.511 a	-	0,41 c	7.511 a
Maize + Massai + Cratilia	6.354 b	508 b	0,96 b	6.862 b
Maize + Massai + Leucaena H.	6.035 b	1.400 a	1,97 a	7.435 a
Maize + Massai + Leucaena C.	6.139 b	1.379 a	1,86 a	7.518 a
Maize + Massai + Albizia	7.016 a	1.156 a	1,01 b	8.172 a
CV%	19,18	24,88	7,89	18,70

Values followed by the same letter, in the columns, do not differ (P> 0.05) between them by the Scott-Knott test.

The woody legumes, *Leucaena* cv. Cuningham and *Leucaena* hybrid continued to show better development and the higher accumulation of biomass, even after having been cut at the maize harvest period. However, no significant difference in relation to the *Albizia* which showed the accumulation similar to the leucenas on its first cut.

The low development of woody legumes is an indication that the line of maize was sown very close to the line of these plants. With this, a strong competition was developed of the maize on the woody legumes, probably at the level of the root system and light. The cratilia has a very slow development, which resulted in a low biomass accumulation in the first assessment after the corn harvest, with lower productivity than other woody legumes. The woody legume intercropping baru was not evaluated in relation to the accumulation of DM, because it did not a show good growth in this intercropping system, which can be observed by the height of the plant 160 days after sowing.

In consortium of massai grass + arachis there is the need for more studies regarding the introduction of these forages with less spacing, where the grass could have an increased production capacity and it would not affect the development of the herbaceous legume, for this exhibits a greater resistance to shading.

The grain yield of maize and total dry biomass accumulation in the consortia are considered satisfactory. The maize and massai grass consortia with woody legumes, *Leucaena* cv. Cuningham, Leucaena hybrid and *Albizia,* are considered viable and recommended for implementation of agroforestry systems.

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Effects of corn processing method and use of crude glycerin on methane production in sheep

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Introduction

The need of an energetic efficiency has encouraged research in a way to enhances the ruminal metabolism of the diet, reducing energy loss to caloric increment and methane production. Studies indicate that the utilization of expanded corn increases the rates of ruminal fermentation and degradation, which can also modify ruminal conditions of pH, fiber fermentation and the ruminal production of methane. On the other hand, crude glycerin has been broadly utilized as a cereal substitute on diets for ruminants (Van Cleef et al., 2015). *In vitro* studies shows a mitigation effect from the crude glycerin on methane production (Lee et al., 2011). The evaluation of methane emission through respiration chambers is considered the "gold standard" method, which allows the precise quantification of gas production (breathing, eructation, rectal emission) and animal consumption, making possible the conjoint evaluation of the energetic metabolism. The objective this paper was to measure the effect of corn processing method and use of crude glycerin on enteric methane production of sheep.

Material and Methods

The experiment was carried out at the Animal Metabolism and Calorimetry Laboratory – (LAMACA) from the School of Veterinary Medicine, Federal University of Minas Gerais (UFMG), in Belo Horizonte, MG, Brazil. The treatments were different at the corn processing method and the presence or absence of crude glycerin: 1) ground corn; 2) ground corn + crude glycerin; 3) expanded corn and 4) expanded corn + crude glycerin. The crude glycerin replaces corn by 10% in natural matter basis, corresponding to inclusion of 5% diet (DM basis). The utilized crude glycerin was provided by ADM Biodiesel Ltda (Archer Daniels Midland Company) (Rondonópolis, MT), and contained 83% glycerol, 2% water, 5% NaCl and 0.003% methanol and was obtained from soybean oil. Glycerin was mix with the other ingredients during the production of the concentrate. The diets were formulated with a roughage:concentrate ration of 50:50 as DM basis, using corn silage as a source of roughage. Eight Santa Inês ewes, no pregnant, averaging 54,5 kg of body weight were randomly assigned according to a 4x4 Latin square design, in a factorial 2x2 (two types of corn processing with or without crude glycerin). Statistical analyses were performed using the PROC GLM of SAS. Orthogonal contrasts were performed to evaluate simple and compound effects. The methane measuring was done along 24h at the open-circuit indirect calorimetry system to ovine, which were previously adapted the experimental diets for 18 days and submitted to a trail of intake and apparent digestibility through 7 days in each experimental period. The animal procedures were approved by the Ethical Committee of Animal Use from University Federal of Minas Gerais (CETEA/UFMG, protocol #071/10).

Results and Conclusions

The contrast on the effect of corn processing indicate no significant differences ($P<0.05$) between treatments with ground corn and expanded corn on methane production (Table 1).

However, Hales et al. (2012) observed that the intensified corn processing (steam-flaked corn or dry-rolled corn) reduced methane production in cows (2.47 vs 3.04 % GE) due a ruminal pH reduction. The addition of crude glycerin on a partial substitution of ground corn, has not modified ($P>0.05$) methane production in sheep, which agrees with Santos et al. (2015) that also haven't observed the effect of crude glycerin inclusion (10% MS diet) on the potential on *in vitro* methane production in diets for sheep. Van Cleef et al. (2015) reported a reduction on the *in vitro* methane production with the utilization of crude glycerin among 7.5 and 30% diet DM. In another way, on diets with expanded corn, the inclusion of crude glycerin resulted in larger production (P<0.05) of enteric methane of all evaluated forms, except on the neutral detergent fiber intake and digestible neutral detergent fiber intake. According to Avila-Stagno et al. (2014), this unexpected result can be associated to the conversion of the glycerol in butyrate or their equimolar conversion to formate or ethanol, generating precursors of methane production. Besides, minor methane production in expanded corn without crude glycerin may have occurred due a bigger flotation on pH values, associated to a fast fermentation of the expanded starch (Hales et al., 2012). Therefore, an interaction is observed between corn processing and the crude glycerin inclusion up to 5% of diet DM.

Table 1. Methane production of sheep fed with corn silage and concentrate containing ground or expanded corn, with or without addition of crude glycerin.

	Ground corn		Expanded corn			Contrasts (*P values*)		
CH4 outputs	(1) without glycerin	(2) with glycerin	(3) without glycerin	(4) with glycerin	SEM	(1-2)	(3-4)	(1+2) - (3+4)
% GE	4.7	3.8	3.0	3.8	0.15	0.441	0.016*	0.211
g. day^{-1}	24.4	27.9	20.5	27.4	1.85	0.526	0.039*	0.322
g.kg^{-1}BW$^{0.75}$	1.2	1.3	1.0	1.3	0.08	0.581	0.015*	0.187
g.kg DMI^{-1}	12.3	14.1	11.1	14.4	0.89	0.493	0.038*	0.751
g.kg dDMI^{-1}	16.7	19.4	15.1	19.8	1.19	0.495	0.038*	0.782
g.kg NDFI^{-1}	19.3	20.9	17.3	19.5	1.72	0.824	0.480^{ns}	0.291
g/.kg dNDFI^{-1}	26.9	29.1	24.0	27.3	1.38	0.802	0.477^{ns}	0.297

GE: Gross Intake Energy; DMI: Dry matter intake; dDMI: Digestible Dry Matter Intake; NDFI: Neutral Detergent Fiber Intake; dNDFI: Digestible Neutral Detergent Fiber Intake; BW: body weight; SEM, standard error of means.

The average production of methane were 3.83 %GE; 25.05 g.day^{-1}; 1.2 g.kg^{-1} BW$^{0.75}$; 12.98 g.kg DMI^{-1}; 17.75 g.kg dDMI^{-1}, 19.25 g.kg NDFI^{-1} and 26.83 g.kg dNDFI^{-1}. Ribeiro Jr et al. (2015) e Teixeira et al. (2015) evaluating methane production in ovine fed exclusively with silage of gamba grass (*Andropogon gayanus*) or elephant grass (*Pennisetum purpureum*) found values of 11.57 and 16.20 g.kg DMI^{-1} and 26.63 and 27.18 g.kg $dDMI^{-1}$, respectively. It's worth mentioning that was not found in literature any studies that associates expanded corn and crude glycerin use in ruminants, therefore further researches are required to a better comprehension about the effects of corn processing together with crude glycerin utilization (Avila-Stagno et al., 2014). Besides, there are few studies that evaluate *in vivo* methane production as a response to glycerin or expanded corn utilization on diet for ruminants.

This study results suggests that use alone of corn processing or crude glycerin utilization (5% diet DM basis) has no influence in methane production. However, there is interaction between expanded corn and crude glycerin. The addition of crude glycerin in diets with expanded corn increases methane production.

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Changes in cattle herd composition and its implications on greenhouse gases emissions in Mato Grosso do Sul State between 2010 and 2014

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Introduction

Cattle ranching is a major agricultural activity in Central Brazil and it plays a major economic role in Mato Grosso do Sul State. In the last few years, local agricultural development has been influenced by other agro-industries, mainly sugar cane and eucalyptus forestry, expanding over grazing areas, causing herd displacements but also leading to changes on local production systems. Herd numbers show a tendency to decrease, while beef production keeps stable. This means improvements on individual husbandry techniques as well as a general re-arrangement of herd structure. This can have important consequences on greenhouse gases (GHG) emissions from the sector in the area. In this context, the goal of this study was to explore the implications of changes on cattle herd size and structure as well as land use change on GHG emissions per unit beef produced per unit of area used for cattle grazing in Mato Grosso do Sul State.

Material and Methods

Cattle herd data for the years 2010 and 2013 were obtained from the Animal Health Agency of Mato Grosso do Sul (IAGRO). The database includes all foot-and-mouth disease vaccination registers for all 79 local municipalities of the State, recording numbers of animals vaccinated, according to sex and age range in months (0 to 12; 12 to 24; 24 to 36 and over 36 months of age). This database also provides information on transit of cattle for slaughter within and outside the State, which was used to estimate emissions per slaughtered head produced in Mato Grosso do Sul. There were other sources of information regarding slaughter numbers, as from the "*Sistema de Informações Gerenciais dos SIF (SIG-SIF)*" from the "*Ministério da Agricultura Pecuária e Abastecimento*" and, also, from the "*Sistema IBGE de Recuperação Automática (SIDRA)*" available from the internet portal of the "*Instituto Brasileiro de Geografia e Estatística (IBGE)*". Their numbers are close to those from IAGRO, however they do not consider animals sent for slaughter in other States as well animals brought in from somewhere else.

Data related to Land Use Change (LUC) were kindly made available by the "*Associação dos Produtores de Soja e Milho de Mato Grosso do Sul (APROSOJA/MS)*", from the database of their "*Sistema de Informações Geográficas do Agronegócio de Mato Grosso do Sul (SIGA/MS)*" which, twice a year, carries out a detailed survey on land use in Mato Grosso do Sul, using remote sensing techniques (satellite imagery), validated by a comprehensive ground truthing.

Methane emission rates from enteric fermentation for each specific age range i.e. category under local conditions are not available in the literature. The most suitable data found for the scope of the study was from Demarchi et al (2003a) and Demarchi et al (2003b). The authors found CH_4 emission factors for different cattle weight categories and seasons with a diet based on *Brachiaria brizantha*. Since this is an exploratory study, other sources of GHG emissions or carbon sequestration from cattle husbandry or LUC were not included.

Results and Conclusions

As shown on Table 1, for the period between 2010 and 2013, results show a decrease of both, grazing area (6.8%) and cattle herd (6.3%) while the number of animals sent to slaughter in the period increased 6.2%, meaning a general improvement on efficiency.

Table 1. Changes in cattle husbandry and related greenhouse gases emissions indicators in Mato Grosso do Sul State between 2010 and 2013

Indicator (unit)	Year 2010	Year 2013	(%)
Pasture area (ha)	21.819.304	20.327.800	-6,8%
Total cattle herd (head)	20.820.881	19.518.592	-6,3%
Cattle sent to slaughter (head)	3.685.045	3.912.757	6,2%
kgCO_2eq from young cattle (00-24 months)	6.261.249.194	6.518.198.348	4,1%
kgCO_2eq from adult cattle (over 24 months)	15.270.467.940	13.134.358.167	-14,0%
Total kgCO_2eq emissions from cattle	21.531.717.134	19.652.556.515	-8,7%
kgCO_2eq per head cattle sent to slaughter	5.843	5.023	-14%
Head sent to slaughter per head in the herd	0,18	0,20	13%
Head sent to slaughter per female >36 months	0,53	0,64	21%
Head sent to slaughter per ha pasture available	0,17	0,19	14%
kgCO_2eq/kg per kg beef* per ha pasture	0,00000119	0,00000110	-7,7%

* kilogram of beef as carcass equivalent

An important change on cattle herd structure in Mato Grosso do Sul could be noticed. There was an increase on number of young animals in the herd (1.1% for 00-12 months and 7.5% for 12-24 months) while animals between 24-36 months and older than 36 months decreased 11.8% and 14.9% respectively. This means that there were less mother cows producing a slightly higher number of calves. As well, steers were being finished faster, since number of animals sent to slaughter have increased. This leads to a smaller area of pastures and, therefore, average stocking rates have increased in the period.

This change on herd structure affected the State's total estimated CH_4enteric emissions from cattle. Total estimated herd emissions decreased 8.7%. This number raises to 14% when emissions per head cattle sent to slaughter is considered.

This kind of estimates, especially without specific emissions rates for different animal categories, as well as important animal husbandry details on pasture quality and feeding leaves some uncertainty regarding the absolute GHG emission values. The available figure adopted for CH_4 emissions, especially for younger animals might overestimate emissions from this category. As well, feeding cattle to speed up finishing reduces total enteric emissions per unit beef produced, but in the other hand, leads to GHG emissions somewhere else. This balance should be considered in the future, through more in-depth studies. Also regarding uncertainty, on the other hand, mother cows usually graze poorer quality pastures, what leads to higher CH_4 emissions per head. In this study, since the same methane emission rates were used for the initial and final year, and there was a decrease of 12.4% in the number of females above 36 months of age in the herd, results presented can be considered conservative in this regard.

Finally, regardless of emission rates adopted for calculating emissions, the fast and substantial decrease of 7.7% on emissions per unit beef produced per unit of area within three years, clearly shows that improvements on general herd efficiency can have an important reflexes on GHG emissions. Finally, as indicated by these numbers, improved cattle ranching efficiency in Brazil, led by higher average stocking rates, leads to substantial reductions on GHG emissions from the sector.

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Reducing GHG emissions and increasing beef production in the Brazilian Amazon: the case of PROGRAMA NOVO CAMPO

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Introduction

Cattle ranching is a key driver of greenhouse gas (GHG) emissions in Brazil (SEEG, 2015). Besides having one of the world´s biggest cattle herd (~200 mi heads), that impact is also related to the relatively low level of management of beef cattle production systems that prevents its full potential to be explored. Although, recent initiatives to increase beef production efficiency in Brazil, such as the PROGRAMA NOVO CAMPO carried out in the Amazon region, mainly through pasture restoration, has offered alternatives to farms in a transition from low investment and limited production to more efficient and productive systems. However, scarce information is available to indicate how specific intensification practices affect the balance of GHG emissions at farm level. Therefore, this paper seeks to complement existing regional initiatives by estimating GHG emissions of beef cattle farms participating in the PROGRAMA NOVO CAMPO.

Material and Methods

The first five farms participating in the PROGRAMA NOVO CAMPO were evaluated in this work. These farms are located in the region of Alta Floresta (MT) and cover approximately 3,500 ha and 7,500 beef cattle heads. At the beginning of the program in 2012, these farms had pastures predominantly degraded and reduced production capacity (~5@ $ha^{-1}yr^{-1}$). After joining the program, these farms had part of their pasture area (~10%) recovered for rotational grazing practice (with a stocking rate of 2-3 AU $ha^{-1}y^{-1}$) - which were maintained with fertilizer applications to the soil, including urea (100 kg N $ha^{-1}yr^{-1}$) and lime (averaging 300 kg $ha^{-1}yr^{-1}$). Along with the introduction of other practices given in the Manual of Boas Práticas Agropecuárias – Gado de Corte (BPA-Embrapa, 2011) and the Guidelines for Sustainable Beef Indicators (GIPS-GTPS, in preparation), after 2 years farms were able to increase meat production (carcass) in around 3 times.

Using the GHG-Protocol Agrícola tool (WRI, 2014), GHG emissions balance of these five farms were accessed from November 2012 to November 2014 considering emissions from cattle, soil inputs and fossil fuel as well as emissions and removals from degraded and improved pastures (variation in soil C stocks), respectively.

Results and Conclusions

Before joining the NOVO CAMPO PROGRAM, the average GHG emissions of the five farms evaluated in this work were 0.4 and 78 t CO2e per hectare and per kilogram of carcass produced, respectively (Figure 1). The cattle (enteric fermentation and manure) were the main source of total emissions (60%), followed by the soil of the degraded pasture area (40%).

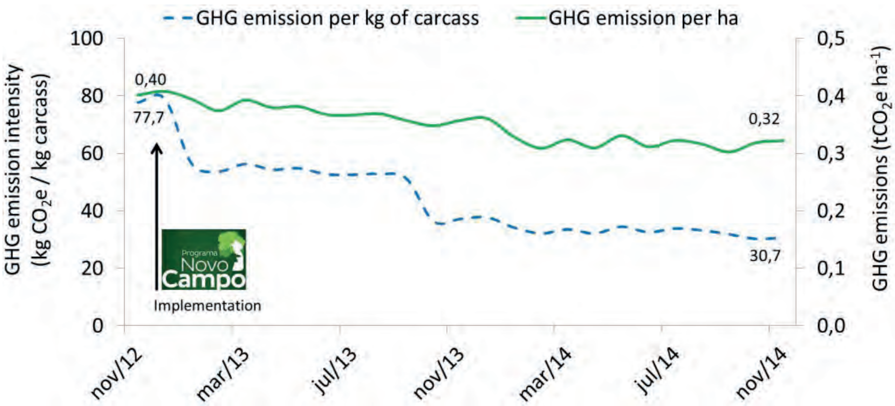

Figure 1. Greenhouse gas (GHG) emissions of 5 beef cattle farms after implementing improved management practices in Alta Floresta (MT)

After joining the PROGRAMA NOVO CAMPO, these farms recovered 453 ha of degraded pastures, out of which 190 ha were with crop--livestock system, totalizing 13% of the total area covered by the program. With the introduction of complementary practices (BPA/GIPS), these farms were able to optimize their herd, discarding less productive animals and accelerating the average slaughtering time in one year (Marcuzzo, 2015).

During this process, farms began to gradually reduce their GHG emissions along with 150% more beef (carcass) produced, even accounting with the emissions from regular application of urea to maintain the recovered pasture area. With smaller and more efficient herd, emissions by the cattle (enteric fermentation and manure) were reduced by 15% and soil carbon sequestration in the recovered pasture alleviated GHG emissions from soil degradation in 30%. As a result, two year after adopting improved practices, GHG emissions were reduced 20% per ha and 60% per kilogram of carcass produced (Figure 1). These results suggest the strategy adopted by the PROGRAMA NOVO CAMPO stands as an option for reducing GHG emissions from beef cattle farms along with higher meat production in the Brazilian Amazon region.

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Terra Boa Program for Pasture Improvement: Potential Impact on Greenhouse Gasses Mitigation through soils in Mato Grosso do Sul (MS) State

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Introduction

Mato Grosso do Sul State has about 20 million hectares of pastures (SIGA-MS, 2016). From this total, close to four million hectares are natural grasslands in the Pantanal wetlands. The balance, or about 16 million hectares, are sown pastures. The State Secretary of Agriculture (Secretaria de Estado de Produção e Agricultura Familiar - SEPAF) estimated that at least 50% of the total cultivated pasture are degraded or with some degree of degradation. These areas have low productivity and may negatively affect environment.

To face the problem of degraded pastures, SEPAF created the "Terra Boa Program" focused on the improvement of pastures in Mato Grosso do Sul (SEPAF, 2016). The Program aims "to promote, within five years, restoration and maintenance of production capacity for two million hectares of degraded pastures in the state". The Program addresses seven major actions: (i) improvement of pastures; (ii) conversion of pastures into cropland; (iii) integrated crop- livestock systems; (iv) integrated crop-livestock-forestry systems; (v) integrated livestock- forestry systems; (vi) conversion of pastures into sugarcane farming; and (vii) afforestation.

All the systems proposed by the Terra Boa Program have potential for not only improving cattle husbandry, grain farming, bioenergy and forestry production, but also reducing greenhouse gases emissions from those areas. A pasture when degraded has a low carbon stock in the soil. Additionally, beef production per unit of area is much lower when compared to improved pastures, since cattle takes longer to reach slaughtering weights. This implies in higher total enteric GHG emissions per animal.

The Terra Boa Program is integrated to the State Program on Climate Change (PROCLIMA), which shall implement the State Policy on Climate Change, complying with the State Law 4.555/2014 (Lei 4.555/2014). Mato Grosso do Sul assumed a voluntary reduction in greenhouse gases emissions (GHG) of 20% by 2020 with the year 2005 as baseline.
In this work, we aimed to estimate the potential contribution of the Terra Boa Program to mitigate greenhouse gases emissions in the next five years, considering only the carbon absorption into soils.

Material and Methods

Estimated Land Use Change (LUC) between 2016 and 2020 was based on Terra Boa Program targets set by the State Secretary of Agriculture (SEPAF) (Table 1), where LUC was allocated into seven groups: improvement of pastures; conversion into cropland; conversion into integrated crop-livestock system (ICL); conversion into integrated crop-livestock-forestry systems (ICLF); conversion into integrated livestock-forestry systems (ILF); conversion into sugarcane; and afforestation.

As for carbon sequestration rates, we adopted estimated values of the ABC Observatory (OBSERVATÓRIO ABC, 2015) for improved pastures (1.0 Mg C-CO_{2e} ha^{-1} yr^{-1}), crops (considered under no-tillage) (0.5 Mg C-CO_{2e} ha^{-1} yr^{-1}), ICL (1.5 Mg C-CO_{2e} ha^{-1} yr^{-1}), ICLF (1.5 Mg C-CO_{2e} ha^{-1} yr^{-1}), and ILF (1.0 Mg C-CO_{2e} ha^{-1} yr^{-1}). Sequestration rates adopted for sugar cane were 1.62 Mg C-CO_{2e} ha^{-1} yr^{-1} (Carvalho et al, 2010). As for afforestation, we considered the rate of 1.22 Mg C-CO_{2e} ha^{-1} yr^{-1} (Corazza et al 1999).

Table 1. Estimated land use change in Mato Grosso do Sul State from 2016 to 2020, as anticipated by the Terra Boa Program (SEPAF, 2016) in 1,000 hectares.

Land use	2016	2017	2018	2019	2020	Total
Improved Pastures	120	180	240	300	360	1.120
Grain farming	20	30	40	50	60	200
ICL*	15	22.5	30	37.5	45	150
ICLF**	15	22.5	30	37.5	45	150
ILF***	10	15	20	25	30	100
Sugarcane farming	10	15	20	25	30	100
Afforestation	10	15	20	25	30	100

*ICL – Integrated Crop-Livestock System; **ICLF – Integrated Crop-Livestock-Forestry System; ***ILF– Integrated Livestock-Forestry System.

Results and Conclusions

The expected changes in land use triggered by the Terra Boa Program (Table 1) have the potential to sequester 2.134 Mt C-CO_{2e} ha^{-1} yr^{-1} (Table 2). This represents about 10% of the estimated GHG emissions related to total local cattle herd in 2014. The System Study Greenhouse Gas Emissions Estimates (SEEG) reported an estimated emission due to enteric fermentation of cattle in Mato Grosso do Sul of 22 M t C-CO_{2e} ha^{-1} yr^{-1}, in 2014 (SEEG, 2016). The largest potential was registered to direct improvement of pastures, which represents the most representative LUC expected.

Table 2. Carbon sequestration potential into soils (1,000 t C-CO_{2e} ha^{-1} yr^{-1}), as a function of land use change in Mato Grosso do Sul (from 2016 to 2020) as anticipated by the Terra Boa Program (SEPAF, 2016).

Land use	2016	2017	2018	2019	2020	Total
Improved Pastures	120	180	240	300	360	1.120
Grain farming	10	15	20	25	30	100
ICL	22.5	33.75	45	56.25	67.5	225
ICLF	22.5	33.75	45	56.25	67.5	225
ILF	10	15	20	25	30	100
Sugarcane farming	16.2	24.3	32.4	40.5	48.6	162
Afforestation	12.2	18.3	24.4	30.5	36.6	122
Total	213.4	320.4	426.8	533.5	640.2	2.134

* ICL – Integrated Crop-Livestock System; **ICLF – Integrated Crop-Livestock--Forestry System; ***ILF– Integrated Livestock-Forestry System.

The GHG mitigation potential of the Program is significant in terms of total emission related to current beef production in Mato Grosso do Sul. The Program has also the potential to increase the land productivity as a whole, reducing emissions per unit of beef produced. We conclude that Terra Boa Program is an important public policy initiative with a high potential to contribute to mitigate GHG emissions in Mato Grosso do Sul, helping the State to reach its voluntary reduction targets towards 2020.

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Improving agricultural inventories of GHG emissions: A UK case study

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Introduction

The UK is committed to ambitious targets to reduce greenhouse gas emissions. Under the Climate Change act of 2008 there is a long-term legally binding requirement to reduce national emissions by at least 80% below the 1990 baseline by 2050, with interim reductions of at least 34% by 2020. Agricultural emissions made up 9% of the total greenhouse gas emissions in 2014, and these are associated with some of the highest uncertainties in national inventory reports (DECC 2016). For this reason a large programme of research has been undertaken in the UK in order to reduce uncertainties associated with agricultural greenhouse gas reporting and to support the development of mitigation actions. This has involved a co- ordinated programme of research to quantify emissions of nitrous oxide from fertilisers and livestock wastes, and enteric methane emissions, the Greenhouse Gas Platform. Work is also being undertaken to improve reporting of greenhouse gas emissions and removals from the Land Use Land Use Change and Forestry sector. Highlights of this research and the implications for national inventory reporting are presented.

Materials and Methods

Nitrous oxide emissions were measured from the range of nitrogen sources that are added to soils under contrasting soil and climatic conditions across the UK. Experiments used standard protocols for experimental design, measurements, data handling and statistical analysis. Measurements of methane emissions from livestock (focusing on cattle and sheep) were used to generate Emission Factors that were representative of different breeds and systems and assess the effect of nutrition (basal forages, concentrates supplements and feed additives). A parallel process of verification and modelling of the data obtained from these research activities was undertaken. Greenhouse gas emissions are also reported from Land Use, Land Use Change and Forestry (LULUCF). IPCC guidelines (IPCC, 2006) are currently used to report emissions resulting from land use change and a study is being carried out to determine whether this reporting can be extended to include cropland and grassland management.

Results and Conclusions

Greenhouse gas emissions from agriculture have remained relatively constant over the past five years, despite significant reductions of emissions in other sectors (Table 1). This places increased pressure agriculture to reduce emissions if overall emission reduction targets are to be met.

Table 1. UK greenhouse gas emissions from agriculture (Mt CO2e) National Inventory Report).

	1990	1995	2000	2005	2010	2013	2014
Carbon dioxide	7.0	7.1	5.7	5.6	5.2	5.3	5.3
Methane	32.6	32.0	30.8	28.7	27.2	27.0	27.4
Nitrous oxide	19.2	19.0	18.0	16.6	15.9	15.8	16.3
Total	**58.7**	**58.1**	**54.6**	**50.9**	**48.3**	**48.1**	**49.1**

The Greenhouse Gas Platform research has provided improved understanding of emissions from agricultural sources. The observed nitrous oxide Emission Factor (EF1 is the proportion of N_2O derived from a nitrogen source) for fertilisers applied to grasslands was 1.3 %, however, the Emission Factor for fertiliser applied to arable crops ranged between 0.5-0.8 % (depending on the nitrogen source) which is below the 1% Tier 1 default value. Nitrous oxide emissions from grazing returns by cattle were also significantly lower than default IPCC values with Emission Factors from dung of 0.2%, and urine of 0.7%, giving a combined weighted Emission Factor of 0.5% (as compared with the default Emission Factor from these sources of 2%). These new Tier 2 nitrous oxide Emission Factors are currently being applied to the UK's inventory reports increasing the relative importance of methane as a greenhouse gas (Fig. 1).

Enteric methane emissions from beef cattle and sheep, showed a limited effect of breed and breed type on emissions. There was a much greater effect of diet type, with animals consuming more higher-quality (lowland) forage than poorer-quality (upland) forages and consequently producing more methane each day on the better quality feeds. This research provided validation of the Tier 2 Emission Factors used to report methane emissions from UK livestock.

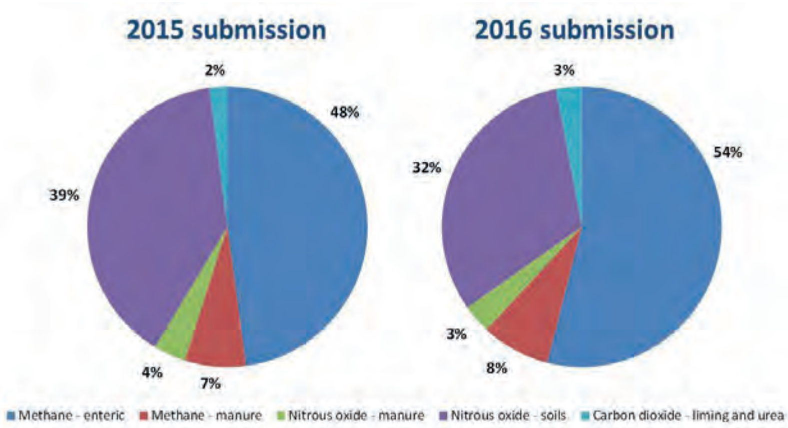

Figure 1. Relative importance of UK agricultural greenhouse gases in inventory reports for 2015 and 2016.

Greenhouse gas emissions from Land Use, Land Use Change and Forestry were responsible for an annual uptake of 9 Mt CO_{2e} in 2014, mostly from the forestry sector. Research is currently being undertaken to establish opportunities to report carbon sequestration by the managment of grasslands remaining grasslands and croplands remaining croplands. Early indications would suggest that this will have only a minor impact on overall greenhouse gas emissions and removals from the agriculture and LULUCF sectors.

This research highlights the importance of the non-CO_2 greenhouse gases in contributing to emissions from agricultural production, and provides improved opportunities to mitigation actions that will deliver further emissions reductions.

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Using imagery satellite to assess the Land Use Change (LUC) from natural and grazing areas to crop farming in Central Brazil

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Introduction

At the same time agriculture is a major source of economic resources for Brazil, it also plays a major role on national greenhouse gases emissions. Brazil has being adopting responsible measures not only to reduce emissions from agriculture, but also to turn it into a sink. The first step to develop sustainable policies in the subject is to have a systematic overview of land use change (LUC) dynamics in major and representative agricultural areas of the country. In this sense, Literature might offer different figures for GHG emissions from the different land uses. However, for reliable estimates, a sound basis of LUC assessment is essential.

In this regard, intending to support estimates of Greenhouse Gases (GHG) emissions from LUC this work has carried out a LUC assessment through analysis of satellite imagery for the regions of Dourados in Mato Grasso do Sul State, Alto Teles Pires and Sinop in Mato Grosso State. These two areas were chosen for their relevance on soybeans farming and the different characteristics of their clearing for cultivation. The LUC analysis covered the period between 1993 and 2013 with temporal scale of 10 years (1993, 2003 and 2013).

Material and Methods

Initially crop farming areas were identified in Landsat satellite images of the last year of the study period (2013) and then compared to the images from the middle (2003) and initial year (1993). Images were a combination of three bands available from Landsat, yielding images with false-color composition, with spectral information outside the sensitive range of the human eye (Piroli et al., 2002), which support identification and differentiation of land use classes to be studied. Applying the methodology described in Esteves et al. (2016), areas were classified as: natural areas (savannah and forest) and agricultural areas (soybean and pasture), following color and texture patterns characteristic for each of these classes.

Figure 1 illustrates the image processing method, showing the main characteristics of each class analyzed: i.e, ***crop farming*** with uniform color and smooth texture in each batch; ***sown pasture*** with non-uniform color and smooth texture in each batch; ***rain forest*** with red color due to intense photosynthetic activity and wrinkled texture caused by tree shading and finally ***savannah*** with red and green color and little wrinkled texture.

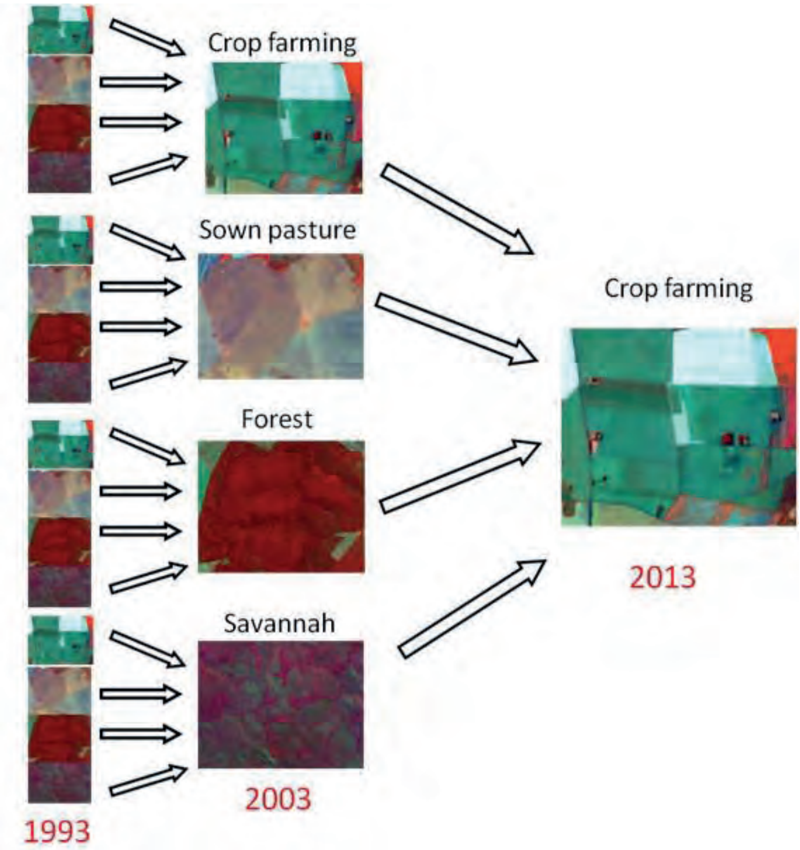

Figure 1: Methodology of analyzed classes

Results

The method for satellite imagery analysis for a larger time horizon proved effective and allowed rather good mapping for comparison with images from recent years. Results evidence substantial difference on LUC patterns in the two regions studied. This might be linked to the time when agricultural expansion reached these zones, being influenced by differences like in infrastructure and environmental regulations as well as by the kind of land cover itself.

Figure 2 shows LUC for the periods between 2003 and 2013 and from 1993 to 2013, in the State of Mato Grosso do Sul State. Regarding the 20 years period, it can be observed that LUC was essentially through conversion of sown pastures to crop farming, mostly soybeans. Higher proportions of pastures being converted to crop farming indicate intensification of cattle ranching in the area, since beef production in the area has been constant with even some increase in the last years (Bungenstab et al, 2014).

In the period between 2003 and 2013, a reduction on LUC can be noticed as well as a substantial reduction of LUC as a whole and especially on converting natural areas, especially savannah into crop farming. This can be explained by the fact that in Mato Grosso do Sul, agricultural expansion, converting natural areas to sown pastures occurred prior 1993 whose areas of more fertile soils were converted to crop farming, essentially soybeans.

In the other hand, in the State of Mato Grosso, were agricultural expansion occurred later, LUC converting natural areas (savannah and rain forest) directly to crop farming were more than 70% of the total LUC in the period between 1993 to 2013, showing a rather different pattern of agricultural expansion. However, in the last decade, clearing natural areas was substantially reduced showing 32% conversion of natural areas and 59% of no LUC. It can be speculated that this is due to improvements on environmental law enforcement and land tenure issues, as well as some change of farmers focus, aiming at better yields instead of larger low fertility areas.

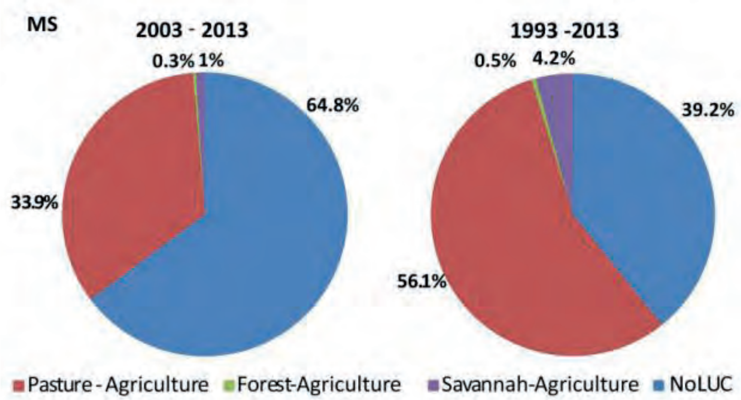

Figure 2: Land Use Change between 1993 and 2013 for Mato Grosso do Sul State, Brazil.

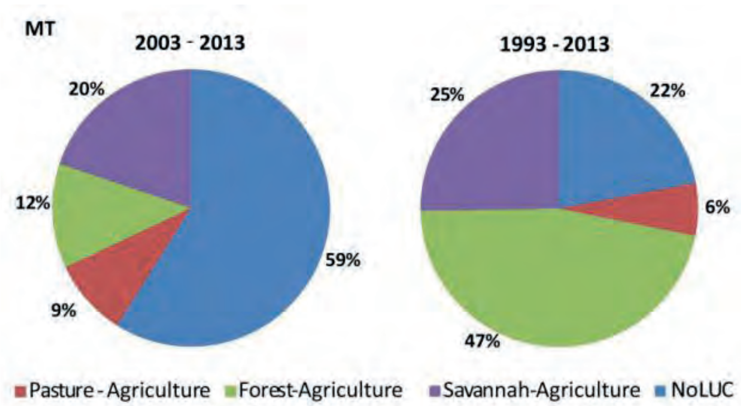

Figure 3: Land Use Change between 1993 and 2013 for Mato Grosso State, Brazil.

Conclusions

Therefore, this work proves that, when estimating GHG emissions from LUC in Brazil, scientists must have a close look on time scales and regional characteristics, segmenting assessments by small regions and avoiding generalizations in order not to go into miscalculations that would lead to wrong conclusions and poor orientation for policy making in both, national and international levels.

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Soil carbon stocks and humification index under Brazilian livestock production systems in the Atlantic forest biome.

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Introduction

Carbon dioxide (CO_2) is a one of the greenhouse gases (GHG) which has caused some of the global climate changes (GCG). Today the CO_2 concentration in the atmosphere reaches 400 ppm mark according to the latest reports (NOAA, 2015). Brazil is one of the most important countries in the global livestock and according to the United Nations (UN) livestock is responsible for 14.5% of GHG emissions (RURAL BR, 2014). Agriculture can be an important ally for the CO_2 mitigation concentration in the atmosphere because contains

3.3 times (about 2500 gigatons) more than carbon the atmosphere (760 gigatons). CO_2 atmospheric can be converted to vegetable mass through biota photosynthesis and this carbon will be retain on soil through a well management of this mass. This mechanism is named as “carbon sequestration”.

The SOM (soil organic matter) is defined as a mixture of compounds in various decomposition stages resulting from plants and animals biodegradation. The chemical characteristics of this organic material are an important indicator for the soil quality classification and about the management practices adopted to that soil. Stable fractions (or humidified) of SOM are directly influenced by soil management, humification index shows how the MOS is stable, ie resistant to microbial decomposition. According to Embrapa Agrobiology, more than 50% of the areas under pasture are in the degradation process. Thus, the SOM decreases, and carbon returns to the air in the form of CO_2 (ALVES et al., 2003).

The main goal of this study was to evaluate the effects of recovery of pastures, under different management systems in the Atlantic Forest Biome, on soil carbon stocks (SCS) and SOM humification, aiming at identifying GHG mitigation alternatives for the cattle raising sector in Brazil. The work also aims to conduct a comparative study of the carbon stocks in the depths of 0-30 cm and 0-100 cm.

Material and Methods

The experiment was carried in two different grazing systems for cattle and a forest native area located in the Embrapa's Southeast Livestock Research Center in São Carlos / SP. The first area is a recovery grazing system (A3), which is performed liming and fertilization with nitrogen (urea) and the second area corresponds to a degraded system where any kind of correction or control was not performed (A4), both under *Brachiaria decumbens* pasture. A native forest area near from the experiment (Atlantic Forest) was used as a positive reference. Samples were collected at the following depths 0-5, 5-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm in six field replicates for each of the three areas concerned. Carbon stocks and SOM quality evaluation were studied in both pasture systems and in the forest area.

The samples preparation consisted of soil drying at room temperature and cleaning the samples, such as the removal of roots and plant residues, and soil homogenization. The soil was gently crushed using a mortar and pestle and passed through a 100 mesh sieve for elemental carbon analyses (CHNS) and the humification index determination.

In a previous study, Xavier (2014) compared methods for soil C stocks calculation: estimation based on a fixed mass (VELDKAMP, 1994) and in order to correct differences caused by land use changes in the soil density estimation using the normalized C content of each soil layer (ELLERT; BETTANY, 1995; SISTI et al., 2004). The SCS were corrected for each system evaluated using as a reference equivalent soil mass under native vegetation (Atlantic Forest), or using the equivalent mass calculation.

For SOM evaluation quality pellets were made from soil to 100 mesh. Then, the samples were analyzed by Laser-Induced Fluorescence Spectroscopy (LIFS) equipped with a diode laser emitting continuous wavelength of 405nm with a power source of around 200 mW. The spectral window was 475-800 nm, with an intensity of 0-4000, integration time 500 ms. For obtain the humification average index were collected five spectra for each sample.

The ratio of the area under fluorescence emission bands and the total organic C content (g kg^{-1}) was defined as the SOM humification index (H_{LIFS}) (MILORI ET AL., 2006).

Results and Conclusions

In this work SCS were evaluated in two ranges layers, 0-30cm and 30-100cm both evaluations using equivalent mass calculation. The results showed that until 1m-depth A3 showed the highest SCS with 142 Mg ha^{-1} versus 99 Mg ha^{-1} of A4 and MT with 115Mg ha^{-1}. The SCS for the first 30 cm layers, A3 showed a SCS with 64Mg ha^{-1}, A4 with 39Mg ha^{-1} and MT with 50 Mg ha^{-1}. The interesting aspect of this trial results was the different contributions of soil layers. Carbon stocks calculated for the 0-30 cm layers represented an average of 43% of the total C accumulation and the 30-100 cm layers with about 57% of the total C stocks, for all pasture systems. Therefore, it is important to emphasize the importance of sampling deep soil layers, especially when studding pastures established with grasses with abundant root system such as *Brachiaria.* Results indicate that the most amount of soil C is stored in deep layers.

For the SOM quality, lower humification indexes were obtained for the surface layers of all soils where occurrence of labile C derived from a continuous supply of fresh material from the cover vegetation and animals (Figure 2). In deeper layers, there is an increase in the H_{LIFS} due to the presence of more recalcitrant C, provided by unsaturated organic compounds containing double bonds and condensed rings.

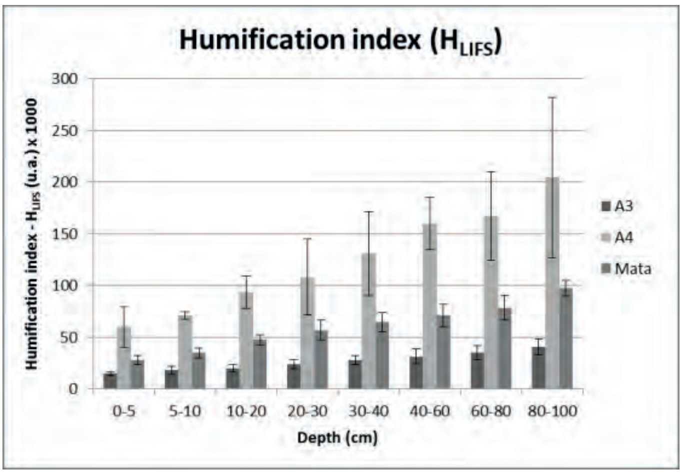

Figure 1: Humification index (H_{LIFS}); A3 – recovering system, A4 – degraded system, MT – Native forest

The analyses of SOM humification complements soil C stocks because the LIFS technique measures recalcitrant C, what can be a sensitive indicator of variances caused by changes in land use and soil management. The "vulnerability" of C is checked in this kind of assessment. In this study, A3 systems, which had the highest C stock values, are susceptible to CO_2 losses if the management is not appropriate, mainly due to the high lability of their soil C, especially at the surface layers.

The soil C stocks associated with the humification indexes showed an alarming situation due to the carbon stored there has a lower humification degree in all layers. This fact reminds us of the fragility of this system to inadequate management. Systems with high C stocks are susceptible to CO_2 losses to atmosphere if the management is not appropriate, mainly due to the high lability of soil C. Results indicate the capacity of well managed tropical grasses to mitigate GHG emissions from livestock production systems.

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Carbon sequestration potential by different eucalyptus genotypes

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Introduction

Carbon sequestration can be defined as the carbon dioxide (CO_2) removal process from the atmosphere and subsequent release of oxygen (O_2) for several terrestrial or aquatic organisms, avoiding the permanence of this gas in the atmosphere.

Carbon sequestration by trees is a kind of Clean Development Mechanism (CDM), in which trees remove CO_2 from the atmosphere and stock it in different plant compartments (leaves, branches, stems and roots). With a large territory, favorable climate for plant growth throughout the year and advanced silvicultural technology, Brazil has strong vocation for forestry, fully complying with the provisions of the CDM.

Eucalyptus plantations are highly efficient in atmospheric CO_2 removal, because they can store large amounts of carbon in all plant parts. Due to Brazilian favorable climatic conditions (rainfall and photoperiod), it is possible to obtain high conversion rates of CO_2 into biomass by eucalyptus trees, due to rapid growth and consequently high productivity.

In Brazil, a large part of eucalypt plantations supply pulp and paper industry, maintaining therefore the carbon stored. Due to the high productivity, eucalyptus cultivation cycles for pulp and paper production last seven years in average, favoring atmospheric CO_2 capture, once growth rate for younger trees is higher compared to older trees. However, due to genetic diversity, different eucalyptus genotypes have different growth rates, which result in different carbon accumulation capacities.

Thus, the objective of this research was evaluating the productivity of eucalyptus relating it to potential carbon sequestration and accumulation by different genetic materials.

Material and Methods

The experiment was carried out at the Embrapa Beef Cattle research center in Campo Grande, Mato Grosso do Sul State, Brazil, located between the geographical coordinates: 20º27’02” S and 54º43’07” W.. Soil was a distroferric red latosol (LVdf), Climate under Köppen classification is a transition zone between Cfa and Aw wet tropical. Mean annual rainfall is 1,560 mm, with rainy summer and a dry light cold winter.

Experimental design was randomized block, with seven treatments and three repetitions. Seven Eucalyptus genotypes were used: 1277 (*E. camaldulensis* x *E. grandis*), I- 144 (*E. urophyla*), I-224 (*E. urophyla* x *E. grandis*) GG 100 (*E. urophyla* x *E. grandis*), H13 (*E. urophyla* x *E. grandis*), H77 (*E. urophyla* x *E. grandis*) and *Corymbia citriodora* (single genotype from seminal seedlings). All genotypes are classified as multi purpose. Each experimental plot had 48 plants, with 3 meters x 2 meters spacing (1,666 plants per hectare).

Measurements of total height and diameter at breast height (DBH) were performed at 48 months after planting. From the height and DBH data, the volume of timber per plant was calculated (using the form factor equal to 0.45) as well was the volume of timber per hectare, using the equation proposed by Porfírio-da-Silva et al. (2009).

The carbon contet on stem was determined using CN analyzer (Sumika Chemical Sumigraph CN 900), according to methodology employed by Kanda et al. (2004). CO_2 eq. was estimated using a conversion factor of 3.67.

Analysis of variance was carried out and, when there were significant differences up to 5% significance between means, these means were compared by Scott Knott test with 5% probability, using SISVAR software (Ferreira, 2008).

Results and Conclusions

Table 1 shows that 48 months after planting, genetic materials studied showed statistically significant differences for all traits. The DBH values of clones I-144 and I-224 were similar to those for the GG 100 and 1277 clones, but the GG 100 and 1277 clones showed greater heights of plants.

Analyzing volume of timber per tree, it can be noticed a formation of three distinct groups, where H77 and H13 clones and *C. citriodora* genotype had the worst performers and GG 100 clones and 1277 the best production of timber per tree, with the others genotypes in the intermediate group. Production of timber per hectare was linearly influenced by these results, keeping the same groupings for that characteristic.

Table 1. Averages of diameter at breast height (DBH), height, volume of timber per tree (Vol./tree) and volume of timber per hectare (Vol./hectare) of different eucalyptus genotypes.

Genotype	DBH (cm)	Height (m)	Vol./tree (m^3 tree^{-1})	Vol./hectare (m^3 ha^{-1})
C. citriodora	0.09 b	8.97 b	0.02 c	40.74 c
H77	0.10 b	9.51 b	0.03 c	57.65 c
H13	0.10 b	10.14 b	0.04 c	63.88 c
I-224	0.13 a	10.65 b	0.06 b	100.36 b
I-144	0.12 a	11.27 b	0.05 b	93.56 b
1277	0.13 a	12.41 a	0.07 a	123.06 a
GG 100	0.13 a	13.61 a	0.08 a	140.55 a
CV (%)	8.54	8.99	21.51	20.04

Means followed by the same letter in the column are not different by Scott-Knott test ($P > 0.05$).

Wood yield (m^3 ha^{-1}) has direct relation with the capacity to sequester and store carbon from the atmosphere by trees, so it can be seen in Figure 1 that the GG 100 and 1277 clones were superior to others when the accumulated carbon content is considered in the tree stem and the equivalent carbon dioxide amount removed from atmosphere.

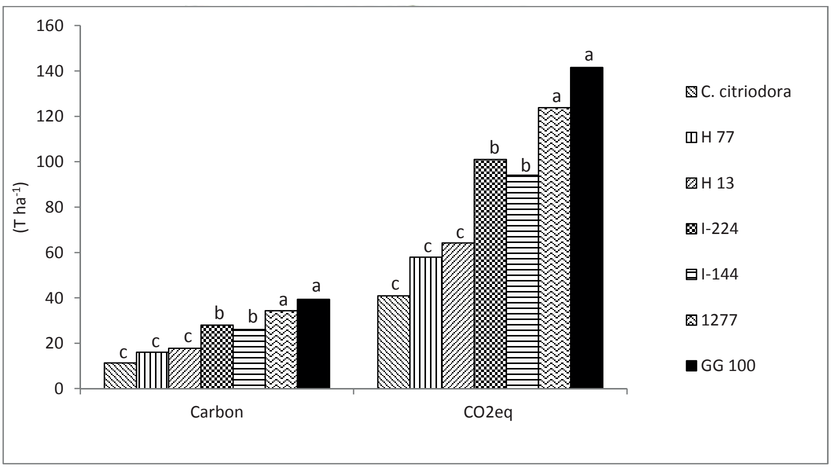

Figure 1. Accumulated carbon amount in the tree stem and amount of CO_{2eq} removed from the atmosphere by the different eucalyptus genotypes at 48 months of age.

Bars with the same letter within each characteristic, do not differ by Scott-Knott test ($P > 0.05$).

Thus, it can be concluded that there is variability in the carbon sequestration capacity by different eucalyptus genotypes and the GG 100 and 1277 clones have the greatest potential for environmental services when it comes to capturing atmospheric carbon dioxide.

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Comparison between carbon stock measurements methods in eucalyptus stems

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Introduction

The levels of greenhouse gases (GHG) have been significantly increased since the Industrial Revolution. However, only after 1980 was that the changes in the levels of GHG were scientifically evident. This finding led to the establishment in 1988, the Intergovernmental Panel on Climate Change (IPCC).

In 1997, during the Conference of the Parties (COP) held in Japan, the Kyoto Protocol was established in order to reduce the emission of GHGs mainly by industrialized countries. Among the mechanisms cited for compensation of GHG emissions there is the Clean Development Mechanism (CDM).

Developing countries, e.g. Brazil, started the implementation of the CDM to generate carbon credits to be traded with developed countries, since they have committed to reduce GHG emissions. Through calculating the GHG that had their volumes avoided and/or removed from the atmosphere emissions, carbon credits are generated. Each carbon credit is equal to a stored GHG ton and/or that have not been released into the atmosphere and they may be negotiated between developed and developing countries.

The forest carbon sequestration is one way of CDM in which trees remove carbon dioxide from the atmosphere and accumulate in the woody matter. By presenting strong forestry vocation, Brazil has great potential for the implementation of CDM projects, and on a global market and increasingly competitive, the possibility of adding value to planted forests by the Forest Carbon Sequestration reinforces the need for projects on forest management and forest measurement.

Thus, this study aimed to compare two carbon stock assessment methodologies in eucalyptus trees.

Material and Methods

The experiment was carried out in Ribas do Rio Pardo, Mato Grosso do Sul State, Brazil, on a farm located between the GPS coordinates 20°26′09″ and 20°27′31″S and 53°56′13″ and 53°57′43″W. The soil of the experimental area is classified as Typic Quartzarenic Orthic (Santos et al., 2013). The weather pattern of the area is classified, according to Koppen (1948), as a transition between CFA and humid Aw.

The experimental data, as well as tree fragments were obtained from forests of clonal eucalyptus H77 (*Eucalyptus urophylla* x *Eucalyptus grandis*), aged between 12, 24 and 36 months. The determination of wood density was held at Plant Physiology and Analytical Chemistry Laboratories of Anhanguera-Uniderp University/Campo Grande (Brazil).

After the characterization of forest stands were selected 12 trees of each age (12, 24 and 36 months), totaling 36 samples, representing all ages of the evaluated population. It was measured the height of the stem and the stem diameter without bark at breast height (diameter at breast height – DBH - 1.30 meters above ground).

Just after the measurements, the selected trees were cut for collect a 10 cm disc of stem at the DBH, for determining the density of the wood, according to the methodology proposed by Vital (1984) and the amount of carbon stored in the stem, according to the methodology proposed by Tedesco et al. (1995) and by Walkley-Black method with external heat, described by Allison (1965).

To estimate the carbon stored in the stem, it was considered that 50% of the total biomass consists of carbon (Soares et al., 2005).

Results and Conclusions

The amount of carbon in the stem determined by destructive and non-destructive methods according to the age of the trees are shown in Table 1. The availability of papers about wood density as a function of tree age and spatial arrangement are scarce in the literature, so we used the same average wood density for the carbon stock calculations for both methods.

Table 1. Carbon stock (t ha^{-1}) in the eucalyptus tree stem, determined by destructive and non-destructive methods, depending on the age of the trees.

Tree	12 months		24 months		36 months	
	Destructive Method	Non-destructive Method	Destructive Method	Non-destructive Method	Destructive Method	Non-destructive Method
1	0,4049	0,4122	0,4119*	0,4676*	0,9148	0,9252
2	0,2957	0,2898	0,5599	0,4991	1,0849	1,0973
3	0,2793	0,2562	0,4156	0,4286	1,0248	0,9919
4	0,3636*	0,3152*	0,6112	0,6065	1,1526	1,1366
5	0,3852	0,3377	0,6317	0,6430	1,0956	1,0872
6	0,3222	0,3100	0,1507*	0,5944*	0,9902	1,0015
7	0,3369	0,3343	0,5352	0,5149	1,2367*	1,1684*
8	0,3262	0,3216	0,4476	0,4442	0,9556	0,9919
9	0,3267	0,2922	0,3670	0,3860	0,8433	0,8163
10	0,2869*	0,3281*	0,3813	0,3646	0,9308*	0,8847*
11	0,3368	0,3182	0,5917	0,5624	1,2729	1,2552
12	0,3280	0,3235	0,5339	0,5168	1,0773	1,0427

*The two data that present the biggest differences between the determination by destructive and non-destructive methods for each age were eliminated.

The regression analysis shows high correlation - upper than 99% (Figure 1) – between two methods for determining the carbon stock in the stems of eucalyptus trees for all ages studied. These results corroborate Reis et al. (1994) that found high correlation between destructive and nondestructive methods for determining carbon in tree stems. Therefore, the nondestructive method can be used to estimate the carbon stock in the stems of eucalyptus trees with a high degree of confidence and with the advantages of higher efficiency and lower cost.

In Figures 2, 3 and 4 are shown separately, the regression equations and correlation between destructive and nondestructive methods for each age studied.

We conclude that the two methods compared to the determination of carbon eucalyptus stems have high correlation. The determination of the amount of carbon stored in the stems of eucalyptus plants by non-destructive method has high reliability.

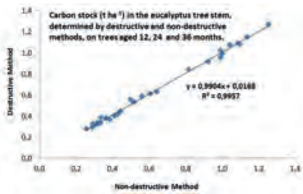

Figure 1. Correlation between carbon stock determined by destructive and non-destructive methods on eucalyptus trees aged 12, 24 and 36 months.

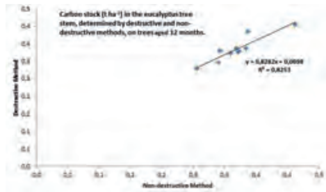

Figure 2. Correlation between carbon stock determined by destructive and non-destructive methods on eucalyptus trees aged 12 months.

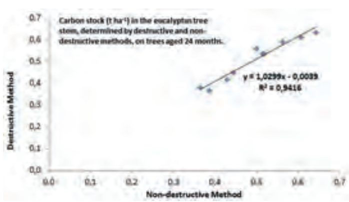

Figure 3. Correlation between carbon stock determined by destructive and non-destructive methods on eucalyptus trees aged 24 months.

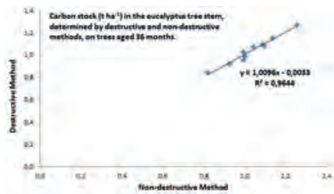

Figure 4. Correlation between carbon stock determined by destructive and non-destructive methods on eucalyptus trees aged 36 months.

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Embrapa, Fundect, Finep, Fundação Manoel de Barros, CNPq.

Carbon and nitrogen stocks in soil under different landscape units at the Pantanal ecosystem, Mato Grosso do Sul, Brazil

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Introduction

The soil organic matter content plays an important role in greenhouse gas emission processes and consequent global climate change. A sound understanding about C sequestration potential in soil could be crucial for the development of effective management approaches in order to reduce CO_2 concentrations in the atmosphere as well as to maintain the ecosystem sustainability. In the Pantanal ecosystem landscapes have a diversified floristic composition and structure. They are consisted by a mosaic of different phytophysionomic features, which are influenced by edaphic factors and variable flooding levels. Furthermore, they have sustained a livestock production with a low level of external inputs, especially regarding to soil management. This study aimed to evaluate the soil carbon and nitrogen storage under different landscape units in the Pantanal ecosystem.

Material and Methods

The study was carry out at the Embrapa Pantanal experimental farm, whose landscape is representative of the most part of the Nhecolandia sub-region. Four different landscape units were studied: forested savannah; arboreal savannah; grassland savannah with *Mesosetum chaseae*, and open grassland with *Axonopus purpusii* (these areas suffer seasonal flooding at contrary grassland savanna with *M. chaseae* the are no flooding areas). Soil samples were collected at 0-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm depths, in three trenches to determine soil bulk density, and in four different transects, accounting 315 samples per landscape unit (45 per depth). The C and N content were assessed by dry combustion in a CHNS analyzer equipment. The results were submitted to ANOVA, and the multiple means comparisons were performed by the Tukey test at 5% probability.

Results and Conclusions

The larger C stocks were found out at 0-10 and 10-20 cm depths in the forested savannah and in the open grassland with *A. purpusii* landscape units (respectively 10.76 and 8.33 Mg C ha^{-1} in open grassland with *A. purpusii* and 6.53 and 5.09 Mg C ha^{-1} in forested savannah) (Table 1). Taking in account the layer 0-100 cm, the C storage was significantly higher in open grassland with *A. purpusii* (33.54 Mg C ha^{-1}) and in forested savannah (33.03 Mg C ha^{-1}). Lower contents occurred in grassland savannah with *M. chaseae* (23.99 Mg C ha^{-1}) and in arboreal savannah (21.91 Mg C ha^{-1}). These landscape units are characterized by natural environments and these soils have never been submitted to any kind of management. Therefore, the results of the open grassland with *A. purpusii* unit might be related to the vegetal residue deposition provided by the annual cycle of flooding, mainly aquatic weeds. Moreover, it may be also related to the soil organic matter quality. Prevailing the presence of recalcitrant C fractions could give rise to a protected compartment, which keeps the C in more stable forms. On the other hand, the C stocks of forest savannah may be due to the higher amount of organic residue and to the litter production provided by a dense and diversified tree vegetation. The reduced soil C storage in the arboreal savannah and grassland savannah with *M. chaseae* units may be associated with a grazing pressure because they remain flood-free in the most part of the year, which allows them to be highly used by cattle.

Besides that, the presence of a dominant vegetation consisted by herbaceous plants under scattered woody plants. It leads to the addition of small organic material amounts to the soil. Regarding N stocks, variations were observed among the landscapes units and soil depths (Table 1). However, significant difference was not detected when the 0-100 cm layer was taking in account. The values were ranging from 2.41 to 3.62 Mg N ha^{-1}, which indicates low capacity of N storage in the soil. The Pantanal natural pastures are subjected to a continuous defoliation, imposed by the grazing pressure. This situation characterizes these environments as an ecosystems marked by merely biomass extraction and almost no nutrients or organic material replacement, except the animals excreta, which are deposited in specific locations. In natural low fertility and unfertilized ecosystems like Pantanal, the main source of nutrients for plants comes from the processes of soil organic matter decomposition and mineralization (MOREIRA e MALAVOLTA, 2004). The depletion of C stocks in soil could bring lower resilience level, which could result in an impairment of the productive capacity and less ecosystem services supply.

Table 1. Carbon and nitrogen stocks in soil under different landscape units at the Pantanal ecosystem, Mato Grosso do Sul, Brazil.

Landscape units*	Soil depth (cm)							
	0-10	10-20	20-30	30-40	40-60	60-80	80-100	0-100
	Soil carbon stocks (Mg C ha^{-1})							
OG	10.76Aa	8.33Ab	4.00Ac	2.52Acde	3.48Bcd	2.48Bde	1.94Be	33.54A
FS	6.53Ba	5.09Bab	3.76Aab	3.54Ab	5.08Aab	4.51Aab	4.52Aab	33.03A
AS	4.48Ca	3.90BCa	3.17Aab	2.32Ab	3.48Bab	2.28Bb	2.29Bb	21.91B
GS	3.81Cab	3.72Cab	3.09A	2.72Ab	4.29ABa	3.17Bab	3.17Bab	23.99B
	Soil nitrogen stocks (Mg N ha^{-1})							
OG	1.12Aa	0.91Aa	0.41Ab	0.25Bb	0.36Ab	0.26Bb	0.21Bb	3.53A
FS	0.62Ba	0.52Bab	0.37Aa	0.67Aa	0.51Aab	0.46Aab	0.46Aab	3.62A
AS	0.48BCa	0.43Bab	0.36Aab	0.26Bb	0.40Aab	0.27ABab	0.27Bb	2.47A
GS	0.39Ca	0.38Ba	0.31Aa	0.28Ba	0.42Aa	0.30Aba	0.32ABa	2.41A

*OG = open grassland with Axonopus purpusii; FS = forested savanna; AS = arboreal savanna; GS = grassland savannah with Mesosetum chaseae. Values followed by different upper-case letters within columns and lower-case letters within rows are significantly different by Tukey test ($p < 0.05$).

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Acknowledgements

The authors thank to EMBRAPA (PECUS Network - Greenhouse gases (GHG) dynamics in brazilian livestock production systems) and to FUNDECT/MS (Concession term nº 094/2014) for providing financial support for this study.

Soil carbon sequestration in grass and grass-legume pastures in the western Brazilian Amazon

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Introduction

Land use change from native forests to pastures in the tropics have impact on global carbon cycle through increased rates of C emissions to the atmosphere and the loss of above- and belowground C accumulation and storage capacity (SILVER et al., 2000). This study was conducted to determine the carbon stock in a Ultisol under a pure *Brachiaria humidicola* (Rendle) Scheick pasture and a mixed pasture of *B. humidicola* and *Arachis pintoi* Krapov. & W. C. Greg cv. BRS Mandobi, both without fertilization. A native forest classified as Bamboo open+dense, on the same soil type, was the reference land use with 137 Mg ha^{-1} of above-ground live biomass (SALIMON et al, 2011).

Material and Methods

The experiment was stablished in 2011 at the Guaxupé farm in Rio Branco, state of Acre, Brazil. Deforestation of the experimental area occurred in 1981. Soil sampling was carried in the pure *Brachiaria humidicola* pasture (G), in the mixed pasture of *B. humidicola* and *Arachis pintoi* cv. BRS Mandobi (GL), and in a native forest (NF) classified as Bamboo open+dense, on the same soil type. In order to account for inter annual variation, soil carbon stocks were measured in 2012 and 2015, in the 0-0.05, 0.05-0.10, 0.10-0.15, 0.15-0.20, 0.20-0.30, 0.30-0.40, 0.40-0.50, 0.50-0.70, 0.70-0.90 and 0.90-1.10

m layers. Carbon (C) content (EMBRAPA, 2011) and soil bulk density (BLAKE e HARTGE, 1986) were determined and C stocks calculated (ELLERT e BETTANY, 1995). Data of soil C stocks for 2012 and 2015 were averaged for the three land uses (NF, G and GL).

Results and Conclusions

There was difference ($P < 0.05$) in soil C stock among the different land uses. Soil C stocks (Mg C ha^{-1}) were 52.8 ± 2.2 in the NF, 72 ± 5.5 in the pure G pasture and 65 ± 10.9 in the mixed GL pasture. Soil C stock in pure G pasture was greater than in NF but similar to mixed GL pasture. There was no difference between soil C stock of NF and mixed GL pasture (Figure 1).

Soil C stocks in the pure G and in the mixed GL pastures represent gains of 36% and 23% respectively, over 34 years in relation to the NF (Figure1). This means a rate of soil C accumulation (Mg ha^{-1} $year^{-1}$) of 0.56 and 0.36 in the pure G and in the mixed GL pastures respectively in this time span. This calculation does not consider the C stock in the aboveground biomass that was lost by burning during deforestation in 1981. In this respect, the gain of soil C stock in the pure G and mixed GL pastures represent 14% and 9%, respectively of the 137 Mg C ha^{-1} in the above-ground live biomass in the NF (SALIMON et al, 2011).

Soil C accumulated in the pure G and mixed GL pastures in relation to the NF, over the 34 year period, was 70.3 and 44.5 Mg CO_2 ha^{-1}, respectively. This indicates that the pastures are functioning as a C-CO_2 drain from the atmosphere, offsetting part of the carbon lost since deforestation in 1981.

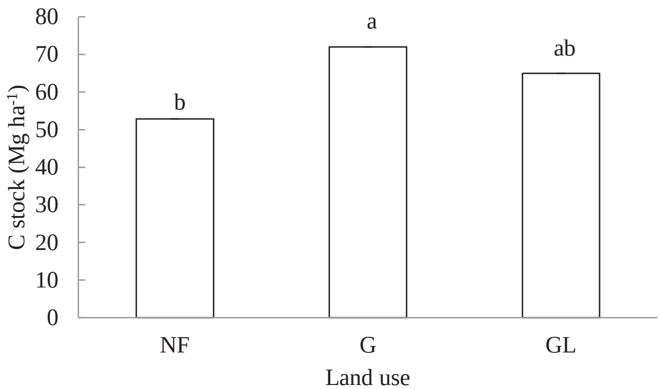

Figure 1. Average 2012-2015 of soil carbon stock (0-1.10 m) at the Guaxupé farm, Acre State, Brazil. NF = native forest. G = single pasture of Brachiaria humidicola and GL = mixed pasture of B. humidicola with Arachis pintoi cv BRS Mandobi. Values are mean of three observations. Different letters indicate significant differences among land uses according Tukey test ($P < 0.05$).

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Soil carbon and nitrogen stocks under natural forested savannah and cultivated pasture in the Pantanal, Mato Grosso do Sul, Brazil

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Introduction

Changes in land use can affect the biogeochemical processes, with consequences to the soil organic matter (SOM) stocks. Depending on the characteristics of the area and management system adopted, these changes may jeopardize the role of soil as one carbon (C) sink on the Earth. A sound understanding of C sequestration potential in soil could be crucial for the development of practical management approaches, to reduce CO2 concentrations in the atmosphere as well as to maintain the sustainability of production systems. In the Pantanal, the establishment of cultivated pastures in no- flooded savannah areas is one of the major land-use changes in the region. They receive no fertilization, and the maintenance of satisfactory levels of production depends on the nutrients naturally released into the soil by the decomposition and mineralization processes related to the SOM dynamics. The goal of this study was to estimate the soil C and N stocks under *Urochloa* spp. pasture with a natural forested savannah as a reference.

Material and Methods

The experiment was carried at the Embrapa Pantanal experimental farm. The studied areas comprised an Urochloa pasture spp., introduced about 21 years ago in an area under non-flooded forested savannah, and as a reference for comparison purposes a natural non-flooded forested savannah adjacent to pasture, which floristic composition and structural and edaphic characteristics are similar to the deforested area. The pasture has never received any fertilizer. It has been using for lactating females and newly weaned calves. When necessary, the pasture has submitted to cleaning by mowing. Soil samples were collected at depths 0-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm in three trenches, to determine soil bulk density, and in four different transects amounting 315 samples per area (45 per depth). The C and N content were assessed by dry combustion in a CHNS analyzer equipment. The stocks from the pasture area were fixed for the same soil mass according to Carvalho et al. (2009). Since the results were not normally distributed, the Kruskal-Wallis/Wilcoxon nonparametric test for means comparisons at 5% of probability was used.

Results and Conclusions

According to Figure 1a, one observes that the higher soil C storage occurred in the sub-surface layers ($p < 0.05$) in both of the areas. Under the natural forested savannah, a larger soil storage C was found at the layer 0-30 cm (13.719 and 10.934 Mg C ha^{-1}, respectively, for natural forested savannah and *Urochloa* spp. pasture). Regarding the layer of 40-100 cm deep, the soil C stocks were higher in the area under pasture (23.021 and 18.691 Mg C ha^{-1}, respectively, for *Urochloa* spp. pasture and natural forested savannah). When one considers the 0-100 cm layer, however, it appears that there were no differences between areas (33.995 and 32.409 Mg C ha^{-1}). These results suggest that 21 years after pasture implantation there was no reduction the in soil C stock when compared to the primary area once the loss of C in its surface layers was offset by the higher storage in the deeper soil layers. As for the soil C, the soil N storage is also greater in the sub-surface layers (Figure 1b). However, a statistical difference ($p < 0.05$) was observed only in the 0-30 cm layer, with stocks ranging from 1.028 to 1.364 Mg N ha^{-1}, respectively, for the soil under *Urochloa* spp. pasture and natural forested savannah). In the 40-100 cm layer, the soil N stocks were 2.054 and 2.245 Mg N ha^{-1}, respectively, for natural forested savannah and *Urochloa* spp. pasture, and in the layer 0-100 cm they ranged from 3.273 to 3.419 Mg ha^{-1}, respectively for *Urochloa* spp. pasture natural and natural forested savannah. Despite not having provoked a reduction in C and N soil stocks, the establishment of pastures in forested savannah areas show certain restraints. The removal of the original vegetation represents losses of about 49 Mg C ha^{-1} associated to the aboveground biomass (FERNANDES et al., 2008). This amount is greater than that stored in the soil up to 1 meter deep. When estimating the C balance for the area, such removal shall be taken into account, which will certainly contribute to obtaining unfavorable balance to the greenhouse gas emissions from the production system. Furthermore, one has to consider the costs of the clearing operation, which make this unattractive agricultural practice. Currently, the trend in the Pantanal has been the introduction of exotic pastures in field areas with low nutritional quality forage.

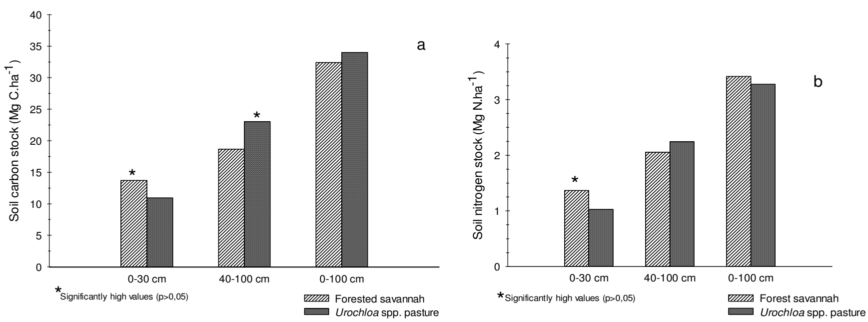

Figure 1. Carbon (a) and nitrogen (b) stocks in soils under natural forested savannah and Urochloa spp. pastures in Pantanal, MS

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Dynamics of C/N and nutrients in Oxisol soils treated with swine digestate

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Introduction

It is well known that intensive swine production can be harmful to the environment in many ways. Firstly, it is necessary to allocate large areas to produce exclusively grain (soya/corn) as feed resources, without considering the provision of ecosystem services like more diversified agroecosystems (Power, 2010). Secondly, groundwater is usually employed at a high rate of 10L per swine (Bergier et al., 2012). Lastly, livestock industrialized wastes (basically manure, urine, hair and feed), if improperly disposed, can hazard the air (ammonia and methane emissions), water (ponds, streams and groundwater) and the pristine and cultivated soils (Buller, 2016). To tackle some of these issues, entrepreneurs in São Gabriel do Oeste (MS, Brazil) have developed a set of technologies grounded on waste biodigestion (Bergier et al., 2013). Diesel adapted machines are now able to convert calorific power of biogas into useful energy at 40% efficiency. Those biogas-driven machines have been successfully employed to distribute swine digestate (effluent) in soils, particularly under pasture for cattle. We present C/N and nutrient soil data of 6 integrated swine-cattle farms in São Gabriel do Oeste that have been applying effluent to pasture over different time spans and variable effluent doses. The results are discussed under the light of effluent application, soil depth and time spans of effluent application.

Material and Methods

Samples of soil were gathered at different depths with a soil sampler between 22/12/2009 and 10/05/2012 in Oxisol soils under pasture of swine-cattle farms in São Gabriel do Oeste. The spanning time of effluent application was the basic criterion to select sampled farms. Soils assumed free of effluent in farms were also sampled as testimony. At the laboratory of Embrapa Pantanal, soil samples followed standard procedures for measuring carbon (C) and nitrogen (N) in a CHNS Elementar, and phosphorous (P), cooper (Cu) and zinc (Zn) in an Atomic Absorption Perkin Elmer 3300.

Results and Conclusions

Figure 1 shows the results in four plots. The plots 1A, 1B and 1C compare C/N with Cu, Zn and P concentrations. The y-axis of these graphs in log-scale is divided at concentration ~ 3.3 mg/kg while the x-axis is divided at C/N ~ 15.3 (means testimony bulk soil values). Data shows that soils treated with effluent between 5-30 cm depth and spanning 6 years present C/N $<<$15.3 and nutrient concentration $>>$3.3 mg/kg. The plot 1D evidences that the farm spanning 6 years of effluent application largely reduce its soil C/N in comparison to soil testimony likely due to priming effect (Fernandes et al., 2011). However, the results indicate that swine digestate can be applied to Oxisol soils to improve its fertility without compromising C/N, particularly at deeper soil layers. The results reinforce that instead of application time span, the application dose is the main variable to be considered as the soil nutrients stock is a balance between effluent input and plant absorption/extraction. As a result, dosage must be carefully amended to avoid C/N reduction and soil saturation with Cu, Zn and P (and other elements e.g. Na, Mg, etc.), as identified to the farm spanning 6 years of effluent application likely with high dosage rates.

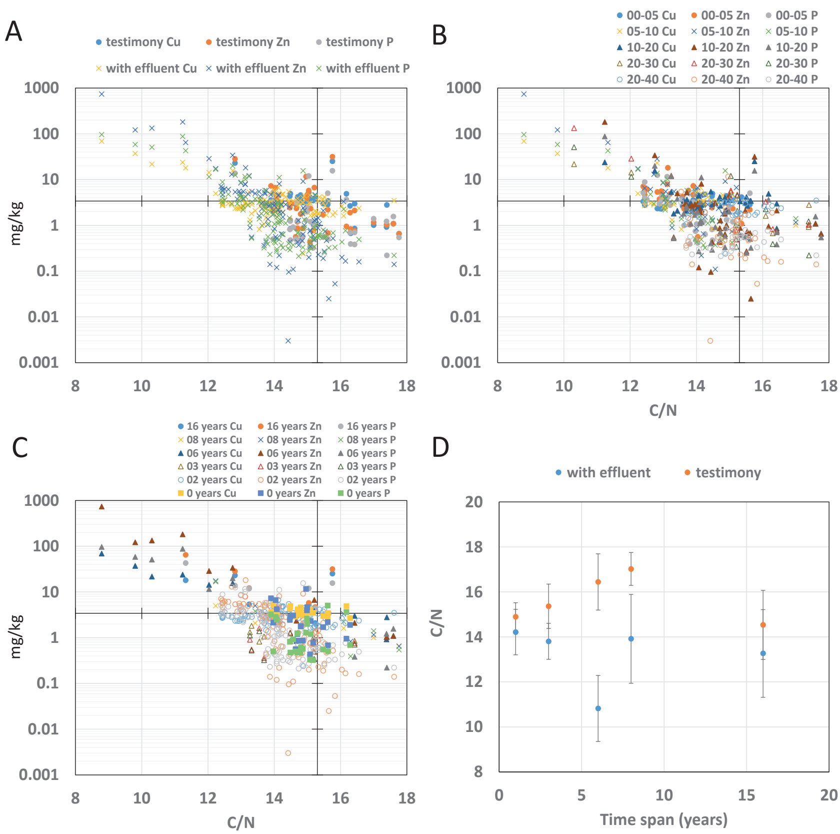

Figure 1. Relationship between C/N with Cu, Zn and P concentrations in soils extracts accordingly to effluent application or not (testimony) (A), soil depth (B), time span of effluent application (C). The origin of the plots A, B and C is defined as the mean C/N and concentration values of testimony soils. The mean C/N (±1SD) against effluent time span is also shown for bulk soils (all depths) with and without (testimony) effluent application (D).

Bergier et al. (2012) have defined an 'acceptable' dosage rate of ~1 hectare of pasture for each 100 swine. Pasture soils treated with digestate can then be well managed to improve C/N ratio over time in the same way as cultivated pasture with mineral NPK (Bergier et al., 2012). By respecting the critical dosage rate, the risk of soil nutrient saturation and C/N depletion can be minimized. State government policy of swine-cattle integration must therefore consider adequate dosages for licensing swine intensive production in Oxisol soils. Government supervision should consider e.g. 4-year monitoring of top soil samples at 0-10 cm depth and the thresholds $C/N < 12$ and Cu, Zn and $P > 10$ mg/kg as a decision support to revoke environmental licenses to keep a better level of sustainability in swine production.

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Livestock production systems balance and the emissions intensity of Greenhouse Gas Emissions on Brazilian Amazon

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Introduction

Global warming resultant from rising in greenhouse gas emissions (GGE) to atmosphere on the last decades leads the mankind to enrich their knowledge about the relationship between the productive activities and GGE´s (FAO, 2013). Nevertheless, the process of technology development and adoption to increase the environmental behavior of production systems should considered the economic and social sustainability of such production systems (SILVA *et al*, 2016).

The beef livestock production on Brazilian Amazon occur on extensive pasture mainly, as it is on the other country´s Biomas (ALVIM *et al*, 2015). The North Region participates with 22% of national cattle herd on 2014 (IBGE, 2016). The research aiming to understand and explain the impacts of this activity on the environment, and search mitigation alternatives technologies will develop a more environmental friendly livestock production system. The identification of Technologies and production models which allows the GEE´s reduction with good financial and social outputs.

This research objective is to compare the GEE´s emissions, production and economic indicators of four production systems of beef livestock on Brazilian Amazon, both single and in combination with others.

Material and Methods

Four beef livestock production systems on Paragominas-PA region where analyzed, two traditional systems (cow-calf (Bz_Td) and full cycle + finishing (BG_Td)) and two proposed systems, with a higher technological level (cow-calf (Bz_At) and full cycle + finishing (BG_At)). The economic analyses was develop using the annual profit by the Family Income indicator (GUIDUCCI et al, 2012), and considered inputs and products prices for year 2014. The calculus of GEE´s production systems used the PECUS Emissions Model version v3.9.6, developed by Pecus Project Research's team. The Model estimates the annual carbon dioxide equivalent amount and the annual beef production for each production system. Aiming a higher comprehension of the alternatives, the production systems evaluation were done one by one and on pair combinations (one cow-calf plus one full cycle + finishing). The area amount on each combination were set by the equilibrium between the supply and demand of calves on each combination, and the results were normalized to one hectare for easier comparison. The interaction between systems could rise different and more accurate conclusions then the ones obtained by a single systems comparison.

Results and Conclusions

The Figure 1 shows the production system singular performance. The Family Income, beef production, supply and demand of calves is bigger on higher technological production systems than on traditional ones. However, the emission intensity behavior is not as straight as the other indicators. The higher technological cow-calf system´s emission intensity is 25% higher than from the traditional one, while the higher technological full cycle + finishing system reduces the emission intensity by 46% compared with the traditional one. The production system individual analyses, when applied to the systems considered, leads to a conclusion that the traditional cow-calf system is better than the technological one, and the opposite occurs with the full cycle + finishing systems on environmental terms. The system BG_At is the best of all four in terms of production and emission intensity, and the second on terms of Family Income.

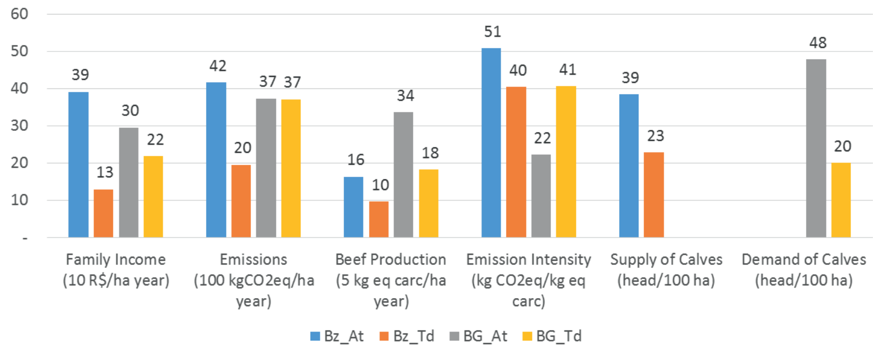

Figure 1 – Family Income, GEE emission per area, beef production, emissions intensity, supply of calves and demand of calves for the production systems individually.
Source: Research data

However, the full cycle + finishing production systems couldn´t exist without the cow-calf production systems, and vice versa. Therefore, the individual analyses could not be the best approach to analyze the systems efficiency. Besides, the combination of areas on each pair of systems is not the same, once the supply and demand capacity of calves on each system differs. In addition, the cow-calf systems main objective is the supply of calves, and compare then by the emission intensity considering beef production could not be the best strategy.

Figure 2 shows the systems combinations indicators performance. The pair's area were set by the supply and demand of calves balance, and then normalized to one hectare. The higher technological pair (Bz_At-BG_At) results on best indicators for Family Income and productivity. The intensification allows an increase on heard, thus increasing the emission by area. However, the emission intensity is the second best, being 19% less of the traditional combination adopted.

The alternative systems combination adoption (Bz_At-BG_At) allows a 96% increase on Family Income, 69% increase on beef production, 37% increase on GEE´s emission by area, and a decrease of 19% on emission intensity when compared with the traditional combination (Bz_Td-BG_Td). However, this production strategy not reach the same emission intensity obtained by the combination of traditional cow-calf system with technological full cycle + finishing production system (Bz_Td-BG_At).

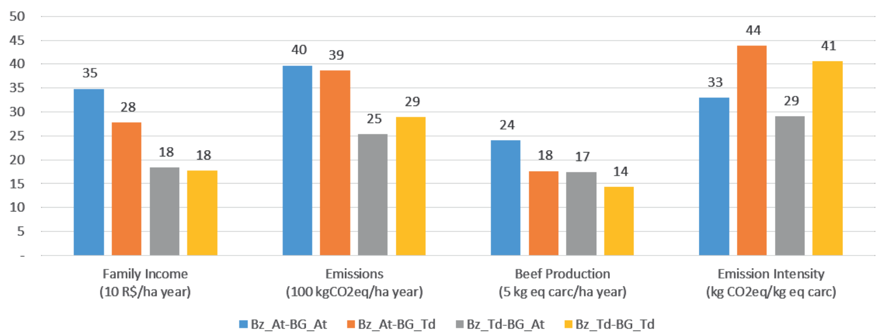

Figure 2 – Family Income, GEE emission per area, beef production and emissions intensity for the production systems combinations.
Source: Research data

Those results suggests a great opportunity to technological cow-calf system development with a stronger environmental strategy, possible allowing the same Family Income and production levels, but with an overall average emission intensity below 29 kg CO_2eq/Kg beef cattle.

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CARBON FOOTPRINT IN DIFFERENT BEEF PROCUCTION SYSTEMS IN THE PAMPA BIOME

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Introduction

The biome Pampa has a large biodiversity mainly in Brazil's south region involving the states of Rio Grande do Sul, Santa Catarina and Paraná. The natural vegetation includes mostly forest ecosystems from the Mata Atlântica, Araucária Forest and Estacionárias Forest (BEHLING et al., 2009). The biome's soil and climatic conditions allow the production of animal protein, relevant in human feeding and necessary to meet the world's demand for food and its constant growth on population.

Moreover, the pursuit of production processes able to decrease possible environmental impacts, primarily in their initial stage, such as grain crops and pastures, as in the industrial phase, is incessant.

This work had the pregnancy, calf, rearing and fattening systems as the research object, considering their high frequency in farms located in Rio Grande do Sul (SEBRAE/FARSUL/SENAR, 2005). Farming in southern Brazil is characterized by the use of natural or cultivated pastures due to suitable climatic conditions and also the small use of supplement (PAULINO; TEIXEIRA, 2009).

Therefore, measuring the different system's environmental impacts is important. However, choosing a methodology to measure and characterize these impacts is substantial for maintaining the system's sustainability and food security.

In this sense, the life cycle analysis (LCA) methodology was applied with the participation of a multidisciplinary team. Hereupon, this study's goal was to analyze the beef cattle from the state of Rio Grande do Sul, where the biome Pampa prevails, using LCA on the three most widely used systems: Native Pasture (NP), Improved Native Pasture (INP) e Fertilized Native Pasture (FNP).

Material and Methods

This study analyzed the livestock production and its full cycle in the State of Rio Grande do Sul (Figure 1), consisting of the stages of pregnancy, growth, calf and steer. Rio Grande do Sul has approximately 13,956,953 head, representing 7% of the Brazilian production (IBGE, 2012). Even though the use of Native Pasture for livestock production is significant in the region, advances in technology are responsible for the implementation of other types of pasture, increasing the stocking rate. Thus, the fertilization of native pasture and the use other species of grasses and vegetables such as ryegrass and clover, respectively, begun (GENRO et al., 2015; RUVIARO et al., 2015; SEBRAE/FARSUL/SENAR, 2005).

The animals were Hereford breed. Also, the pregnancy and growth phases used data from Ruviaro et al. (2015), while the rearing and fattening phase used data from Genro et al. (2015). Table 1 presents the most common production systems, involving NP, INP and FNP, making a combination of these systems in 20%, 40%, 60% and 80% ratio.

Figure 1 - The Rio Grande do Sul Location, Source: Google Maps (2016)

Table 1 - Scenario combination used to calculate the GHG

Scenario	Productive Sistem
I	Native Pasture
II	Fertilized Native Pasture
III	Improved Native Pasture
IV	Native Pasture 80% - Fertilized Native Pasture 20%
V	Native Pasture 80% - Improved Native Pasture 20%
VI	Native Pasture 60% - Fertilized Native Pasture 40%
VII	Native Pasture 60% - Improved Native Pasture 40%
VIII	Native Pasture 40% - Fertilized Native Pasture 60%
IX	Native Pasture 40% - Improved Native Pasture 60%
X	Native Pasture 20% - Fertilized Native Pasture 80%
XI	Native Pasture 20% - Improved Native Pasture 80%

The weight gain varied according to the diet, and each scenario determined a different final weight, being 460 kg, 450 kg and 440 kg of live weight for NP, FNP and INP, respectively (Table 2).

Table 1 – Systems description, days of grazing, live weight gain and live weight supported

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI
	days of grazing	1260	758	666	1114	1072	994	930	898	822	822	736
Calf	live weight, kg	166	180	190	168	171	171	175	174	180	177	185
Rearing		264	348	375	280	286	297	308	314	331	331	353
Fattening		460	450	440	458	456	456	452	454	448	452	444
Calf	live weight supported, kg/ha	582	814	944	628	654	675	727	721	799	768	872
Rearing		564	133	837	607	619	649	673	692	728	735	783
Fattening		564	144	837	607	619	649	673	692	728	735	783

Results and Conclusions

Depending on the degree of intensification, it's possible to note a reduction in greenhouse gas emissions. On system I, CH_4 accounted for 95% of the emissions from animals in native pasture while in system III, Fertilized Native Pasture, CH_4 accounted for 89% of the emissions (Figure 2).

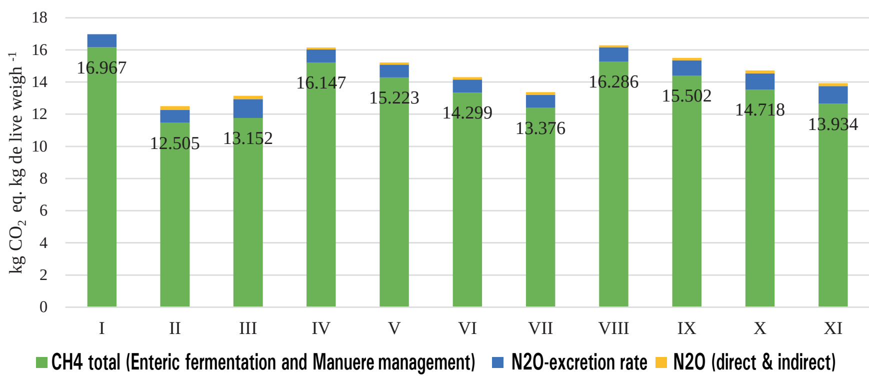

Figure 2 - Methane emissions, nitrous oxide and CO2 equivalent in the different systems

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Total organic carbon stock in Luvisol under natural grassland with different intensifications in Pampa biome

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Introduction

The Pampa Biome occurs in just 2.07% of Brazilian territory, but in Rio Grande do Sul state occurs in 63% (176,496 km2) of gaucho territory. Is characterized by predomination of natural grassland with shrubs and tree vegetation in mosaic (Campos). Because of the natural grasslands, livestock production is one of the main economic activities. Natural grass ecosystems of world might be responsible for an annual sink of about 0.5 Gt carbon (Scurlock and Hall, 1998). Despite of the potential of mitigation, the society has paid attention in this livestock production system, mainly in your environmental impact. In addition to the sporadic livestock exclosure and stocking rate adjustment, other alternative practice to make more productive this livestock system (in Campos) is fertilizer application, and hibernal forages sowing (Overbeck et al, 2007; Boldrini, 2009; Nabinger et al, 2009). The objective of this work was evaluating the total organic carbon stock in a Luvisol under natural grassland with different intensifications rates.

Material and Methods

The work was conducted at Embrapa Pecuária Sul (Bagé/RS, Brazil). The experimental area has 61 ha with 4 treatments (3 repetitions): natural grassland (CN); natural grassland improved by fertilization (CN+A); natural grassland improved by fertilization and introduction of exotic season species ryegrass (*Lolium multiflorum* Lam.) and red clover (*Trifolium pratense* L.) (CN+A+F); and natural grassland with traditional management without stocking rate adjustment (CNT). The fertilization was made with 300 kg/ha of diammonium phosphate (DAP) twice a year. During all experiment time, the area was grazed by Hereford steers with forage offers of 12 kg/ 100kg of live weight. The soil is classified as a sandy clay Luvisol (Soil Taxonomy) or Luvissolo Órtico háplico típico (Brazilian System of Soil Classification – Embrapa, 2006). Soil samples for physical and chemical analysis were taken off in 2015, in the 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-30 cm, 30-40 cm and 40- 50 cm layers with three replicates for each site evaluation. Soil bunk density was determined by the core method. Total organic carbon was determined by following Costa et al. (2008) using a Total Organic Carbon Analyzer (Shimadzu TOC-VCSH) in Geochemistry Soil Laboratory (UFRGS). The data was assessed by one-way ANOVA followed by a Tukey test ($P<0.05$).

Results and Conclusions

The soil bulk density did not differ significantly in none the layers of soil (Figure 1a). The 0-5 cm layer had the lowest values (1.22 g cm^{-3} on average) and the layer of 40-50 cm, the highest values (1.50 g cm^{-3} on average). The low values of soil bulk density, in the 0-5 cm and 5-10 cm layers, do not indicated soil compaction by traffic of steers, despite the larger stocking rate in the treatments CN+A and CN+A+F. Just as soil bulk density, soil organic matter did not differ in the different layers of soil (Figure 1b). The 0-5cm layer showed the highest values (3.5% on average) and the layer of 40-50 cm lower values (1.2% on average).

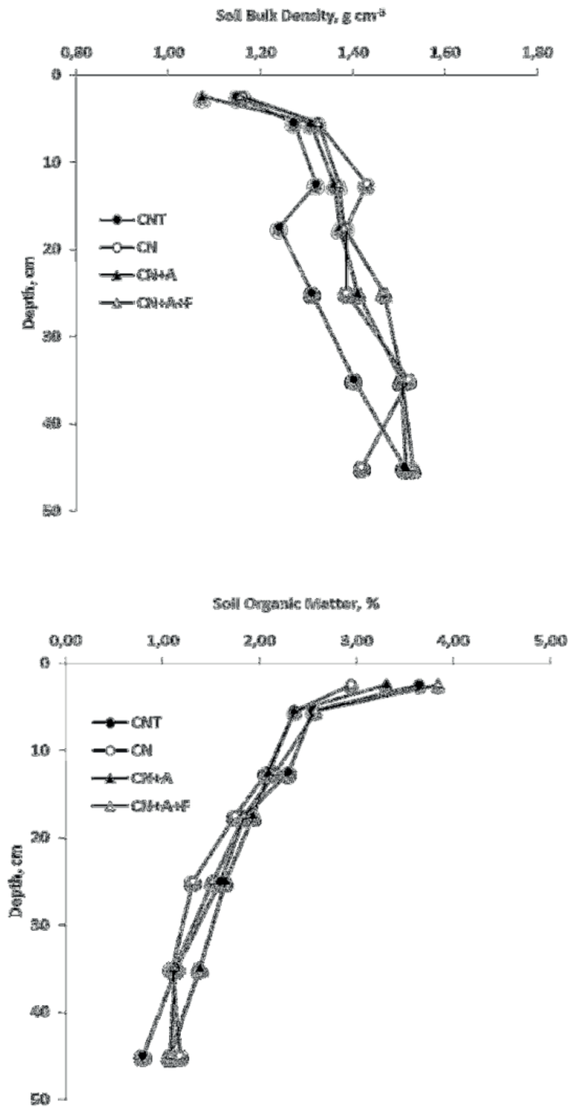

Figure 1. Soil bulk density (a) and soil organic matter (b) in a Luvisol under natural grassland with different intensifications (CNT – natural grassland with traditional management; CN – natural grassland, CN + A – natural grassland improved by fertilization; CN + A + F – natural grassland improved by fertilization and introduction of ryegrass and red clover).

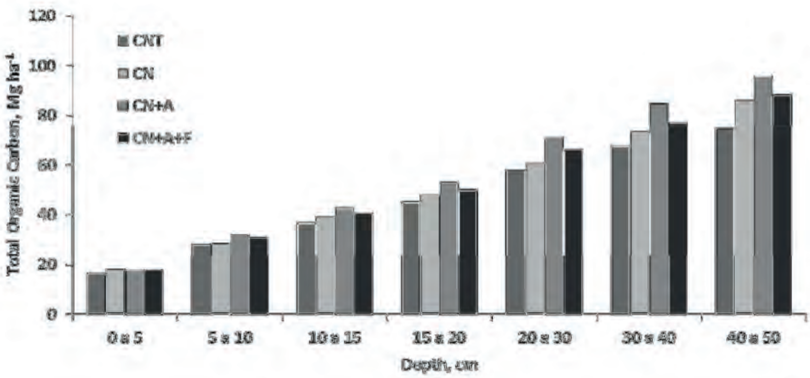

Figure 2. Soil stock of total organic carbon at different depths in a Luvisol under natural grassland with different intensifications (CNT – natural grassland with traditional management; CN – natural grassland, CN+A – natural grassland improved by fertilization; CN+A+F – natural grassland improved by fertilization and introduction of ryegrass and red clover). Columns with the same letters do not differ by Tukey test ($P < 0.05$).

The differences imposed by the treatments of different intensifications (fertilization, overseeded and stocking rate) in natural grassland were not enough to cause differences between the stocks of the total soil organic carbon. Probably because the forage offers was the same for all treatments (12 kg in dry matter/100 kg of live weight).

We conclude that the managements (fertilization and introduction of ryegrass and red clover) to improve productivity of cattle in natural grassland do not affect the stock of total soil carbon when the forage offers is proper.

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Evaluation of the stability of soil organic matter in different types of livestock management

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Introduction

Agricultural and livestock perform an important role in the economy, especially in a country like Brazil, where the natural conditions favor advantages for the development of agribusiness, while generating jobs for the population, income and consumer market for industrial goods. Of the 850 million hectares (Mha) existing in the country, 200 Mha are destined for livestock (Sparovek et al., 2007).

There is concern about the practice of livestock, since this type of management can liberate to the atmosphere greenhouse gases (GHGs), on the other hand, various agricultural practices are able to offset GHG emissions to the atmosphere by sequestering carbon in the atmosphere to the soil. Carbon sequestration can be achieved by the introduction of grass species, well-managed pastures and no soil disturbance, favor carbon accumulation process in the soil (Roscoe et al., 2006).

One way to evaluate the carbon sequestration by the soil is the quantification of the stock and the characterization of soil organic matter (SOM). The SOM is the largest carbon reservoir of the terrestrial surface, reservoir that is dynamic and may vary with management practices. The study of humic substances (HS), which is the SOM highly decomposed, can provide information about the stability of the carbon present in this soil (Segnini, 2007).

One way to assess such impacts is analyzing soil organic matter (SOM). It's possible measure the changes suffered by the SOM using their fluorescence properties (Kalbitz et al., 1999).

Thus, the aim of this study was to evaluate the amount of carbon present in humic acid (HA) and check the humification indices thereof in different types of livestock management.

Material and Methods

To attain the proposed objectives humic acids of five areas of different pastures were extracted. Table 1 details the characteristics of the five areas evaluated. The experimental area is located in the city of São Carlos, SP, Brazil

Table 1. Description of the samples about of kind management, texture and stocking.

Experimental area	management	texture	stocking rate
Area 1	irrigated	medium sandy	high
Area 2	dry	loamy	high
Area 3	in recovery	loamy	medium
Area 4	degraded	medium sandy	short
Area 5	native forest	medium	without

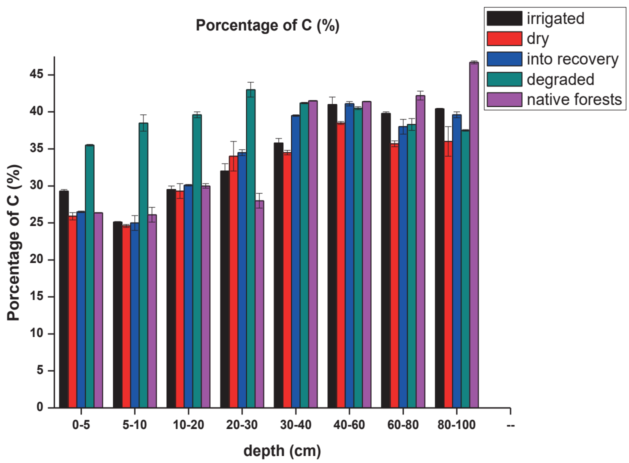
The sampling was conducted in 8 depths (0-5, 5-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm) for each area, totaling 40 samples soil. The extraction and purification of humic acids of soil followed the recommendations described by Swift (1996) and the International Humic Substances Society (IHSS).

The fraction of humic substances used for the analysis was the humic acid. Was used an elemental analyzer (CHNS) Perkin-Elmer (2400 Serious II CHNS/O Elemental Analyzer) model, to determine the humification index was used luminescence spectrometer Perkin Elmer LS--50B model and the indexes were calculated according to the method proposed by Milori et al., 2002.

Results and Conclusions

The average values of carbon for each area evaluated are shown in figure 1.

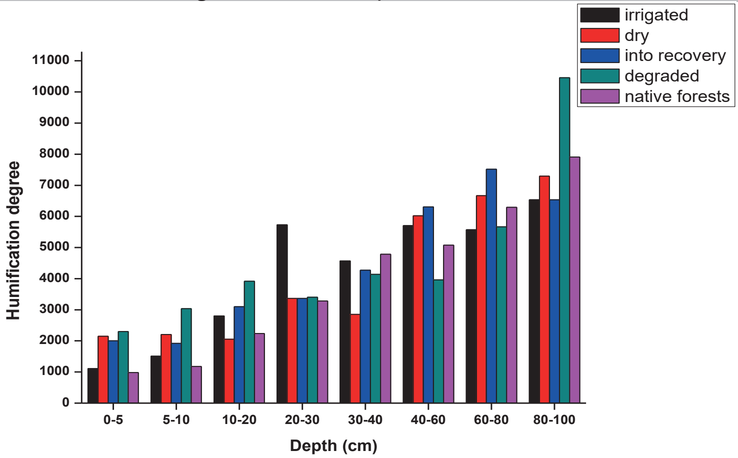
Figure 1. Carbon content in humic acids in percentage (%).



It is observed that the carbon values increase with depth for all evaluated areas, except for the degraded area that keeps the carbon content of around 35 to 40% for all depths. This behavior in degraded area suggests the presence of a SOM which is already more humified in the whole soil profile. For the other areas, it can be said that still have a fresher SOM in surface. Were evaluated the carbon content of the whole soil in the same samples from this study, and lower carbon content was found for the degraded area, thus indicating that pasture degradation leads to loss of carbon to the atmosphere (Segnini et al. , 2014).

The humification indexes are in Figure 2. The values of humification indexes increase with increasing depth for all evaluated areas.

Figure 2. Humification indexes obtained by Milori et al., 2002. The values of humification indexes are given in arbitrary units.



Analyzing separately the areas observed that the degraded area has the largest humification index values at depths of 0 to 20 cm, and 80 to 100 cm. Already the native forest has the smallest humification values in almost all depths. The irrigated area has higher values of the humification index in the intermediary of the soil profile horizons, between 20 to 40 cm. The dry areas and recovery have similar behavior, both increase the values of the humification index in the deeper horizons.

The degraded area has the highest values of humification indexes, along with the higher carbon values, thus suggesting the presence of a SOM most recalcitrant, which in turn will not easily interact with the soil, leaving the soil more depleted and less fertile. Already the native forest showed lowest values of humification indexes in this area there is a more labile organic material, that is, the SOM is subject to more interactions with the soil compartments, resulting in a more fertile soil.

Although this study is very preliminary to effective analysis of pasture management, the results showed a coherence between the fluorescence results with carbon content. To make a more accurate assessment about carbon cycling and effective recommendation on pasture management, you need to relate the results with other soil parameters such as physical parameters, and thus can establish a management that allows a carbon stability in the soil.

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Soil carbon content and stock in tropical pastures in a milk production system

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Introduction

In the context of global climate change, soil and its forms of use are in focus, especially with regard to agriculture and livestock production. Agricultural soils can act as a source or as a sink of greenhouse gases (GHG), depending on the management system that are submitted (IPCC, 2001). Management systems that increase the addition of vegetable wastes and retention of soil C constitute important alternatives to increase the drain capacity C-CO_2 atmospheric and GHG mitigation, contributing to the efforts to avoid global warming (Bayer et al., 2006).

The aim of this study was to evaluate the impact of pasture management on the soil C stocks, focusing on the sustainability of livestock farming in Brazil. Carbon stocks and C accumulation rates were compared in the surface (0-30 cm) and in deeper layers (30-100 cm) of soil, having a native forest as reference.

Material and Methods

The study was carried out at Embrapa Pecuária Sudeste, São Paulo state, Brazil. Soil C was evaluated in pastures under two types of management in a milk production sytem in a dystrophic Red yellow Latossol (Oxisol): EXT - extensive with low stocking rate; IIR - intensively managed and irrigated with high stocking rate. The EXT pasture was composed of two paddocks (bloks), 3.0 ha each, containing *Brachiaria spp*. and *Cynodon nlemfuensis* Vanderyst, managed as continuous grazing systems, without fertilization. Pastures in IIR system were stablished with *Panicum maximum* Jacq cv. Tanzânia and overseeded with *Avena byzantina* cv. São Carlos and *Loliun multifloram* Lan. cv. BRS Ponteio, in autumn. The IIR system consisted of two similar 1.6 ha rotational systems, divided in 27 paddocks with 600 m^2 each, intermittently grazed, with a day of occupation and 26 days of rest. The intensive managed pastures were limed and fertilized with superphosphate and potassium chloride to achieve respectively, 20 mg $P.dm^{-3}$ and 4% K in soil CTC - cation exchange capacity. Nitrogen was applied at the rate of 600 kg $ha^{-1}year^{-1}$. Cows grazing all pastures received a dietary supplement (concentrate) formulated according to the NRC (2001) in the rate of 1 kg of concentrate per 3 kg of milk produced. All grazing systems were submitted to stocking rate adjustments using the “put and take” technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

Soil samples were collected in different depths: 0-5, 5-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm; with six replicates (three replicates/block) and two cores from each field replicate. Samples from each depth interval were collected using an aluminum ring of known volume and pooled for the subsequent evaluation of dry soil weight (105 ºC). Individual soil samples were air-dried and ground in a mortar to pass a 0.150 mm sieve. Carbon concentration was analyzed using CHN equipment. Carbon stock (Mg ha^{-1}) of each sample was calculated and corrected to an equivalent mass depth (Ellert and Bettany, 1996), using the native forest (Atlantic Forest) soil as reference. In addition, C accumulation rates in the 0-30 and 0-100 cm soil layers of each pasture were calculated. Data were analyzed by the SAS® (SAS Institute, 2002) program, using the Mixed Procedure.

Results

The type of pasture and the soil layer affected the C concentration (%) in the soils (Table 1). The concentration of soil carbon was higher in EXT, compared to IIR and the forest (FOR) which had similar concentrations. Carbon concentration was higher in the first layer (0-5 cm) of soil, decreasing as the depth increased. There was a pasture/soil layer interaction only for the depth of 0-5 cm, in which soil C concentration was higher in EXT (4.47%) than in IRR and FOR pastures (2.37 and 2.24%, respectively).

The type of grazing system did not affect the C stock variable. The soil layer influenced that variable. Carbon stock in the 0-100 cm layer was 121% higher than in the 0-30 cm layer, Sthal, et al. (2016) indicating that carbon stocks should be considered in layers as deep as 100 cm.

Table1. Soil carbon concentration (%) and stock (t ha^{-1}) in pastures under intensive and extensive managements, and in the native forest.

	Grazing System			Soil Layers (cm)									P Level		
Item	EXT	IIR	FOR	0-5	5-10	10- 20	20-30	30-40	40-60	60-80	80-100	SEM	Tre	Layers	TrexLayers
C (%)	1.6^a	1.3^b	1.3^b	3.1^a	1.9^b	1.4^c	1.3^d	1.1^e	1.0^f	0.8^g	0.8^g	0.06	0.0046	<0.0001	<0.0001
							0-30				0-100				
C (t ha^{-1})*	107.54	95.29	94.94	-	-		61.7^b	-	-	-	136.7^a	6.73	NS	<0.0001	NS

$^{a-g}$ means followed by different letters within a line are different ($p \leq 0.05$)SEM: standard error of the means; Tre: treatments; NS: non-significant ($P>0.05$); *Corrected stocks of carbon . EXT: extensive with low stocking rate; IIR: intensively managed and irrigated with high stocking rate; FOR: Atlantic Forest

Conclusions

Soil in pastures under extensive management may have higher C concentration than soils in intensively managed pastures and in tropical forests but C stocks may not differ between these areas. For pastures, it is important to consider the C stock as deep as 100 cm, in view of the large amounts of C that may be stored in depths below 30 cm in the soil.

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Assessment of soil carbon content in pastures with different managements

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Introduction

The Amazon region plays an important role in the global carbon cycle due to its land extension and amount of carbon stored both in the vegetation and in the soil (Aguiar et al., 2012). In the past 50 years, this region underwent an intense process of soil use change, thus studies investigating the carbon dynamics in agricultural and livestock production systems in the Amazon are of key importance.

It is observed that, in the current food production scenario, there are increasingly more public policies that foster agricultural and livestock activities than towards high-production systems that also promote environmental gains (Salton et al., 2011; Carvalho et al., 2014a).

This research aimed to investigate the dynamics of the soil carbon content in a native forest – poorly managed pasture – silvopastoral system chronosequence.

Material and Methods

The areas studied are located at Vitória Farm in Paragominas, state of

Pará, Brazil. The farm was established in the late 1960s, when part of the native forest was removed for the implementation of homogeneous pastures. By the 1990s, those pastures were suffering from agricultural degradation process (high infestation by weeds) and, in 2009, the area was overhauled, when the silvopastoral system was implemented in part of the land. The silvopastoral system is made up of the tree species *Schizolobium amazonicum* (Paricá) and by the forage grass *Brachiaria brizantha* cv piatã. Between 2009 and 2012, crop rotation with *Zea mays* x forage grass was performed in the system following guidelines of the no-tillage system.

The soil in the area is classified as high-clay dystrophic yellow latosol. The chronosequence investigated was as follows: remaining native forest (collection in 1992 by Camargo et al., 1997), pasture under agricultural degradation (collection in 1992 by Camargo et al., 1997), and pasture under silvopastoral system (collection in 2013).

Soil was collected from layers 0-10, 10-20, and 20-30 cm deep with three repetitions and the sites were selected away from the zone of interference of the trees' root system. The soil carbon content was assessed in a Carlo Erba elemental analyzer. Results were evaluated considering the different soil use systems and soil layers, through variance analysis (ANOVA) and mean comparison test Tukey at 5% probability, using the software SAS.

Results and Conclusions

When the degraded pasture (DP) area was compared to native forest (initial reference), significant carbon loss was found in the DP area due to poor management (Table 1). The carbon content in the 0-10 cm--deep-layer was statistically different between the silvopastoral system (SP) and the DP (Table 1). In the 10-30 cm-deep range, the results of the same systems were statistically similar, however, the SP system had higher absolute values than the DP.

Table 1. Mean C content (g kg^{-1}) in different soil management systems at Vitória Farm (Paragominas, PA, Brazil) between 1992 and 2013

	Soil use system		
Layer (cm)	NF	DP	SP
0-10	26.2 ± 0.13 A	22.4 ± 0.07 A	27.4 ± 0.18 A
10-20	17.3 ± 0.06 A	10.1 ± 0.03 B	12.8 ± 0.15 AB
20-30	9.0 ± 0 A	7.6 ± 0.07 A	10.5 ± 0.05 A

Means followed by the same letter in the line do not differ among themselves by the Tukey test ($\alpha = 0.05$); NF: Native forest; DP: Degraded Pasture evaluated in 1992; SP: Pasture under integrated Forest-livestock system with Paricá.

It is inferred that the pasture overhaul with soil fertility correction, adequation of the stocking rate, and incorporation of no-tillage planting for growing corn x forage grass (for three harvests) impacted the increase in soil carbon content in the area studied. It is important to point out that the integrated cultivation systems in no-tillage planting on straw leads to a greater increase in organic matter, which also benefits the soil's physical structure and favors the establishment of roots and water infiltration into the soil (Martorano et al., 2009).

Carvalho et al. (2014b), in a similar study, identified greater carbon stock in a crop- livestock area compared to a poorly managed homogenous pasture. Besides the benefits of the production system, agriculture and livestock integration systems also have the potential to control greenhouse gas emission from farming and ranching. According to Silva et al. (2014), the crop-livestock integration system can potentially act as a CO_2 sinkhole as long as the grazing intensity is correct. In turn, Salton et al. (2014) identified that the crop-livestock integration system had better productivity and environmental efficiency. Those authors also report that the system is recommended for the different regions of Brazil.

Overall, it was found that pasture overhaul and responsible management led to an increase in carbon content in the area. Therefore, multiplying information on effective soil management systems, as is the case observed at Vitória Farm in Paragominas, PA, Brazil, becomes necessary.

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Tradeoff between profitability and GHG emissions by beef cattle systems in Brazilian Amazon

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Introduction

The debate on the relationship between human activities and the growth in the emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere has brought the need to study more deeply the relationship between productive activities and the emission of these greenhouse gases (GHG) (FAO, 2013). Thus, the definition of what changes should be implemented in the production process aiming to reduce GHG emissions level should also consider the economic and social sustainability of the activity (SILVA *et al*, 2016).

Beef cattle in Amazon, as in most of Brazil, is also predominantly developed in an extensive manner (ALVIM *et al*, 2015). The North Region had in 2014 a cattle herd of 45,826,142 beef heads, which represented 22% of the whole national herd, with emphasis to State of Pará with 19,911,217 - 43% of the regional cattle (IBGE, 2016). The study on the effects of this activity on the environment and the search for alternatives to mitigate the negative impacts will enable the development of more sustainable livestock. The increase in the adoption of more sustainable livestock systems, especially from an environmental point of view depends on the establishment of incentives to producers and, therefore, it is essential to identify models which present these virtuous characteristics, as well as economic performance, in order to define strategies for this combination.

The analysis of the tradeoff between profitability and GHG emissions in agricultural systems can be used to reconcile economic performance and environmental performance at a given productive context, given the scarcity of resources and the need of making decisions about their use. This way, various scenarios can be simulated, in which the comparison between the economic and environmental performance of productive activities provides information for the definition of actions that seek to achieve the sustainability that embraces economic and environmental indicators (STOORVOGEL *et al.*, 2004).

This work aims to show comparatively the performance of economic profitability indicators and GHG emissions in the development of beef cattle activity in the Amazon, having as reference two types of production systems and two level of technology adopted in the State of Pará, which are located in the middle region Southeast Pará and micro region Paragominas, within the context of studies conducted by PECUS Network - Greenhouse gases (GHG) dynamics in Brazilian livestock production systems.

Material and Methods

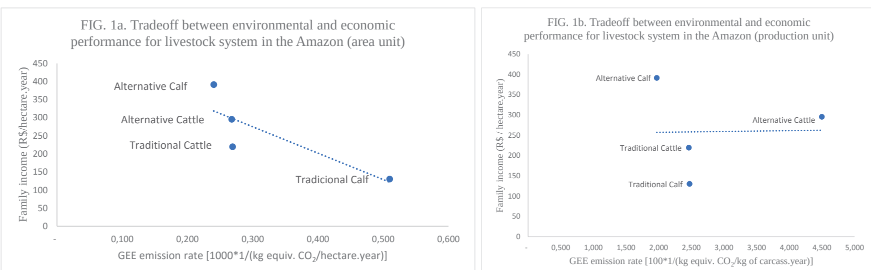
Four production systems in the micro region of Paragominas were evaluated, two systems considered modal and classified as traditional and two considered as alternative and with greater use of technology in the year 2014. Two models had as goal the production of calves (one traditional and other alternative) and the other two the production of live cattle, also with the two aspects. The economic evaluation was performed through the cost-benefit analysis and in accordance with the methodology shown in Guiducci et al. (2012), using as indicators, among others, the net income and the family income. It was considered the prices of inputs and products for the year 2014. For the calculation of GHG emissions it was used the Model Emissions PECUS v3.9.6 developed by the PECUS project team, with estimation of emission of GEE (CH_4 + CO_2 + N_2O converted for equivalent CO_2) as environmental indicator.

For comparison between the economic and environmental performance of systems, jointly, it was used the tradeoff method, which portrays the idea of compensatory exchanges between performances.

Results and Conclusions

The results presented here consider only the indicators "family income" as indicator of profitability and the "emission of GEE," as proxies for economic and environmental performance, respectively.

Figure 1 shows the relationships between economic and environmental performance for each of the evaluated systems. In Figure 1a, it was considered emissions per unit of area (viewpoint of farmers), the Calf Alternative System, for example, with the highest economic performance (higher profitability per hectare) and, on the other hand, the lowest environmental performance (lower rate of emission, i.e. greater volume of emission). At the other end, we see the Traditional Calf and the Fat Cattle Traditional systems with higher environmental performance but with lower economic performance. Similarly, it is established that the alternative systems presented higher economic performance and lower environmental performance while the reverse occurs with traditional systems.



Legend: ……… Trend line

FIGURE 1. Tradeoff between environmental and economic performance for livestock system.

However, Figure 1b, which considers emissions per unit of area (viewpoint of consumers), shows the system production with the highest economic performance and highest productivity, having also higher environmental performance. The trend line has positive slightly slope. These systems are alternative systems for calves and cattle.

These results indicate that considering the evaluated models and their assumptions, there is an inverse relationship between economic performance and environmental performance in beef cattle in Brazilian Amazon defined by the negative slope of the trend line in the chart (Fig. 1a - viewpoint of farmers as decision makers). From that, it is inferred the need of establishing compensatory measures to encourage the adoption of more appropriate systems in environmental terms, assuming that the economic performance is determining factor for the decision-making of producers concerning adoption of the kind of system. As a suggestion for new researches, there is the need for quantification of the compensatory measures to be adopted, aiming at the balance of costs and social benefits resulting of such measures, represented by the valuation of the tradeoffs between economic and environmental performance

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Appendix

Table 1-A. Emissions of GEE and profitability for year related to livestock systems in the Amazon

livestock system	kg Eqv. CO_2. / ha.year	kg Eqv.CO_2/ kg of carcass.year	Family Income (R$ / ha.year)
Tradicional Calf	1.960,85	40,46	130,15
Alternative Calf	4.162,49	50,75	391,27
Traditional Cattle	3.716,25	40,63	219,47
Alternative Cattle	3.734,91	22,23	295,37

Indicators of technological levels in milk production farms and impact on productivity of the factors

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Introduction

Milk production systems in Brazil are very heterogeneous regarding the use of production technology. In general, the technology used in a farm reflects both physical productivity of factors used and the economic results of the production process. In the case of physical productivity, three indicators may be used to compare the effect of the technological profile of differences between farms: animal productivity, labor productivity and the productivity of the land. Productivity gains are expected in these three indicators when intensifying production technology. The same should occur in a positive way with economic performance indicators. Otherwise, the technology is being applied properly in the productive process.

The present study aimed to evaluate the impact of technology of these indicators in milk- producing farms seeking to guide studies of mitigation of greenhouse gas emissions in dairy farming.

Material and Methods

To perform this study three typical farms of milk production was selected by extension workers of Emater/Paraná, specialists in dairy farms. The selection of the farms followed an approach known as Typical Farm Approach or Reference Production Systems (Hemme et al., 2015), methodology adopted by Embrapa to conduct socio-economic research on milk production farms (Stock & Carneiro, 2008; Stock et. al., 2008).

The farms are located in the Northwest of Paraná, in the municipality of São José da Boa Vista and represent three different technological profiles of dairy farms in that region: low, medium and high technology. Economics and technical coefficients was collect to represent each technology with the support of extension workers.

The estimation and analysis of costs and profitability of farms followed the standard methodology (Guiducci et al., 2012) adopted by the network of Pecus team. Three variables were chosen to indicate the technological level of the farms: area of land used for the dairy activity, amount of adult cows present in the herd and daily milk production. Two other indicators were chosen to represent the technological level: capital investment in the dairy activity and expenditure on feed concentrates. The productivity of the factors was indicated by the milk yield per cow, per acreage unit and per worker on the farm. The profitability indicators were the direct expenses per liter of milk produced and family income per acreage. The three farms were coded as S1, S2 and S3 according to the technological level represented respectively by low, medium and high.

Results and Conclusions

By compering those farms with typical dairy farms in other Brazilian States (Minas Gerais and Goiás, for example) the farms are not considered large in terms of acreage. However, they are representative in terms of land use that prevails in the Southern of Brazil.

The milk production per farm is higher than the average of production observed in other regions of the country as well as the yield per cow. The farm selected to represent the low technology system (S1) had a yield per cow of 17.1 liters, which is also higher than the national average of 4.3 liters/day, in 2014. The indicator variables of productivity and profitability factors, in general, showed an expected consistency (table 1).

Table 1. Indicators of size, productivity of factors and profitability of farms representing three technological levels observed in the Northwest of the State of Paraná.

		Milk production system		
Indicator	Unit	S1	S2	S3
Area occupied with the dairy activity	ha	17.1	25.4	20.6
Milk production	L/day	365	1,570	1,250
Adult cows in the herd	Head	21	82	50
Total investment in the dairy activity	R$/ha	51,644.00	73,836.00	90,376.00
Expenditure on concentrated feed	R$/cow/year	2,186.00	2,585.00	3,559.00
Herd productivity	L/cow/day	17.4	19.1	25.0
Land productivity	L/ha/year	7,814	22,552	22,148
Labor productivity	L/worker/day	243	349	417
Costs per litter	R$/L	0.76	0.78	0.87
Family income	R$/ha	4,004.06	10,578.70	10,617.05

The increase of operating capital (variable "total investment in the dairy activity"), represented by investments in land, herd, machinery and equipment, agreed with the expansion of productivity, especially animal yield.

By analyzing the farms from low to high technologies, the variables investment and yield per cow clearly showed a trend in the same direction, i. e. the higher the investment in the dairy activity the higher the animal yield. Similarly, if considered the costs of feed (variable "expenditure on concentrated feed") as an indicator of technology and comparing with the animal productivity, a consistent path between the two variables is observed as well.

Labor productivity was another indicator consistently impacted by investment in the dairy activity and expenditure on concentrated feed. The productivity of land was similar in the farms of medium and high technologies (S2 and S3). However, by comparison both S1 and S2 with the low-tech farm (S1) it can be observed that the impact was significant and consistent in this productivity factor. The profitability indicators showed that medium-and high-tech farms produced more family income per acreage than the low-profile technological farm. On the other hand, the expenses were similar in the two farms of lower technology (S1 and S2), but higher in the S3 farm. This seems an expected behavior, considering the hypothesis that farms with higher technology are also those that present higher production scale (milk production in the case). However, they increase the total income from the farm to the extent that technological investments increase the scale of production. In this case, then, lower margin provides more total income resulting from the increased scale of production.

This exploratory study found that stepping up technological indicators lined up with gains in productivity indicators and total profitability in milk-producing farms. The gain of scale, as expected, seems to be an important strategy to increase the total profitability of the dairy activity, although the net margin from each unit produced has been descending with technological intensification. Studies with a larger sample of farms with similar production system may confirm this statement.

For further research in this direction, other quantitative and qualitative indicators of technical and economic performance could be considered, making possible to use the data in simulations and complementary sensitivity analysis and greenhouse gas mitigation.

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Typifying beef cattle producers in Brazilian biomes

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Introduction

According to the 2006 Agricultural Census, Brazilian cattle production encompasses over 170 million heads on approximately 150 million ha of grasslands (IBGE, 2015), placing the country as the second largest bovine herd worldwide. The objective of this study was to show the variability of beef cattle in the country, grouping producers into homogeneous groups according to their production characteristics. Knowing these groups and the differences among them is essential for research, development, technology transfer and appropriate public policies.

Material and Methods

Special tabulations were performed by IBGE to meet the objectives of the study. Data from holdings in the Agricultural Census 2006 were filtered for holdings with beef cattle herd of over 500 heads for the Pantanal and over 200 heads for all other biomes. The selected data used for the analysis cover a large proportion of the national beef herd, including 88% of the "Cerrado", 86% of the "Amazônia", 77% of the "Mata Atlântica", 82% of the "Pampa" and 95% of the "Pantanal".

Fifteen variables from Census questionnaire were created covering the following production aspects for each holding: main activity (cow-calf, stocker, finishing and combinations); technological and intensification levels (stocking rate, natural and sown pastures, fertilization of pastures, use of concentrated feed, feedlot, insemination and technical assistance); degree of diversification (percentage of the holding used land area allocated to pastures, crops, planted forests and agroforestry systems); economic importance of beef cattle (share of the total production value) and herd size (live weight). The holding used land area was defined as the sum of areas for crops (temporary and permanent), pastures (natural and sown), planted forests and agroforestry systems. In some cases, other variables were added to represent a biome specific characteristic.

Factor analysis was applied to the variables selected in order to identify unobservable factors that represented the diverse characteristics of producers from each biome. Then, the factors with the most significant contributions to explain the total variability of the information were used as the classification criteria of producers in relatively homogeneous groups by cluster analysis.

Results and Conclusions

The clusters found for beef cattle producers in each biome are described below.

Cerrado: In 2006, 33% of Brazilian beef cattle holdings were in the Cerrado biome, occupying 43% of the Brazilian area of pastures with 40% of the Brazilian beef cattle. Six groups were identified, four of them specialized in beef cattle with the following characteristics: i) holdings with a full cycle on grass, with some sale of calves and steers and intermediate technological level (46% of the holdings, 43% of the pasture area and 42% of the herd of this biome); ii) holdings with predominance of stocker and finishing phases on grass, low technological level (25% of holdings, 20% of the pasture area and

19% of the herd); iii) mostly holdings for cow-calf, low technological level (16% of holdings, 13% of pasture area, 11% of the herd); iv) large holdings for full cycle process on grass, with higher technological level (5% of the holdings, 20% of pasture area, 22% of the herd). The holdings non- specialized in beef cattle (full cycle production) shared their area between grass and crops or forestry, accounting for just over 8% of the holdings, 4% of the pasture area and 6% of the herd.

Pantanal: The Pantanal was responsible for 1% of Brazilian holdings for beef cattle, 7% of the pasture area and 3% of the herd, according to the 2006 Census. Seven groups were found, two of them dedicated to extensive cow-calf and stocker, representing together 66% of the holdings, 64% of pasture area and 52% of the herd. Three groups were identified as full cycle holdings and showed marked technological gradient, especially in regard to pasture management: i) large extensive holdings, with a predominance of natural pasture and some sown pastures, but without the use of fertilizers (7% of the holdings, 21% of the of pasture area, 29% of the herd); ii) holdings with predominance of sown pasture not degraded and fertilizer use (3% of holdings, 2% of the pasture area and 3% of the herd); iii) smaller holdings that combine a full cycle production with crops, forests and agroforestry systems (2% of holdings, less than 1% of the pasture area and 1% of the herd). There was also holdings dedicated to stocker-finishing and finishing on grass that accounted for 20% of the holdings, 12% of the pasture area, and 14% of the herd. The presence of stocker and finishing or full cycle beef systems in the Pantanal is linked to higher elevation areas (the “Pantanal plateau”), which concentrate the sown pastures, most of which is in transition zones for the Cerrado. Analysis of geomorphology (ASSINE *et al*., 2015) and vegetation (SILVA *et al*., 2007) maps combined with the IBGE’s map of the Pantanal biome supported the results of the typology.

Amazônia: This biome holds 25% of beef cattle holdings, which held 24% of the pasture area and 28% of the herd for this activity in 2006. For this biome six groups were considered representative: i) low-tech holdings dedicated to full cycle with some selling of calves (61% of the holdings, 60% of the pasture area and 60% of the herd); ii) low-tech holdings for finishing on grass (19% of the holdings, 18% of the pasture area and 14% of the herd); iii) full cycle production on holdings with diversified production, areas of equivalent size for crops and pastures, with the presence of planted forests and agroforestry systems (7% of the holdings, 3% of the pasture area and 5% of herd); iv) full cycle, low technology, smaller herd (9% of the holdings, 6% of the pasture area and 6% of the herd); v) full cycle with higher technological level, especially fertilization of pastures and technical guidance of producers (5% of the holdings, 10% of the pasture area and 10% of the herd; and vi) large holdings with intermediate technology, full cycle, buying calves (0.2% of the holdings, 4% of the pasture area and 5% of the herd).

Mata Atlântica: This biome holds 29% of the holdings, 16% of the pasture area and 21% of the Brazilian herd in 2006. Seven groups were found: i) full cycle on grass, lower technology (34% of the holdings, 39% of the pasture area and 37% of the herd); ii) full cycle on grass with higher technological level and larger herds (5% of the holdings, 14% of the pasture area and 15% of the herd); iii) holdings with full cycle and diversified production, combining crops and beef cattle (12% of the holdings, 6% of the pasture area and 9% of the herd); iv) holdings with diversified production combining planted forests and the full cycle (0.5% of the holdings, 0.3% of the pasture area and 0.4% of the herd); v) cow-calf and stocker production systems, lower technological level (22% of the holdings, 18% of the pasture area and 16% of the herd); vi) low-tech finishing systems on grass (24% of holdings, 22% of the pasture area and 20% of the herd); vii) finishing with feedlot (3% of the holdings, 2% of the pasture area and 3% of the herd).

Pampa: The Pampa represented 6% of the holdings, 6% of the pasture area and 5% of the Brazilian beef cattle herd in 2006. All the groups for this biome included the presence of crops, characteristic of production systems of this biome. On average, 13% of the areas were designed to crops. Three groups were more representative, all with a predominance of natural pasture and total area of pasture about 90% of the holding used land area: i) full cycle on grass, with intermediate technology (41% of the holdings, 52% of the pasture area and 52% of the herd); ii) low-tech holdings for cow-calf and cow-calf - stocker on grass (25% of the holdings, 23% of the pasture area and 22% of the herd); iii) finishing on pasture, low-tech (15% of holdings, 13% of pasture area and 11% of the herd). A fourth group (full cycle and finishing) presented crop area similar to pasture area (46% and 48% of the holding used land area, respectively) and better technological level compared to the groups above (12% of the holdings, 7% of the pasture area and 9% of the herd). Three smaller groups had the highest technological levels: i) holdings with full cycle and diversified production, with crops, planted forests and agroforestry systems (2% of the holdings, 2% of the pasture area and 2% of the herd); ii) finishing with feedlot (2% of the holdings, 1% of the pasture area and 2% of the herd); and iii) production of full cycle with a significant presence of fodder for cutting (2% of holdings, 0.5% of the pasture area and 1% of the herd). The last group was composed by holdings performing full cycle with degraded pastures that would require greater efforts for fertilization (1% of the holdings, 1% of the pasture area and 1% of the herd).

Experts considered that this typology represented the Brazilian beef cattle production systems appropriately.

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Changes in the economic and environmental performance assessment of beef cattle production systems on natural grassland in southern Brazil

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Introduction

The increased concentration of greenhouse gas (GHG) in the atmosphere is a global concern. Starting in the last decade, studies and debates about the contribution of beef cattle production to greenhouse gases have intensified, mobilized by different institutions; among them, universities, farmers associations, public figures, the media in general, as well as the Intergovernmental Panel on Climate Change (IPCC). Some recent studies have demonstrated that higher or lower methane production depends fundamentally on the conditions of the production system (Genro et al., 2014; Moscat, 2015).

In addition, the interest sparked by this topic has fostered the necessity for mitigation systems evaluations that integrate economic and environmental performance. These evaluations have the goal of determining if systems that are capable of mitigating the emission of greenhouse gases are also economically feasible. The tools and strategies that are expected to be utilized by producers should be economically sustainable, otherwise, they run the risk of not being implemented (Berndt, 2010).

The objective of this study was to analyze the economic and environmental performance of pasture production systems with different levels of intensification in backgrounding and finishing cattle in southern Brazil in 2015 and 2016. This information will be able to provide important guidelines for farmers making decisions on greenhouse gas mitigation systems and understand its evolution over time.

Material and Methods

The experiment was conducted in an area belonging to Embrapa South Livestock, located in Bagé, Rio Grande do Sul--under the purview of Pecus Network-- during 2013. Economic analysis used current (May 2015) fat cattle prices (R$ 5,40 kg LW^{-1} and costs. Nine paddocks , approximately seven hectares in size, located in a grassland area were used. Three paddocks were assigned to each of three treatments: natural grassland field (NG); natural grassland with nitrogen fertilizer (NGF); natural grassland with nitrogen fertilizer and overseeding of two hibernal species: ryegrass (*Lolium multiflorum*) and red clover (*Trifolium pratense*) (NGFS). In all the treatments, the pasture was managed in order to maintain the fodder supply at 12% (12 kg of dry matter/100 kg live weight). For this, three Hereford steers were used in each paddock, where methane emission evaluations were conducted. In addition, sufficient animals were used to maintain the forage supply at 12%. The average annual capacity of the paddock, including the regulator animals, was nine animals (NG), 12 animals (NGF) and 13 animals (NGFS). Methane emissions by the animals were measured using the sulphur hexaflouride marker technique, over a five day period, in all seasons of the year (starting on January 21, June 5, July 22, and October 28). Methane samples were collected in the proximity of the animals' noses with the assistance of regulatory air intake valves, and stored in stainless steel tubes. Data relative to pasture management and animal health conditions were collected in the same fashion during the experimental period. The economic analysis of the emissions was obtained by relating the gross margin and the methane emission per hectare. This emission/benefit relation allowed for the measurement of economic return for each gram of methane emission in each of the three studied systems, taking into consideration the effective operational costs and payments to outsourced mechanized services.

Results and Conclusions

Lower methane emissions by area occurred in the NF system with lower meat production per hectare, with a value of 97.32 kg of CH_4/ha/year. However, if we analyze the methane production per kilo of live weight gain (LWG), the lowest observed value was in systems with higher intensification (Table 1). This demonstrates that methane emission per kilo of LWG is lowered with system intensification (Genro et al., 2014).

Table 1. Stocking rate values (kg LW ha^{-1}), live weight gain per area (kg LW ha^{-1} $year^{-1}$), methane emission by live weight gain (g CH4 kg LWG^{-1} day^{-1}), gross margin per area (R$ ha^{-1} $year^{-1}$) in each of the three systems in 2015 and 2016.

	Stocking rate (kg LW ha^{-1})	Weight gain (kg LWG ha^{-1} $year^{-1}$)	CH_4 emission (g CH_4 kg LWG^{-1} day^{-1})	Gross Margin (R$ ha^{-1} $year^{-1}$) 2015	Gross Margin (R$ ha^{-1} $year^{-1}$) 2016
NG	423	123	0.79	103,90	133,00
NGF	583	228	0.49	201,50	184,20
NGFS	628	310	0.43	416,00	307,00

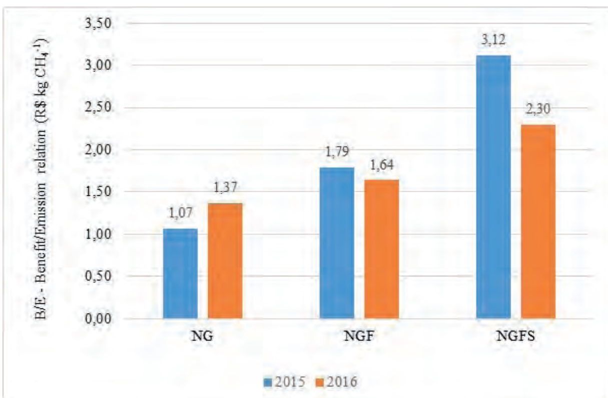

Figure 1. Comparison the changes the Benefit/Emission relation (R$ kg CH4-1) in natural grassland field (NG); natural grassland with nitrogen fertilizer (NGF); natural grassland with nitrogen fertilizer and overseeding of two hibernal species (NGFS) between 2015 and 2016.

The improvement in environmental performance obtained with intensification also resulted in an improvement in economic performance. There was an increase in economic return per hectare with fertilization and enhancement of natural grassland as compared to NG. The relation between financial benefit and the emission of one kg of methane is better to NGFS. If a farmer sought the same profit, but decided not to invest in increasing productivity, on average, this decision would double the amount of methane emissions for the same meat production. It should be noted that the advantages of intensification may be even greater when the soil carbon balance is considered in the economic analyses (Berndt, 2010). However, due to rising costs although there was an increase in prices received by producers the advantage of NGF and NGFS systems decreased

The use of fertilization and the introduction of hibernal species to native grasslands has been shown to be sustainable both in terms of methane emission per kilo of live weight, as well as in productive and economic terms per hectare and in terms of the cost/benefit relation of emissions. However, an important research topic is to understand how is the relationship between prices received and prices paid by producers and emissions in different systems. Perhaps there is a limit, a relationship between inputs and products that stimulate or not to intensify systems.

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Resumos

Nelore cattle methane emissions in native and cultivated pastures of the Pantanal at the end of the rainy season.

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Introduction

The Pantanal has numerous fields of native pastures with natural ability for beef cattle production, especially for the phase creates. Due to weather conditions and the playback time of establishment, the births are concentrated during the rainy season. The implantation of cultivated pastures aims to improve the diet of cows, causing an increase in reproductive performance of the herd. This study aimed to measure rates of methane emission of beef cows in the conditions of native or mixed pasture (cultivated and native) Pantanal.

Material and Methods

Twelve calved cows containing rumen sulfur fluoride capsules ($SF6$) known flow, were randomly assigned to two treatments with six replications, and placed in areas with native or cultivated pastures, the Experimental Farm Nhumirim (Embrapa Pantanal). Methane emission rates were estimated from the concentration of the tracer gas $SF6$ according to the technique described by Johnson et al., 1994. The samples were collected between March 23 and April 12, 2015, after the animals They were subjected to a period of 14 days of adaptation. The data were subjected to variance analysis (F test) for the data dispersion treatment and the Student's t test.

Results and Conclusions

It was observed that the emission of methane showed high variability ($P < 0.05$) between animals of the same treatment, but no differences ($P > 0.05$) between them (Table 1). The daily variations may be related to environmental issues (climate variability) and differences in diet quality between grazing sites, since the paddocks where animals graze large areas, regular feature of the region.

Table 1. Means of methane emissions in mixed and native pastures of the Pantanal.

	Pastures		P
Methane emissions	Mixed	Native	
Per animal (g/dia)	295,85[a]	322,57 [b]	0,5308
Animal variation – Test F (P value)	0,0011	0,0053	-

Means followed by different letters in the same line differ statistically.

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Soil GHG emissions in different livestock production systems in the Brazilian Cerrado

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Introduction. Greenhouse gas emissions are mainly associated with changes in land use in Brazil, especially the conversion of forests to pasture or agricultural systems. The objective of this study was to evaluate soil metane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) in three production systems.

Material and Methods. The study was conducted in a Oxisol, on a long-term experiment at the National Center of Beef Cattle Research, Campo Grande, MS, Brazil. Treatments were: continuous *Brachiaria decumbens* cv Basilisk without maintenance fertilization (CPWF); integrated crop-livestock with forage *Brachiaria brizantha* cv BRS Piatã, with annual maintenance fertilization, plus eucalyptus trees rows of 22 x 2 m (ICLF) and integrated crop- livestock with forage *Brachiaria brizantha* cv BRS Piatã, with annual maintenance fertilization and no trees (ICL). Five replications inside two blocks were utilized for measurements. An adjacent area with natural vegetation of Cerrado (Savanah) was evaluated as reference (CER). Soil GHG emissions estimates were performed from February 2014 to April 2015, reaching 13 sampling times. Gases fluxes were measured by static chambers technic. The soil gas flux rates were calculated for each chamber from the linear increase in headspace gas concentration over the sampling time. Results were evaluated by ANOVA procedure and Tukey test ($P < 0,05$).

Results and Conclusions. The total cumulative annual N_2O emission from grazing systems was higher in ICLF, followed by ICL, CER and CPWF. The lower emission in CPWF may be related to the non-supply of nitrogen fertilization in this system. For CH_4, ICL has the system with higher emission, which may be associated with higher soil moisture content, when compared to CPWF and ICLF systems, and CER. The CO_2 emissions were higher for ICL, followed by ICLF and CPWF, and smaller in CER, probably due to greater natural stabilization of the carbon in this system. Higher emissions of CO_2 in ICL may represent a higher flow in the dynamics of soil organic matter, and not necessarily loss of soil carbon.

Table 1. Cumulative annual average emissions of N2O, CH4 and CO2, and soil moisture in different crop and livestock production systems, and native vegetation of Cerrado (Savanah).

Treatment	N_2O-N, mg m^{-2}	CH_4-C, mg m^{-2}	CO_2-C, g m^{-2}	Soil moisture, %
CPWF	6 **c**	43 **b**	1660 **b**	16 **b**
ICL	44 **ab**	491 **a**	2666 **a**	26 **a**
ICLF	68 **a**	-108 **b**	1783 **b**	18 **b**
CER	42 **b**	-441 **c**	1076 **c**	24 **a**

*Means followed by the same letter in the column do not differ by Tukey test ($P > 0.05$).

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Methane emissions per area from Holstein and Holstein/Jersey dairy cows in two different grazing systems –preliminary results

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Introduction

The increase in greenhouse gases in the atmosphere is a widely discussed topic, with methane (CH_4) generally mentioned as a gas with a global warming potential 25 times greater than carbon dioxide (CO_2) (IPCC, 2006).

In Brazil, CH_4 emission from enteric fermentation in the dairy sector is estimated to produce 12% of total CH_4 emission from agriculture (MCTI, 2014). Suggestions to reduce CH_4 emissions per area include the adoption of cultivated pastures and the improvement of native pastures, increasing the carrying capacity of grazing areas with the consequent increase of stocking rates and productivity in animal production systems (Oliveira et al., 2015).

Therefore, the aim of this study was to estimate CH_4 emissions per ha from **Holstein and Holstein/Jersey** lactating dairy cows in two grazing systems..

Material and Methods

The experiment was conducted at Embrapa Southeast Livestock, using 24 lactating dairy cows (12Holstein and 12Jersey-Holstein cross) in a 2 x 2 factorial design with two pasture systems: extensive with low stocking rate - EXT - and intensively managed and irrigated with high stocking rate - IIR. Evaluations were carried out during the total lactation period of the cows (270 d).

Cows received a dietary supplement formulated according to the NRC (2001), in a rate of 1 kg of concentrate per 3 kg of milk produced. The EXT system consisted of two paddocks of 3.0 ha each, containing a misture of *Brachiaria spp*. and *Cynodon nlemfuensis* Vanderyst, managed as continuous grazing systems. The IIR system was cultivated with *Panicum maximum* Jacq cv. Tanzânia and overseeded with *Avena byzantina* cv. São Carlos and *Loliun multifloram* Lan. cv. BRS Ponteio, in autumn. The IIR system consisted of two similar 1.6 ha areas managed as rotational grazing systems. Each area was divided in 27 padocks, with 600 m^2 each, intermittently grazed, with a day of occupation and 26 days of rest.

All of the grazing systems were submitted to stocking rate adjustments using the “put and take” technique (Mott and Lucas, 1952) and visual evaluation of forage availability.

The sulfur hexafluoride tracer technique, as described by K. A. Johnson and D. E. Johnson (1995), adapted by Primavesi et al. (2004) and improved by Berndt et al. (2014), was used for determination of enteric methane from the cows,. Measurements were performed three times during the lactating period (in winter, spring and summer).

Total CH_4 emissions were calculated per hectare (kg CH_4 ha^{-1} per 270 d lactation), according to genotypes and grazing system. The CH_4 emission factors for total milk yield (MY) and 3.5% fat corrected milk

(FCM) per ha were calculated by dividing the total CH_4 emission per ha by MY and FCM, respectively. Data were analyzed by the SAS® (SAS Institute, 2002) program, using Mixed Procedure.

Results

Annual average stocking rates were 1.9 and 2.1 animals ha^{-1} in EXT and 6.6 and 7.9 animals ha^{-1} in IIR, for Holstein and Jersey-Holstein breeds, respectively. Milk yield did not differ between breeds (mean of 34.7 kg d^{-1}). Total methane emission per ha was higher in IIR (379.4 kg ha^{-1}) compared to EXT (97.7 kg ha^{-1}) ($P<0.0001$), however, CH_4 emissions per milk yield (mean of 18.0 g kg MY^{-1})) and fat corrected milk production (mean of 18.8 g kg FCM^{-1})), did not differ between the grazing systems. The CH_4 emissions per hectare (kg ha^{-1}) were not affected by genotype ($P=0.2160$). However, Jersey-Holstein cows emitted less CH_4 per MY^{-1} ($P=0.0307$) and per FCM^{-1} ($P=0.0949$) than Holstein cows (Figure 1).

In the winter, CH_4 emissions per ha (147.62 kg ha^{-1}, P=0,0004), per MY (14.39 g kg MY^{-1}, P=0,0003) and per FCM (14.47 g kg FCM^{-1}, P=0,0004) were lower than in spring (323.95 kg ha^{-1}, 19.33 g kg MY^{-1} and 20.51 g kg FCM^{-1}, respectively) and summer (244.09 kg ha^{-1}, 20.28 g kg MY^{-1}, 21.47 g kg FCM^{-1}, respectively). It was observed interaction between season and grazing system for total CH_4 emissions per ha ($P=0.0023$). The total emission was higher in IIR system than in EXT in all seasons but the difference was smaller during the winter.

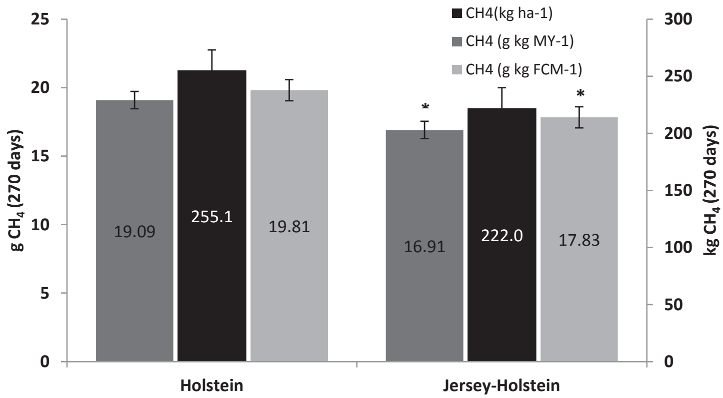

Figure 1. CH4 emissions from lactating dairy cows according to genotype (Holstein vs Jersey- Holstein) during 270 days of lactating.

Conclusions

It may be concluded that the higher methane emission per area in intensively managed grazing systems is compensated by the higher milk productivity in these systems, resulting in CH4 emission per kg of milk produced not different compared to less intensive systems. In that sense, intensifying milk production may attend the growing demand for milk without the opening of new areas, avoiding deforestation.

Additionally, Jersey-Holstein cows seem to be an alternative to reduce CH4 emissions, emitting less CH4 per kg of milk produced than Holstein cows.

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Methodological proposal to evaluate the potential of carbon sequestration

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Introduction

Pastures in Brazil represents an area of 151.519.048 million of hectare (MMA, 2007). Some studies prove that a pasture area with proper management can sequester more carbon from the atmosphere than in some areas of native vegetation in the Cerrado biome (Bustamante et al., 2006). The soil is a key component in the process of emission and sequestration of carbon from the atmospheric. According to Tarré et al., 2001, productive pastures areas, i.e, those in which there is no degradation indicate that the dynamics of soil organic carbon system is intense and thus the stock of carbon covered by grassland soils may have increased over the years and even be higher than the natural vegetation.

Material and Methods

The Rio Vermelho watershed inserted in Cerrado biome, in the western portion of the state of Goiás, it occupies an area of approximately 11,000 square kilometers, is the main basin of the right bank of the contribution of the Araguaia River. In this area were collected data soil using a cylinder about 5 cm in the layers 0-5, 5-10, 10-20, 20-30 cm deep, the first and second area were of savanna and pasture in inceptsoil (cambisols).

Results and Conclusions

Table 1 is the result of the analysis of soils in Cerradão area, is evident a higher content of organic matter in the initial layers and tends to decrease the topsheet 0-5 for the backsheet collection 20-30 this area corresponds to an inceptsoil, which has a higher content of sand, than silt and clay. In the pasture area in the same class of soil bulk density varied 1.43 to 1.16 g/cm^3.

Table 1.Data from laboratorial analyses of the Cerradão area.

<table>
<tr><th>Municipality</th><th>Seq N.</th><th>Description</th><th>Soil Class</th><th>Geology</th><th>Relief</th><th>Layer of soil (cm)</th><th>Density (g/cm^3)</th><th>Clay %</th><th>Silt %</th><th>Sand %</th><th>O.M %</th></tr>
<tr><td>Goiás</td><td>1</td><td rowspan="4">Cerradão</td><td rowspan="4">Inceptsoil</td><td rowspan="4">granite</td><td rowspan="4">Flat</td><td>0-5</td><td>1.59</td><td>23.0</td><td>17.0</td><td>60.0</td><td>3.0</td></tr>
<tr><td>Goiás</td><td>1</td><td>5-10</td><td>1.43</td><td>30.0</td><td>14.0</td><td>56.0</td><td>1.3</td></tr>
<tr><td>Goiás</td><td>1</td><td>10-20</td><td>1.53</td><td>33.0</td><td>16.0</td><td>51.0</td><td>1.3</td></tr>
<tr><td>Goiás</td><td>1</td><td>20-30</td><td>1.46</td><td>35.0</td><td>18.0</td><td>47.0</td><td>0.7</td></tr>
</table>

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Enteric methane emissions by goats in grazing in caatinga

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Introduction

Caatinga is an important food source for the animals of the semi--arid region, but the low quality forage at certain times of year limits animal performance and increases the emission of methane gas. Thus, the objective of this study was to evaluate the forage intake and emission of methane by goats fed grassland savanna during two periods of the year.

Material and Methods

The study was conducted at Semi-arid Embrapa in dry and rainy seasons with 24 female goats grazing in Caatinga. On dry season, the animals received concentrated feed supplementation. The animals received titanium dioxide indicators of fecal output. We used ruminal emptying technique (SANTOS, 2008) for determining chemical composition and digestibility of diet. Dry matter intake, organic matter intake and crude protein intake were calculated. The methane was measured using methodology proposed by Johnson and Johnson (1995).

Results and Conclusions

Dry matter and organic matter intake were higher in the dry season, while the crude protein intake was similar between the two periods. There was no difference in relation the methane production. Supplementation probably contributed to improve the intake of animals at the period when forage availability is reduced. The quality of provided supplementation helped to improve the feed efficiency of the animals during the dry season.

Table 1. Intake and methane emissions by goats grazing Caatinga

Parameter	Dry season	Rainy season	VC(%)
DMI	735,99a	606,16b	25,21
OMI	655,92a	547,25b	25,13
CPI	113,44	110,93	25,40
	Methane emissions		
g/day	50,81	18,23	3,37
kg/year	11,12	11,12	0,5
g/kg DMI	75,19	43,26	3,62

DMI- dry matter intake; OMI – organic matter intake; CPI – crude protein intake; VC - variation coefficient. Means followed by different letters in the line represent difference by Fisher test ($p < 0.05$).

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To Embrapa and CAPES.

Enteric Methane Emissions from crossbred cattle from different breeds of bulls in confinement

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Introduction

At present there is a need to increase the productivity of systems due to an increasing demand for food and a shrinking area available for agricultural production. One solution is confinement of livestock and the use of genetic groups that are more efficient at transforming feed into product (meat). Feed efficiency may be related to enteric methane emissions, which generate energetic losses when produced by the animal. The objective of this study was to measure enteric methane emissions from crossbred cattle bred from different breeds of bulls.

Material and Methods

The study used 44 crossbred animals, in confinement, bred from females of the Nelore breed and ½ Angus + ½ Nelore and ½ Senepol + ½ Nelore crosses, produced in terminal crosses with three breeds of bulls: 17 Angus offspring, 15 Canchim offspring (artificial breed 5/8 Charolais) and 12 Charolais offsping, raised on pasture and finished in confinement. A feedlot was provided, with automated troughs (GrowSafe system) that measure daily dry matter intake. The diet consisted of 40% concentrate and 60% roughage, with 71% TDN, 13.1% CP and 51.8% DM. Methane emissions were measured using the GreenFeed system. Data was analyzed using the MIXED procedure of SAS and averages were compared using Tukey's test, with significant differences at $p < 0.05$.

Results and Conclusions

The Canchim breed presented lower values for average daily gain (ADG) when compared with the Angus breed. However, statistical differences were not observed for the variables related to enteric methane emissions. It may be concluded that that there were no differences between the breeds of bulls used for crossbreeding in terms of enteric methane emissions, despite the differences in consumption and weight gain.

Table 1. Weight gain and methane emission variables for different breeds of bulls used in the terminal crossbreeding.

	Bull Breed			
	Canchim	**Angus**	**Charolesa**	***P***
ADG (kg/d)	1.638 ± 0.06^{b}	2.033 ± 0.06^{a}	1.882 ± 0.07^{ab}	*<.0001*
CH_4 (g/d)	152.4 ± 6.39	171.6 ± 6.00	170.4 ± 7.14	*0.0701*
CH_4ADG (g CH_4/kg ADG)	94.33 ± 4.14	84.97 ± 3.89	92.03 ± 4.63	*0.2404*

$^{a, b}$ Different letters in the same row differ (p < 0.05) according to the Tukey test. ADG: average dairy gain, CH4: methane.

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Concentration and Emission Factors of Greenhouse Gases and Ammonia in swine Gestation Rooms

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Introduction

Brazil is the world's fourth major swine producer, holding most production in the south region. This study monitored ambience and gaseous emissions in swine gestation rooms located in Concordia, Santa Catarina, where 12,5% of the sow herd is concentrated.

Material and Methods

In five weeks, from August to September 2014, naturally ventilated gestation rooms (box + stall) were monitored: daily, for temperature and relative humidity (using TESTO 174H data-loggers) and weekly, for air velocity, relative humidity, temperature (using a high precision probe TESTO 435) and gaseous concentrations (using air pumps and TEDLAR® bags), as described in ROBIN et al. (2006) and ROBIN et al. (2010). Feed and manure samples were collected weekly and daily water consumption was measured according to TAVARES (2014). Photo-acoustic reading of gas samples was carried in INNOVA 1412. Feed and manure were analysed according to the *Standart Methods.* Emission factors were quantified with respect to the concentration differences.

Results and Conclusions

Table 1 –Concentrations inside and outside de rooms (ppm)

Lodging	CO_2	NH_3	N_2O
Box	969,6	4,8	0,434
Stall	990,9	6,6	0,434
Outdoor	508,9	0,9	0,364

Table 2 – Emission factors inside the rooms (g animal^{-1} day^{-1})

Lodging	N_2O	NH_3	N	CO_2	CH_4	C
Box	0,4	7,3	7,7	743,9	16,9	760,8
Stall	0,5	12,1	12,6	919,9	11,7	931,6

Concentrations and emission factors were generally higher in stalls, respected legal thresholds and were in accordance with literature data.

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Enteric methane emissions from Angus steers during grazing and feedlot in Southeast Buenos Aires Province, Argentina

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Introduction

Methane emissions (CH_4) from ruminants depend on the dry matter intake (DMI) and quality of the diet. The aim of this study was to obtain local emission factors of CH_4 from grazing steers in two seasons of contrasting pasture quality and during the finishing period.

Material and Methods

Methane was quantified using a modified SF_6 tracer technique of 5 continuous days of sample collection (Berndt et al., 2014). Live weight and CH_4 were measured from 18 Angus steers during spring and summer grazing, and during finishing at INTA EEA Balcarce, Argentina. Steers grazed a mixed pasture of *Festuca arundinacea* and *Medicago sativa* in rotational daily allocation. Individual DMI was estimated (NRC, 1996) during grazing and measured (offered - refused feed) during finishing. On that period steers were fed a high concentrate diet of corn grain, corn silage, sunflower expeller, mineral salt, and urea (68, 23, 6, 2.2, and 0.8% of DM, respectively). Results were analyzed with ANOVA and Tukey test ($P = 0.05$).

Results and Conclusions

The *in vitro* DM digestibility (DMD) was 78.4, 67.9, and 75.9% for spring, summer, and finishing diets, respectively. A 10% lower DMD in summer resulted in 17% higher CH_4 in g/day ($P<0.05$; Table 1). Average CH_4 (g/d) produced during summer grazing was 39% higher than the finishing period ($P<0.05$; Table 1). Although relative differences between periods were as expected, absolute results of CH_4 were higher than reported previously for this type of animals and feeds. The cause of this difference is under study.

Table 1. Performance characteristics and methane (CH4) emission (mean ± SEM) from Angus steers during grazing and finishing.

	[1]LW, kg	[2]LWG,kg/day	CH_4, g/day	[3]DMI,kg/day	CH_4, g/kgDMI	[4]Ym
Spring	246 ± 6.7 [a]	0.9 ± 0.05 [a]	189.8 ± 11.1 [a]	7.0 ± 0.1 [a]	26.5 ± 1.3 [b]	0.080 ± 0.004 [b]
Summer	271 ± 6.9 [b]	0.7 ± 0.04 [a]	229.3 ± 6.8 [b]	8.3 ± 0.1 [b]	27.2 ± 0.7 [b]	0.082 ± 0.002 [b]
Finishing	341 ± 8.3 [c]	1.3 ± 0.07 [b]	164.4 ± 9.6 [a]	10.2 ± 0.2 [c]	16.1 ± 0.9 [a]	0.048 ± 0.003 [a]

Within columns, mean values with different letter differ ($P<0.05$). [1]LW: live weight; [2]LWG: LW gain; [3]DMI: dry matter intake; [4]Ym: lost of gross energy intake as CH4.

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N_2O and CH_4 emission from cattle excreta in two livestock production system in Brazilian Cerrado

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Introduction. Urine and dung deposited by cattle on pasture are important sources of greenhouse gases such as nitrous oxide (N_2O) and methane (CH_4). Our objectives were to determine the impact of excreta type, seasonal climate and livestock production system on soil N_2O and CH_4 emissions.

Material and Methods. The study was carried out in a clayed Oxisol, on a long-term experiment at the Embrapa Agropecuária Oeste, Dourados, MS, Brazil, with *Brachiaria decumbens* integrated with crop each two year (ICL) and permanent pasture of *B. decumbens* without fertilization (PP). On each livestock production system, one area of 15 x 20m was isolated from animals and the experiment was develop. We added urine (2.2 L) and fresh feces (2.6 kg) inside of bases (40 x 60cm) previously fixed in pasture soil, and other base were maintained without excreta for discount soil emissions. Gases flux were measured by static chambers technic. The gas flux rates were calculated for each cha ber from the linear increase in headspace gas concentration over the sampling time. For each gas, the soil gas emission was discounted from emission of the excreta. Results were evaluated by ANOVA procedure and Tukey test ($P < 0.05$).

Results and Conclusions. Feces were the main source of CH_4 emissions in the pastures (99%) and did not differ (P<0.05) between livestock systems. In the rainy season an increase of soil CH_4 emissions has been observed, maybe due to rainfall and higher air humidity keep longer initial moisture content of feces. Urine was the main source of N_2O (96%) and higher emissions were observed in ICL than PP. Urine was the major source of gas emission from excreta and represented 73% of carbon dioxide equivalent (CO_{2eq}) emission in ICL and 62% in PP.

Table 1. Cumulative average emissions of N2O, CH4, and CO2eq from excreta deposited in integrate crop-livestock (ICP) and permanent pasture (PP) in Brazilian Cerrado (Savanah)

Production system	Excreta	N_2O (mg m^{-2}) Rainy season	Dry season	*Mean*	CH_4 (mg m^{-2}) Rainy season	Dry season	*Mean*	CO_{2eq} (g m^{-2})
ICL	**Feces**	18 Aa	10 Aa	*14 A*	2615 Aa	311 Ab	*1463 A*	45 A
PP		9 Aa	22 Aa	*15 A*	2778 aA	310 Ab	*1544 A*	47 A
ICL	**Urine**	631 Aa	281 Aa	*456 A*	9 Aa	10 Aa	*10 A*	121 A
PP		277 Ba	294 Aa	*285 A*	5 Aa	20 Aa	*12 A*	76 B

Means followed by the same capital letter in the column (for each excreta) and small letter in the row (between season) are not significantly different Tukey test (P> 0.05). CO2eq = N2O x 265 + CH4 x 28

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LOSSES BY VOLATILIZATION AND FOLIAR EMISSION OF AMMONIA IN PASTURE FERTILIZED WITH SOURCES AND NITROGEN RATES

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Introduction

Nowadays nitrogen is the most commonly used nutrient in food production around the world. These happens mainly in the form of urea, because the low cost is the biggest attraction of this source. Although, the ammonia losses related to nitrogen fertilization may hinder their use. The objective of this study is to quantify the losses by volatilization and foliar emission of N- NH_3 *Urochloa brizantha* cv. Marandu fertilized with different sources and rates of nitrogen.

Material and Methods

The experiment was conducted in a greenhouse located at the State University of Mato Grosso do Sul, University Unit of Cassilândia. The experimental design was a randomized block with four replications and a factorial 4 x 5, setting 20 treatments. Those consisted of four nitrogen fertilizers (ammonium nitrate, urea common, protected urea polymer and urea treated with NBPT (N- (n-butyl) thiophosphoric triamide) applied in five doses (0, 25, 50, 75 and 100 mg dm^{-3}) one time on the surface of the soil. The evaluations consisted in measuring the losses by volatilization and foliar emission of NH_3 from foam absorber method, for a total period of 26 days.

Results and Conclusions

Regarding the losses by volatilization, there was no interaction between sources and doses (Table 1). The common urea and urea coated with polymer had shown the greatest losses in higher doses, but did not exceed 12% of the N applied. The urea treated with NBPT slowed its peak volatilization at 13 days and volatilized only 4% of the N applied. Ammonium nitrate was the source which recorded the lowest rates of volatilization and foliar emission.

Table1. Interaction between sources and N doses on N-NH3 volatilization in grazing
Urochloa brizantha cv. Marandu

Nitrogen dose (mg dm^3)	Nitrogen source			
	NA	**U**	**PU**	**NBPT**
0	1,91 aA	2,27 aA	1,84 aA	2,61 aA
25	3,34 aA	22,83 bB	37,81 cB	6,34 aA
50	3,15 aA	40,66 bC	34,74 bB	15,04 aA
75	2,98 aA	60,69 cD	51,94 cC	38,41 bB
100	2,97 aA	109,47cE	93,22 dD	51,15 bB

Means followed by different little (in line) and capital (in colum) letters are different ($P<0.05$ Tukey). NA = Ammonium Nitrate, U = Ureia, PU = protected urea polymer e NBPT = urea treated with NBPT

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Intensities of Methane Emissions from Canchim Steers Finished in Feedlots

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Introduction

Livestock is responsible for 14.5% of total anthropogenic emissions of greenhouse gases - GHG (FAO, 2013). Studies evaluating GHG from different lineages within of the same cattle breed are scarce. The objective of this study was to evaluate the intensities of methane emissions (kg CH_4/kg Live Weight) from two lineages of Canchim steers (3/8 Nelore + 5/8 Charolais).

Material and Methods

The study was conducted at Embrapa Southeast Livestock, Sao Carlos, SP, Brazil, from June to September 2015. Twenty-four Canchim steers were evaluated in feedlot, separated according to their lineages, with 12 belonging to the new lineage (NL) and 12 to the ancient lineage (AL), with an initial body weight of 368 ± 38 kg and age of 21 ± 3 months. The animals were allocated in collective pens with an electronic trough for individual dry matter intake (DMI) measurement (Grow Safe System). Methane (CH_4) and carbon dioxide (CO_2) emissions (grams/day) were evaluated using the GreenFeed System (C-Lock Inc., Rapid City, SD). Data were analyzed using the MIXED procedure of SAS and averages were compared using Tukey's test, with significant differences at $P<0.05$.

Results and Conclusions

The CH_4 emissions of the NL were higher than the AL, as were the emissions of CO_2, but CH_4 emissions relative to the DMI, DWG and LW were similar for the two lineages (Table 1). Although CH_4 emissions were higher for the NL, the NL also displayed a better performance, resulting in lower emissions intensities (Table 1).

Table 1: Emissions and emission intensities from Canchim steers lineages

	Ancient lineage	New lineage	p-value
CH_4 (grams/day)	155.28[a]	177.75[b]	0.0130
CO_2 (grams/day)	7008.05[a]	7577.83[b]	0.0219
CH_4/DMI (kg/kg)	0.01842	0.01833	0.9446
CH_4/DWG (kg/kg)	0.1383	0.1387	0.9669
CH_4/LW (kg/kg)	0.00038	0.00039	0.6832

a,b: letters in the same row differ at ($P<0.005$) using the Tukey's test

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Nitrous oxide emission factor for cattle urine and dung in subtropical Brazilian pastureland

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Introduction

The Brazilian cattle herd is over 200 million heads and its excreta contribute to 41% of the national nitrous oxide (N_2O) emission, a potent greenhouse gas. According to the Intergovernmental Panel on Climate Change (IPCC), the emission factor (EF) of N_2O from cattle urine or dung on pasture is 2% (Tier 1), but this is a global value that may not suit many agroecosystems around the world. The objective of this study was assess if this IPCC's 2% default EF for urine and dung N_2O emission is appropriate for subtropical Brazilian pasture.

Material and Methods

A field experiment on a Cambisol in Pinhais-PR, Brazil, included a control treatment (no excreta) and application of urine (U) and dung (E). The experimental design was a randomized block design with four replications. Metal collars of 0.083 m² were inserted into the soil and served to delimit the treatment spots and to support the gas collecting chamber (static chamber method). Air samples were analyzed by gas chromatography. Assessments occurred from January to October 2014, in three seasons representing summer, autumn, and winter.

Results and Conclusions

The emission factor for N_2O-N across the three stations averaged 0.30% and 0.11% for urine and dung, respectively, lower than the 2% indicated by the IPCC. Different emission factors for urine and dung suggest that such excreta should be considered separately, not together, as suggested by the IPCC.

Table 1. Emission factor (EF%) for urine and dung applied in the summer, autumn and winter seasons for 70 days at each season.

Season	U (%)	Mean-U (%)	D (%)	Mean-D (%)
Summer	0,18 Ba	0,13 A	0,07 Ba	0,07 B
Autumn	0,35 Aa	0,20 A	0,10 ABa	0,11 AB
Winter	0,36 Aa	0,26 A	0,16 Ab	0,17 A
Mean	0,30 a	0,20 ± 0,07	0,11 a	0,12 ± 0,05

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OXIDE NITROUS EMISSIONS IN MARANDU PALISADEGRASS IN FUNCTION OF DOSES NITROGEN FERTILIZER

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Introduction

Much of the pasture areas in Brazil have some degree of degradation (Dias Filho, 2014). The correct use of fertilizers in these areas, particularly nitrogen, allows to recover the carrying capacity and vigor of plants, however, favors the emission of greenhouse gases, mainly nitrous oxide (N_2O). Thus, the objective was to characterize the emissions of N_2O soil of Marandu palisadegrass pasture with nitrogen fertilizer in the Amazon biome.

Material and Methods

The experiment was conducted in a Amazon Biome area. Were evaluated six experimental plots of Marandu palisadegrass, including two N rates (0 and 50 kg / ha) in the form of Ammonium Sulfate with three replications, following a randomized block design. The gas samples were taken in March and April 2015 in two consecutive cycles of 28 days starting from the collection two days before fertilization. the method of static cameras (bottom-up model) for the collection of N2O was used. The gas analysis was taken descriptively, using the means of each treatment.

Results and Conclusions

The flow rates of N2O during the experiment were higher in the fertilized pasture (174, 18 μg N m^{-2} h^{-1}) than to the pasture without fertilization (101,05 μg N m^{-2} h^{-1}) with higher peak registered 10 days after fertilization with the first 462,436 μg N m^{-2} h^{-1}, and 4 days with 341,706 μg N m^{-2} h^{-1} after the second fertilization. Gomes (2006) reports that the increase in N_2O emissions after fertilization indicates an intense effect and short-lived, ranging from days to just over a week after fertilization. Furthermore, the availability of nitrogen in the soil stimulates denitrifying bacteria that produce nitrate, intermediate for the synthesis of N_2O. Higher emissions of N_2O are observed in Marandu palisadegrass pastures with nitrogen fertilizer.

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Greenhouse gases fluxes in Semiarid of Pernambuco

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Introduction

Agriculture and livestock are responsible for 70% of Brazilian emissions of CH_4 and for 87% of N_2O emissions (BRASIL, 2010). The main effects of animals on soil N_2O emissions are due to the N concentration in the urine and feces (OENEMA et al., 1997). The objective of this study was to monitor the soil fluxes of CO_2, CH_4 and N_2O in Buffel grass, in grazed Caatinga and in a native Caatinga area in Pernambuco semiarid region.

Material and Methods

In each area, four static chambers were installed. Gases samples were collected from February 2015 to February 2016. Concentrations of CO_2, CH_4 and N_2O in the samples were determined in a gas chromatograph equipped with FID and ECD.

Results and Conclusions

N_2O fluxes were similar in the areas until July 2015. The highest values were found in the native Caatinga between September and October and in grazed Caatinga in December. Negative fluxes of N_2O occurred in grazed Caatinga in September 2015 and in grazed buffel in January 2016. The largest CH_4 fluxes occurred in the native Caatinga between April and June 2015 and in January 2016. CO_2 fluxes were higher from October 2015 to February 2016. These variations in the soil gases fluxes are related to the rainfall in the area.

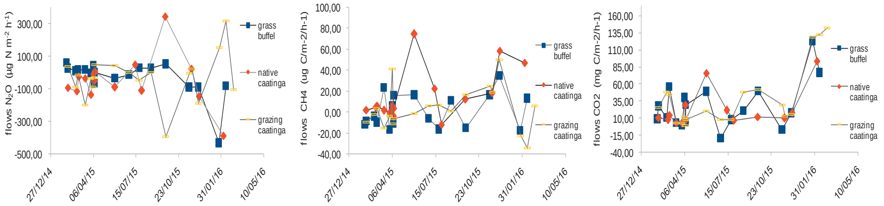

Figura1. Greenhouse gases fluxes in Buffel grass, grazed Caatinga and native Caatinga areas in Pernambuco semiarid

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Ruminal methane emissions in grazing beef heifers

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Introduction

Brazil is one of the largest beef exporter in the world, and this is due to the introduction of Nellore cattle which has been adapted to the edaphoclimatic conditions of the country. With more than 200 million head, distributed in different production managements, producing through mainly extensive grazing system, Brazil has the responsibility to increase its productivity. That means, to produce more in smaller areas using fewer animals. One option to achieve that goal is to make the rotational management, thus, it may provide a better control of food supply for animals. However, it is also necessary to be concerned about the environment, especially for the methane produced from enteric fermentation in rumen. The objective of this study was to measure the emission of enteric methane in beef heifers in rotational and continuous grazing systems.

Material and Methods

The experiment was conducted at FZEA / USP in Pirassununga / SP in the year of 2014. It was used 18 Nellore heifers with an average initial body weight of 275 kg grazing *Brachiaria brizantha* cv Marandu pasture under two grazing systems. The continuous grazing system was composed of three areas of 3.10, 3.86 and 5.63 ha and the rotational system consisted of 3 paddocks of 0.315 ha each (7 days occupation x 28 days of rest). Every 35 days, the heifers body weight (BW) was obtained and average daily gain (ADG) was calculated. The measurement of ruminal methane was performed by tracer gas SF6 technique, in which animals were adapted for 15 days to the use of halters and sarongs for data collection. Collections were held four times a year for 5 consecutive days which were 01/20, 04/28, 07/07 and 09/21 representing, respectively, Summer, Fall, Winter and Spring seasons. The CH4 and SF6 concentrations were determined by a gas chromatography by Embrapa Meio Ambiente, Jaguariuna / SP. The data was submitted to analysis of variance by MIXED procedure using the SAS statistical software and applied multiple test averages for comparison of treatments.

Results and Conclusions

The results are shown in Table 1.

Table 1. Methane variables of heifers in continuous and rotational grazing system.

Heifers	Treatment		Average	*P*
	Continuous	Rotational		
BW (kg)	341,1	333,0	340,1	*0,5430*
ADG (kg/d)	0,587	0,543	0,540	*0,6138*
CH_4 (g/d)	171,1	174,4	176,7	*0,7589*
CH_4ADG (g CH_4/kg ADG)	656,4	789,1	723,7	*0,6839*
CH_4BW (g CH_4/kg BW)	0,501	0,521	0,516	*0,4317*

BW: body weight, ADG: avarege daily gain, CH4: methane emission.

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Pecus, Embrapa Meio Ambiente, Embrapa Pecuária Sudeste.

Selection of appropriate GHG emission calculators to evaluate on-farm pasture-based beef cattle production in the tropics

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Introduction

Evaluating strategies for mitigating greenhouse gas (GHG) emissions in beef production, the major source in tropical countries, requires tools able to assess main sources and sinks of that production as well as be adaptable for local conditions. This work shows the selection of GHG calculators for on-farm assessments in pasture-based beef cattle systems in the tropics.

Material and Methods

Based on the methodology proposed by Colomb et al. (2013), a literature review was carried out for the identification of GHG calculators able to: 1) be applied under pasture-based beef cattle farms in the tropics, 2) cover all main on-farm sources and sinks (cattle, inputs and soil carbon stocks) and 3) allow variables and emission factors be freely changed by the user.

Results and Conclusions

After literature review, more than 40 calculators were identified to estimate GHG emissions from agricultural systems. However, only two fit in the criteria described above: GHG- Protocolo Agricola (WRI, 2014) and EX-ACT (Bernoux et al., 2010). Although, the use of these tools may show trade-offs. While the GHG-Protocol is more sensitive to capture variations in emissions of the herd, the EX-ACT can better represent changes in soil C stocks as well as the visualization of project additionalities. Results of this work provide information to producers, experts and decision makers for selecting, using and developing GHG calculators applicable to pasture-based beef production system in the tropics.

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Acknowledgements

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Spatial Patterns of Pasturelands, Stocking Rates of Cattle, and Methane Emission Estimates from Enteric Fermentation in Brazilian Livestock

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Introduction

In this work, we present a new high-resolution (approximately 1 km x 1 km) spatially explicit reconstruction of pastureland (natural and planted) from 1940 to 2012 and stocking rate of cattle maps from 1990 to 2012 which we used to investigate the shifting in historical patterns of the Brazilian livestock. Here we also present one of the possible uses for our land use database: the historical spatially explicit modeling of the methane emission from enteric fermentation in Brazilian livestock.

Material and Methods

We reconstructed the agricultural historical patterns by combining agricultural census data provided by the Brazilian Institute of Geography and Statistics (*IBGE - Instituto Brasileiro de Geografia e Estatística*) and remote sensing data for entire Brazil at 30" spatial resolution (approximately 1 km x 1 km). Methane emissions were calculated according to the Second Brazilian Inventory of Anthropogenic Greenhouse Gas Emission and Removal (*2º Inventário Brasileiro de Emissões e Remoções Antrópicas de Gases de Efeito Estufa*, MCTI, 2010).

Results and Conclusions

Natural pastureland expanded until the 1970s and, after that, most areas with natural pasture were replaced by planted pasture, which is more profitable. In 2012, natural pastures were still predominant in the Pampas and the Pantanal. On the other hand, planted pastureland expanded in area between 1975 and 2012, especially in the Cerrado biome. Brazilian stocking rate of cattle increased, but remains close to 1.0 head/ha between 1990 and 2010. Total pasturelands has decreased in area while stocking rates of cattle increased gradually in entire Brazil, except in Amazonia. The spatially explicit modeling of the methane emission from enteric fermentation show a spatial heterogeneity of emissions. Between 1990 and 2012, we observe the emergence of cores with high CH_4 emissions in Rondônia, eastern Pará, Mato Grosso, and Acre. Our results provide new insights about land use change, productivity, and GHG emissions in Brazilian territory that could guide future agricultural and conservation discussions, decisions, and policies.

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Acknowledgements

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Applicative Model to Estimate: The Diesel Consumption in Agricultural Crops; CO_2 Emissions; and Neutralize Proposals by Forestry Projects.

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Introduction

The present research has the purpose to make available to scientific institutions and society in general, a mathematical model which permits calculate the diesel consumption and the respective CO_2 emissions from different agricultural crops; as well, subsidize the creation of a digital applicative, which indicates, from CO_2 amount released to atmosphere, the compensatory mitigation options (forestry project models).

Material and Methods

The research meets 41 crops (38 evergreen and 03 temporary) information, from 2000 to 2012, obtained in the Instituto Brasileiro de Geografia e Estatística (IBGE) Surveys; in the Nacional Energy Balance (BEN/MME-EPE). As well as in the EMBRAPA reports, from Banco Nacional de Desenvolvimento Econômico e Social (BNDES) and from Instituto de Estudos Avançados (IEA/USP). In addition of agronomical research data, done in Brazil and abroad, to compose the calculation spreadsheets of diesel consumption and CO_2 emissions.

Results and Conclusions

The spreadsheet set present data by individual or joined crops, in addition of the diesel consumption and respective emissions, of planted area, of rates and energy conventions. It also presents estimates of agricultural mechanization and internal production transport parameters, and suggests 04 forestry mitigation options: **urban afforestation projects, reforestation, forestry protection projects and agroforestry system.** For each of them are indicated public and/or private partnership, to facilitate the measures adoption by agricultural companies and farmers. As CO_2 sequestration options, a correlation was made between sequestration and mitigation ways, it is considered the Carbon sequestration by plants to its grown and also the consumption reduction of petroleum products resulting from the anhydrous ethyl alcohol (ethanol) and biodiesel production.

Furthermore, was possible compare the average annual diesel consumption of temporary crops (soy, cotton and cane) with the sum of all the 38 evergreen crops. Was found e.g., that only soy crops demands, without discounting the 5% of soy oil (B5) used in biodiesel composition, an almost six time bigger reforestation to sequestrate CO_2 emission. Would be necessary to plant, at least, on average a 1531 ha/year area. That is feasible.

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Water balance climatology under conditions of future climate scenarios in the Pantanal Nhecolândia, Brazil

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The study of global climate change is the subject of several international and national initiatives to outline future climate scenarios, quantifying impacts and proposed mitigation and adaptation measures. The objective of this work is to investigate the behavior of water conditions due to global warming analyzing future water availability for the Pantanal Sul Mato-grossense. To investigate the water behavior, the water balance (BH) was performed, climatology according to the method of Thornthwaite and Mather (1995), for average conditions and then used to monthly rainfall scenarios (10% and 20% of decrease) and temperature (increase of 2,5°C and 3,5°C) for the period 2011-2040 (Marengo et al., 2016). For the medium conditions were used climatological series (1977-2014) of air temperature and rainfall of climatological station Nhumirim, located in the sub region of Nhecolândia, Pantanal, MS. It was noted by the BH that average conditions water deficiency predominates in most months, except, in a few months when the water supply from the rainfall exceeds the atmospheric demand. The results obtained with the scenarios of higher temperatures and decreased precipitation point critical situation for water resources, and may interfere with agricultural and hydrological activities in the sub region of Nhecolândia.

Keywords: global warming, water availability, future scenarios.

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Modelo de Aplicativo para Estimar: O Consumo de Óleo Diesel de Cultivos Agrícolas; As Emissões de CO_2; e Propostas para Neutralizá-las, por meio de Projetos Florestais.

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Introduction

O presente estudo tem a finalidade de colocar à disposição das instituições científicas e dasociedade em geral, um modelo matemático que permite calcular o consumo de óleo diesel e asrespectivas emissões de dióxido de carbono (CO_2) de diferentes cultivos agrícolas; bem como,subsidiar a elaboração de um aplicativo digital, que indique, a partir da quantidade de CO_2lançado na atmosfera, as opções de mitigação compensatória (modelos de projetos florestais).

Material and Methods

A pesquisa reúne informações de 41 cultivos (38 perenes e 03 temporários), de 2000 a 2012, obtidos nos Levantamentos do Instituto Brasileiro de Geografia e Estatística (FIBGE); no Balanço Energético Nacional (BEN/MME-EPE); bem como, nos relatórios da EMBRAPA, do Banco Nacional de Desenvolvimento Econômico e Social (BNDES) e do Instituto de Estudos Avançados (IEA/USP); além de dados de pesquisas agronômicas, feitas no Brasil e no exterior, para compor as planilhas de cálculo de consumo de diesel e das emissão de CO_2

Results and Conclusions

O conjunto de planilhas apresenta, por cultivos individuais ou agrupados, além do consumo de óleo diesel e das respectivas emissões, dados: de área plantada, de produção e índices de conversões energéticas. Apresenta, também, estimativas relativas a parâmetros de mecanização agrícola e de transporte interno da produção; e sugere 04 opções florestais de mitigação: projeto de arborização urbana, reflorestamento, projeto de proteção florestal e sistema agroflorestal (SAF). Para cada uma delas são indicadas parcerias públicas e/ou privadas, para facilitar a adoção das iniciativas pelas empresas agrícolas e produtores rurais. Quanto as opções de sequestro de CO_2, foi feita uma correlação entre elas e as formas de mitigação, considerou-se a captação de Carbono das plantas para o seu crescimento e também a redução do consumo de derivados de petróleo decorrente da produção de álcool etílico anidro (etanol) e biodiesel.

Outrossim, possibilitou comparar o consumo médio anual de diesel dos cultivos temporários(soja, algodão e cana) com a soma de todos os 38 cultivos perenes. Verificou-se, por exemplo,que só os plantios de soja exigiriam, sem descontar os 5% do óleo de soja (B5) utilizados nacomposição de biodiesel, um reflorestamento quase seis vezes maior para abater suas emissõesde CO_2. Seria necessário plantar, em média, uma área de 1.531 hectares/ano. O que é factível.

Reference

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A Comparison of Farm-Level Greenhouse Gas Calculators in their Application on Beef Production Systems

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Introduction

Agriculture in the United Kingdom was responsible for the emission of 48 Mt CO_2-eq in 2008, a contribution of 8% to national emissions (Comittee on Climate Change 2010). With current UK climate commitments, UK agriculture is required to achieve a 34% reduction by 2020 (Comittee on Climate Change 2008). The livestock sector contributes substantially to agricultural emissions (Moran et al. 2011) and hence is likely to come under considerable scrutiny. Quantifying and mitigating for GHG emissions from livestock is therefore of considerable policy importance.

A number of footprinting tools, developed in a variety of contexts, are available to assist with this process (Colomb et al. 2012; Whittaker et al. 2013). Whilst the relevance of such tools to policy is well recognised (e.g. Hall et al. 2010), an overarching lack of consensus in GHG accounting methods is apparent between tools, reflecting the range of contexts in which they are developed. Reviews to date have focused on largely or entirely on qualitative approaches to assess tools (e.g. Hall et al., 2010; Colomb et al., 2012; Whittaker et al., 2013). Given the limitations of such approaches, particularly where methodological transparency is lacking, the requirement for a comprehensive, empirical assessment of the performance of these tools in the context of real-world data is increasingly apparent.

This study sought to fulfil that requirement through a critical comparison of tool estimates based on representative UK livestock enterprises. Robust conclusions were sought as to the consequences of existing differences in accounting methods on the final farm-level footprint, and on corresponding implications for users and policy makers.

Material and Methods

Data from seven UK beef farms was sourced and used to produce a GHG footprint from five different farm-level calculators. Beef production was focused on for data collection; this reflects the high environmental impact of beef as compared to other livestock enterprises, and provides a link between each of the farms for comparison of emissions intensity. The farms represented a typical mix of UK beef production systems, and all contained additional crop and livestock enterprises.

Calculators were selected based on pre-defined criteria. Tools had to be greenhouse gas calculators specific to the agricultural sector. Tools had to be, if not UK- specific, at least UK applicable. Additionally, it was determined that tools must be publically available without cost, and must function at farm level. The calculators chosen for comparison were:
AgRE Calc, a tool developed by SAC Consulting.
The Cool Farm Tool, developed by the University of Aberdeen.
The CALM Tool, developed by the Countryside Land & Business Association
CPLANv0, a tool developed by the agricultural consultancy business SEE360 Ltd.
The CFF Tool, developed by the not-for-profit organisation Climate Friendly Food as part of the Farm Carbon Cutting Toolkit.

Results and Conclusions

Seven farm-level datasets were processed through the five tools, giving a total of 35 emissions estimates. Excluding sequestration by woodland, these totals ranged from 0.15 (CPLANv0, Farm G) to 4.02

kt CO_2-eq year^{-1} (AgRE Calc, Farm A). A considerable amount of this variability is attributable to the tools themselves (Fig. 1).

The CPLANv0 tool appears consistently below the general trend. AgRE Calc produces the highest results on average. A partial grouping is apparent, with results from CALM, the Cool Farm Tool, the CFF calculator and, to some extent, AgRE Calc, following a similar pattern.

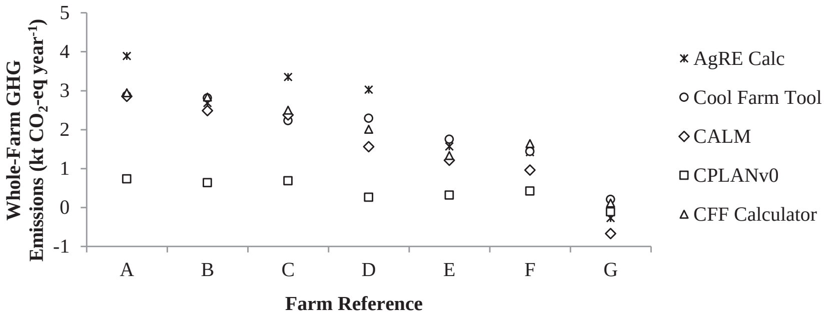

Figure 1. Total GHG footprints, including sequestration by woodland, for each of the five calculators over the seven sample farms.

Direct emissions from livestock varied considerably, and represented the largest overall emissions category, contributing between 43% and 92% (M = 72%, N = 35) to the overall farm-level footprint. Emissions from land/crops and embedded emissions were also highly variable. Fuel and electricity emissions were more consistent, whilst estimates of sequestration by woodland varied widely.

GHG emissions intensities for beef production, in kg CO_2-eq kg beef LW^{-1} were calculated for each estimate. The mean emissions intensities calculated by the tools showed some similarity to comparable values from the literature, though some tools, notably CPLANv0, underestimated by comparison.

At the level of a single farm, this study shows that the magnitude of the emissions estimate may vary considerably depending on the tool employed. Additionally, where tools are employed for scenario modelling purposes, such as to hypothetically test proposed mitigation measures, it is vital that tools react predictably and consistently to changes in the input data. This study uncovered a number of areas where, owing to differences in methodology, this may not be the case.

It is important that users of farm-level tools acknowledge these issues and treat results with appropriate caution. Particularly where a tool is sought for the purpose of influencing or informing policy decisions, it is vitally important not only that known variation be accounted for, but that areas of opacity in methodology be recognised and addressed. Similarly, it is essential that developers, in recognition of the potential impact of these tools, take steps to address the limitations which hinder their application.

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Mitigation of emissions from sugar cane crop by anaerobic digestion of sugarcane wastes

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Introduction

Biogas from anaerobic digestionof residual biomasses has been researched in the last decades encouraged by problems of fossil energy dependence on national economies.[1,2]Anaerobic digestion is a promisingalternative to generate bioenergy and to reduce environmental impacts related to the wastes of the bioethanol industry.[3,4]

Material and Methods

This work aimed to contribute to environmental benefits by mitigating methane emissions from the sugar cane crop. Batch experiments of mesophilic anaerobic digestion using an Automatic Methane Potential Test System II (AMPTS II, Bioprocess control, Sweden) were applied for the tests of methane potential of the filter cakeand vinasse residues. The sample and inoculum collection was in an ethanol industry of the Goiás State. The inoculum multiplication carried out under a minimal feeding regime and under physical chemical monitoring. Batch tests were performed following the treatments: (a) inoculum + vinasse, (b) inoculum + filter cake and (c) inoculum + a blendof filter cake and vinasse. The inoculum/substrate-ratio was 2 on the basis of volatile solids (VS). AMPTS II setup run under the same conditions in all experiments of 400 mL working volume and 250 mL headspace.

Results and Conclusions

The results of the AMPTS II tests showed that the methane potential of the blend of the residues of filter cake and vinasse in (c) tests was higher than the other treatments. The anaerobic digestion applied to the residues of the sugar cane processing may be an alternative way to mitigate emissions from the sugar cane crop, since the organic matter is being mineralized to biomethane and inorganic compounds before returning to the sugar cane field.

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Confection of SF_6 capsules used to estimate ruminal methane production in ruminants

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Introduction: In recent decades, the concentration of methane and other greenhouse gases that cause the global warming is increasing, associated with human population growth and related activities, involving the agricultural environment. One of the more notable activities is the production of beef cattle, which emit methane from fermentation in the rumen. The SF_6 tracer technique is used to measure these methane emission rates. This methodology requires care and depending on the preparation, may compromise the efficiency of lifetime and enteric methane collection from the animals. This study aimed to evaluate the effectiveness of the use of new and old materials to build the SF_6 capsules.

Material and Methods: The capsules were made and filled at Embrapa Southeast Livestock. 100 brass permeation capsules were filled with 1391 ± 62.39 mg of SF_6, according to the methodology described by Johnson et al. (2007). Of the 100 capsules, 25 were made with a new capsule and frit (NN), 25 with a new capsule and used frit (NU), 25 with an used capsule and frit (UU) and 25 with an used capsule and new frit (UN). All capsules were kept in an incubator at 39°C, simulating rumen conditions. The determination of the emission rates of the capsules was performed by gravimetric methods, weighed weekly for 107 days. Analytical scales were used with 0.0001g accuracy. The data were submitted to analysis of variance by the MIXED procedure using the SAS statistical software and multiple test averages applied for comparison of treatments.

Results and Conclusions: After filling all capsules, 3 had defects and lost the SF_6 gas, of these, two were UN and one was UU. The results are shown in Table 1.

Variable	Treatments*				Mean ± SD	*P*
	NN	NU	UN	UU		
Empty (mg)	27647^{c}	27733^{c}	27835^{b}	27971^{a}	27794 ± 17.71	<*.0001*
Filled (mg)	29059^{c}	29157^{b}	29210^{b}	29321^{a}	29185 ± 15.88	<*.0001*
SF_6 (mg)	1411.9^{ab}	1424.3^{a}	1375.2^{bc}	1350^{c}	1391.1 ± 6.34	<*.0001*
Emission (mg/day)	3.212	3.173	3.427	3.006	3.202 ± 0.06	*0.1102*
Lifetime (months)	12.8^{ab}	13.5^{a}	11.8^{b}	13.0^{ab}	12.8 ± 0.22	*0.0395*

a, b, c Different letters in the same row differ ($p < 0.05$) by the Tukey test.
*NN: new capsule and frit, NU: new capsule and used frit, UN: used capsule and new frit, UU: used capsule and frit.

There were no differences observed in SF_6 emission using used and new materials. The differences observed in the capsule lifetime were related to the SF_6 load.

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Multi-season effects of biochar and N on N_2O-N fluxes in a Ferralsol

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Introduction

Biochar is the charred by-product of biomass pyrolysis (Sohi et al. 2010). A wood biochar is generally alkaline and rich in micro pores, characteristics that in theory would contribute to increase absorption of ammonium and soil water, lowering nitrous oxide (N_2O-N) (Clough and Condron 2010). Yet, detailed and consistent information about soil born N_2O-N fluxes with biochar amendment under real farming conditions are lacking.

Material and Methods

We used manual, static chambers to quantify N_2O-N fluxes arising from a Ferralsol throughout four cropping seasons after a single application of wood biochar (32 Mg ha^{-1}, incorporated to a depth of 0-15 cm) followed by annual N applications (90 kg N ha^{-1}). Soil ammonium (N-NH_4^+) and nitrate (N-NO_3^-) availability and water filled pore space (WFPS) were measured alongside N_2O-N fluxes.

Results and Conclusions

A single application of 32 Mg ha^{-1} biochar amendment does not mitigate N_2O-N fluxes from the N fertilizer applied. The mineral N application enhances N_2O-N fluxes, soil N-NH_4^+ and N-NO_3^- availability, especially in seasons characterized by lower WFPS.

Table 1. Nominal significance level (p values) arising from F tests for the effects of mineral N fertilization (N) and biochar (CHAR), and their interaction (N*CHAR), on N2O-N fluxes and soil related variables along four cropping seasons on a clay Ferralsol.

Effects	N_2O-N	N-NH^+_4	N-NO^-_3	WFPS	N_2O-N	N-NH^+_4	N-NO^-_3	WFPS
	--------------------------*S0.0*------------------------				--------------------------*S0.5*------------------------			
N	0.4605	0.2075	**0.0081(↑)**	0.9362	**0.0408(↑)**	**<.0001(↑)**	**0.0001(↑)**	0.2685
CHAR	0.7876	0.8772	0.4548	0.5487	0.4012	0.7191	0.8314	0.4633
N*CHAR	0.1159	0.6985	0.5054	0.3153	0.3256	0.8515	0.5461	0.9359
	---------------------------*S1.5*-----------------------				-------------------------*S2.5*-------------------------			
N	0.0791	**<.0001(↑)**	**<.0001(↑)**	**<.0001(↓)**	**0.0024(↑)**	**<.0001(↑)**	**<.0001(↑)**	**<.0001(↓)**
CHAR	0.0804	0.1898	0.6637	**<.0001(↓)**	0.9767	0.1898	0.6637	**<.0001(↓)**
N*CHAR	0.5707	0.5212	0.6818	0.5093	0.3098	0.5212	0.6818	0.5093

N_2O-N: nitrous oxide fluxes (µg m^{-2} per hour); N-NO_3^-: available soil nitrate (mg kg^{-1}); N-NH_4^+: available soil ammonium (mg kg^{-1}); and WFPS: soil water filled pore space (%). Seasons: immediately (S0.0) and at 0.5 (S0.5), 1.5 (S1.5) and 2.5 (S2.5) years after biochar application. (↑): increases; (↓) decreases.

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Mitigation of nitrous oxide emission from cattle excreta in pasture with dicyandiamide (DCD)

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Introduction

The agricultural activity is a major contributor to the emission of nitrous oxide (N_2O) and the adoption of management practices that minimize this emission is crucial. The Brazilian cattle herd is over 200 million heads and its excreta contribute to 41% of national N_2O emission. Thus the objective of this study was to evaluate the efficiency of dicyandiamide (DCD), a nitrification inhibitor at reducing the emission of N_2O and determining the best way of applying the inhibitor, if sprayed onto or mixed with urine and dairy manure.

Material and Methods

The study was conducted at the experimental farm of the Federal University of Parana, in Pinhais-PR, from January to October 2014 in three seasons representing the Summer, Autumn and Winter. The treatments were: soil without excreta and without DCD (control group); application of urine (U), urine mixed with DCD (U+DM) and urine sprayed with DCD (U+DP); application of dung (D); dung mixed with DCD (D+DM) and dung sprayed with DCD (D+DP). The experimental design was a randomized block design with four replications. Metal collars of 0.083 m^2 were inserted into the soil and served to delimit the treatment spots and to support the gas collecting chamber (static chamber method). Air samples were analyzed by gas chromatography.

Results and Conclusions

The use of DCD mixed with urine reduced N_2O emissions by 79 and 55% in autumn and winter, respectively. When sprayed, DCD was efficient only in autumn, with a reduction of 45% of emission. In Summer, the use of DCD was not efficient to reduce emissions. In autumn, there was no significant difference in the forms of application of DCD, being both efficient in reducing emissions. For dung, DCD was significantly efficient only in winter, and when applied in mixed form, which may be related to the originally low N_2O emission in this type of excreta.

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Effect of the use of the SF_6 tracer gas technique on the performance of Nellore Cattle

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Introduction: Alongside the increasing global demand for red meat there is also increasing pressure from environmentalists to increase the productivity of systems. Recent studies have highlighted the environmental aspects of production systems, assessing methane (CH_4) emissions, the principal gas emitted by ruminants, among other sources of GHG emissions. The sulphur hexaflouride (SF_6) tracer gas technique is the most widely used and recognized for measuring rates of CH_4 emissions, however, it is a technique that involves subjecting the animal to alterations in routine due to the use of collecting apparatus in the head and neck area. The objective of this study was to assess the effect of using the the SF_6 tracer gas technique for measuring CH_4 on the performance of the animals grazing pasture.

Material and Methods: The experiment was carried out at the São Paulo Agency for Agribusiness Technology (Agência Paulista de Tecnologia dos Agronegócios – APTA) in Colina/SP, in 2014 and 2015, over a total period of 432 days. The study used 96 steers for assessment of performance, randomly distributed across 12 paddocks, uniform in terms of breed (Nelore), age, sex (uncastrated males) and initial body weight (197 kg). Of these animals, 25 were used to assess enteric methane emissions from pasture (Methane group). For the sampling and measurement of methane the SF_6 tracer gas technique was used, as refined by Berndt et al. (2014). The methane samples were taken during 5 consecutive days, changing the yoke every 24 hours. The animals were adapted to the sampling apparatus (yoke and halter) for a period of 10 days. Six samples were taken, two in each phase of the experiment: dry season (135 days), wet season (168 days) and pasture confinement (129 days). Data were analyzed using the statistical package SAS 9.2 MIXED procedure (SAS, 2008). Means were compared using the "t" test to the 10% level of significance.

Results and Conclusions

Table 1. Performance variables of Nellore.

Variables	**Treatments**		**Means ± SE**	***P***
	Methane Group	**Control Group**		
	***n*=25**	***n*=71**		
Live weight (kg)	514.0	506,5	510.3 ± 12.07	*0,5425*
Average daily gain (kg/d)	0,752	0,756	0,754 ± 0.026	*0,8961*
Carcass weight (kg)	301.5	299.8	300,7 ± 7.225	*0,8133*

Based on these results we can conclude that the SF6 tracer gas technique did not affect the performance of the animals in a pasture production system.

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Grape byproduct reduce enteric methane emissions when fed to sheep

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Introduction

Just in *Rio Grande do Sul* state, 702.09 million kg of grape had been process in local industry in 2015 (IBRAVIN, 2015). Grape marc represent 20% of all grape processed in industry and it has been use to fertilize vines (MACHADO et al., 2015). Although, this grape marc can also be used to benefit nutritionally animals diet. Grape marc has also a good quantity of fat and tannins (Spanghero et al., 2009) which has been reported to be an efficient diet strategy to reduce methane (CH_4) from rumen. The aim was evaluate the influence of feeding sheep with grape marc on CH_4 emissions.

Material and Methods

The experiment was conduct in an experimental sheep barn where eight animals were randomly allocate in two groups: control (CON) group and grape group (GG). The CON received a basal diet (BD) containing 440.3g of concentrate mix DM/d; 380.7g of alfalfa hay DM/d and 170g of rice grass hay DM/d. The GG received the BD with the replacement in 25% total dry matter by dried grape marc (DGM). Daily CH_4 emission was measure using the SF6 tracer technique and the air sampling system used stainless steel cylinders (0.5 L volume) as sample collection device with sample flow regulated by a brass ball-bearing.

Results and Conclusions

Sheep of GG group had lower CH_4 emissions (g/sheep per day) than CON group (P= 0,03). In the current experiment, we obtained a 14% decrease in CH_4 emissions when dried grape marc was fed to sheep. The additional 25% of DGM decrease the enteric methane emission, but further studies has to be made to elucidate the main mechanism of this change.

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Adaptive phenotypic plasticity of the native forage grass *Paspalum fasciculatum*: a trait relevant to climatic changes in wetlands

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Phenotypic plasticity is a mechanism for adaptation to highly variable environmental conditions presented by determined species, such as occurs in grasslands located in wetter areas of the Brazilian Pantanal, that are under periodic flooding/drought cycles. These areas may have yearly variations in flooding level and intensity, which favour certain plant species over others. This factor results in uncertainty concerning the forage availability, especially when facing extreme weather conditions of drought or flooding. This study has been conducted to detect natural forage species having adaptive phenotypic plasticity in wetlands to withstand extreme conditions in drought/flooding cycles. The screening targeted native forage species, which grow in wetlands and have been brought to the Active Germplasm Bank (AGB) of natural forages of the Pantanal. The AGB is located at the Nhumirim ranch, Nhecolândia sub-region, Pantanal, Mato Grosso do Sul State, by the edge of natural ponds. The AGB conserves accessions mainly of *Hemarthria altissima*, *Hymenachne amplexicaulis* and *Steinchisma laxum*. However, accessions of other species such as *Luziola subintegra, Oryza latifolia*, *Paspalum almum*, *P. fasciculatum, P. plicatulum* and *P. wrightii* have also been included to assess their adaptation to wetlands. It was observed that *P. fasciculatum* supported periods both of hydric stress and flooding better than the other species maintained in the AGB, besides showing a high dry mass yield, even on sandy soil, therefore presenting a great potential for carbon sequestration. From these results, we recommend to continue collecting accessions of *P.*

fasciculatum from different Pantanal environments aiming at expanding its genetic diversity for future genetic improvement programs. *Paspalum fasciculatum* is a vigorous (C_4) native forage species with great potential for optimizing carbon flow in different climatic conditions, as well as to contribute to the year round forage supply for livestock and wildlife, despite periodic flooding or drought.

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Feedlot pen surface greenhouse gases emissions from Nellore or Brangus bulls finished on diets with contrasting fat levels

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Introduction

The objective of this study was to evaluate greenhouse gases (GHG) emissions from a feedlot pen surface where Nellore and Brangus bulls were fed diets with low or high fat.

Material and Methods

Four pens were selected to be the experimental units, each one receiving a treatment as the combination of the diets and breeds tested: 1) Low fat, Nellore (n = 10); 2) High fat, Nellore (n = 9); 1) Low fat, Brangus (n = 10); 2) High fat, Brangus (n = 10). Fat levels were 3.2% and 6.4%, (ether extract % DM). Pens were rotationally occupied during all feedlot period (84 days) and each animal remained for at least 48 hours in two occasions in the pen of his respective treatment. GHG emission was measured using gas chambers (32 cm X 53 cm X 32 cm), according to Costa Jr. et al. (2014). The samples were analyzed for methane (CH_4), carbon dioxide (CO_2) and nitrogen oxide (NO_2) by gas chromatography. Obtained values were used on formulas taking into account temperatures, chamber volume and surface area, atmospheric pressure and collection time to estimate the flux of each gas as mass/area/time (mg/m^2/d). Only descriptive statistical analysis are presented.

Results and Conclusions

From Table 1, an extremely high variability can be observed, what is usual in this kind of study but was aggravated by the greatly variable weather conditions during the experiment. Further analysis including other effects (i.e. time, rain, soil moisture) are needed. The mean data of 81 g CO_2-Eq./pen/day represents about 3% of the expected daily enteric emission of the animals.

Table 1. Flux ± standard deviation (mg/m^2/day) of Methane, Nitrogen Oxide and Carbon Dioxide for high fat (HF) or low fat (LF) diets fed to Brangus (Bran) or Nellore (Nel) bulls and the mean CO_2-Eq for each treatment (g/day/pen)

Variable	Methane	Nitrogen Oxide	Carbon Dioxide	CO_2- Eq (g/d/pen)
HF, Bran	0.64 ± 0.84	6.78 ± 6.66	717 ± 324	113
LF, Bran	1.09 ± 1.52	1.97 ± 1.79	485 ± 180	45
HF, Nel	0.57 ± 0.55	2.12 ± 1.28	487 ± 203	46
LF, Nel	1.13 ± 6.66	7.24 ± 9.24	755 ± 258	121

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Critical carbon input to maintain current soil carbon stocks in agricultural management systems

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Introduction

Agricultural systems have a significant potential to increase carbon sequestration and mitigate greenhouse gas emissions and they can be management strategies to reduce C footprint from farm. The aim of this study was estimate the critical C input for maintaining soil organic carbon in perennial agricultural systems (pastures), woodlands and annual cropping systems.

Material and Methods

The study was conducted in five agricultural systems: a) Native forest (NF), b) improved pasture of Tanzania grass (TIP), c) degraded pasture of Tanzania grass (DP), d) hay area with *Urochloa brizantha* syn. *Brachiaria brizantha* (H) and e) Corn crop conventionally cultivated for 10 years (CTC), located in Sertaozinho, State of Sao Paulo, Brazil. Mean annual temperature (22.8ºC), precipitation (1.12 mm) and soil clay content (70.1%). The Rothamsted carbon model (RothC, version 26.3) was used to estimate C input rates to maintain to current soil C level (Wang et al., 2016).

Results and Conclusions

Carbon stocks for the different agricultural systems ranged from 54.3

to 97.1 Mg C ha^{-1}. The improved pasture (fertilized with 300 kg per ha of formula 20-05-20) increased the C stock. The critical C input ranged from 2.0 to 3.57 Mg C ha^{-1} for degraded pasture and native forest, respectively.

Table 1. Soil carbon stock (0-30 cm) and C sustain, for the different land use systems and soil management: degraded pasture (DP), conventional tillage corn (CTC), hay field (H), improved pasture (IP) and native forest (NF).

Carbon	Degraded pasture (DP)	Conventional tillage corn (CTC)	Hay Field (H)	Improved pasture (IP)	Native Forest (NF)
	----------	----------	Mg ha^{-1}	----------	----------
C stock	54.3c	61.1c	63.0b	65.9b	97.1a
C sustain	2.00a	2.25b	2.32b	2.42b	3.57a

Means (n = 5) followed by the same letters refer to the comparison among systems and do not differ significantly at $p < 0.05$.

The critical C input can be estimated by using the current SOC level, mean precipitation, annual temperature and soil clay content.

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Irony as a support for journalistic discourse on livestock raising and climate change

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Introduction

It is not always that Brazilian media associate climate change to livestock raising, which is considered as one of its causes (Neiva, 2016). When this happens, statements assume a status of environmental vigilance, which manifests itself by means of irony, a figure of speech used in journalism to draw the attention of interlocutors. The aim of this qualitative study is to investigate how journalistic discourse stands in relation to the livestock raising/climate change duo at two distinct points in time for Brazilian agriculture and livestock raising research.

Material and Methods

The approach of French-school Discourse Analysis and Critical Discourse Analysis, developed by van Dijk (2005), provide the necessary tools to investigate and understand the meanings that involve the discursive process and the conditions under which it is produced and received. Two journalistic texts published in Brazil were evaluated: the first from 2009, in a CBN radio station broadcast, by columnist Arnaldo Jabor, criticizing the inertia with which Brazilian meat producers and consumers face the global warming issue; the second was published in 2016 by the O Globo newspaper informing the results of research conducted by Pecus Network, which indicates a new methodology to measure greenhouse gas emissions by livestock. The two statements were selected on purpose from the Google search platform.

Results and Conclusions

Discourse Analysis allows one to link signs found in statements to their authors' ideological positions. The two discourses that were analyzed reveal the conflict between two groups: those who call attention to the risks of livestock raising and are concerned with environmental causes (endogroup) and those related directly or indirectly with livestock raising practice (exogroup). In both cases, those making statements use irony to attract the attention of readers and listeners, to call for attitudes, to raise opinions and to indicate mistrust. The conclusion is that the use of irony in journalistic discourse is legitimate, but that it entails the risk that interlocutors might not understand its intention. This happens because irony works with implicit contradictions and requires that author and receiver present compatible mental models.

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Carbon content in sandy soils under different use and management systems

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Introduction. Quantifying soil carbon content is important to assess soil indicators related to adequate management conducted by producers in their agricultural systems. The objective of this study was to evaluate the total soil carbon content in soils under different use and management systems.

Material and Methods. The experiment was conducted in a sandy soil (Quartzpsamment) with clay content lower than 3%. Soil use and management systems, evaluated as treatments, were: eucalyptus forest with 18 months of planting , trees spaced by 4 x 2 m (EUC); degraded pasture of *Brachiaria decumbens* cv Basilisk (PAST), and natural vegetation of Cerrado (CER). Soil samples for total carbon analysis content (C) and soil density (Ds) were carried out between December, 2013 and March, 2014. Samples were taken in four replications for each treatment and soil depth. Determination of soil C was done with a NC analyzer (Sumika Chemicals Sumigraph-NC 900), in accord with Kanda et al. (2004). Soil density (Ds) was evaluated as EMBRAPA (1997).

Results and Conclusions. In the treatments studied: soil use and management systems, the lowest carbon content was found in the eucalyptus forest (EUC). On the other hand, largest C values were measured in the natural vegetation (CER), followed by Brachiaria pastures (PAST). Differences related to soil carbon content were statistically different among treatments in the first 20 cm depth. Below this, it was not observed significant differences for each measured soil layer. Although there was a trend for higher values in CER, with depth, no differences were observed when compared to managed areas.

Table 1. Carbon contents and soil density in different management systems and depths.

Depth (cm)	Soil carbon			Soil density		
	EUC	PAST	CER	EUC	PAST	CER
	--------------------	C %	-------------------	-------------------	Ds g dm^{-3}	----------------
0-5	0,500 Ac	0,757 Ab	1,150 Aa	1,36	1,45	1,27
5-10	0,407 ABb	0,510 Bab	0,577 Ba	1,46	1,60	1,39
10-20	0,332 ABCb	0,402 BCab	0,482 BCa	1,53	1,59	1,46
20-30	0,235 BCDa	0,267 CDa	0,307 CDa	1,56	1,58	1,53
30-40	0,217 CDa	0,220 CDa	0,295 Da	1,54	1,56	1,54
40-60	0,177 CDa	0,202 Da	0,260 Da	1,59	1,55	1,54
60-80	0,145 Da	0,147 Da	0,212 Da	1,57	1,56	1,55
80-100	0,132 Da	0,142 Da	0,147 Da	1,58	1,55	1,50
Mean	**0,268 c**	**0,331 b**	**0,429 a**	**1,53**	**1,55**	**1,47**

Means followed by the same capital letters in the column and small letters in the line do not differ -Tukey (P>0.05).

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The Impact of the Implementation of an Integrated Crop-Livestock-Forest System in a Ferralsol of the Brazilian Savannah (Cerrado)

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Introduction

Conservationist agricultural systems and soil management should sequester carbon from the atmosphere. In this sense integrated Crop--Livestock-Forest systems (iCLF) stand out as an alternative because with its diverse composition promotes a range of environmental services, including being carbon (C) sink due to its removal by its forest component. However there is only little information on the potential that iCLF has for carbon accumulation in the soil. Therefore, these systems have to be evaluated under field conditions and in different biomes of Brazil so that we can confirm this behavior. This study aimed to contribute to the analysis of an iCLF system in the Brazilian savannah in Goiás state.

Material and Methods

The evaluation was made three years after its implementation in southern Goiás State of Brazil, in the Boa Vereda Farm (18°27’43.19”S, 49°35’58.53”W), where the iCLF, conventional pasture (CP) and a recovered pasture (RP) were implemented. Total organic carbon (TOC) and nitrogen (N) concentrations were evaluated up to a meter depth in eight layers. In the iCLF each sampling point had six soil profiles placed in different positions to represent situations according to the presence or not of trees and transition zones between trees and pasture. The soil texture, bulk density and the isotope ratio ($\delta^{13}C$) were evaluated to validate the comparability of the investigated areas.

Results and Conclusions

Study results showed that the management used during the implementation of iCLF, which included soil tillage with disc plowing, influenced negatively the C and N stocks in the 0-0.3m layer. Another factor that likely influenced the input of C and N in the soil was the low productivity of the pasture, result of the shading by the eucalyptus trees (*Eucalyptus urograndis*) on the grass (*Urochloa brizantha*), due to the implementation of eucalyptus rows in the north-south direction. Considering a layer 0.0 to 1.0 m, however, the management did not influence the stock of TOC and total N due to compensation of the loss of the stock of TOC and total N in the surface layer by the accumulation of these elements in deeper layers (0.3-1.0 m). Thus, despite the loss of carbon and nitrogen in the surface layer of the soil, it was possible to infer that the iCLF showed potential for carbon accumulation in the soil, the deeper layers after three years of its implementation.

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Soil carbon and nitrogen stocks in subtropical Oxisol in southern Brazil under tillage systems and integrated crop-livestock

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Introduction

No-tillage (NT) promotes physical protection of carbon (C) and nitrogen (N) in stable aggregates, increasing their stocks; but little is known about the quantitative effects of the use of integrated crop-livestock (ICL) for the accumulation of these elements in subtropical soil. The objective of this study was to evaluate the potential of the NT and ICL in stocks of C and N in the soil, in a nine-year experiment in a subtropical Oxisol Bruno, Castro, Parana, Brazil.

Material and Methods

Selected treatments were: ryegrass (*Lolium multiflorium*) grazed by dairy cattle in winter and maize (*Zea mays*) silage in the summer, in conventional tillage with plowing and disking in winter (ICL-CT) or no--till (ICL-NT); and continuous crop system where ryegrass served only as cover crop in conventional tillage (CC-CT) or no-till (CC-NT). Soil samples up to 1 m depth were analyzed by dry combustion (elementary Vario EL III) for determination of C and N; stocks were based on the values of concentration of C and N and density, and were subsequently corrected by the equivalent mass of soil, which considers equal mass of soil between treatments, and the PC as a reference (Sisti et al., 2004).

Results and Conclusions

NT increased C stock in the 0-20 cm, both in CC and in ICL at rates of 0.26 and 0.52 Mg ha^{-1} $year^{-1}$, respectively; with the same trend for N, accumulation rate of 0.3 Mg ha^{-1} $year^{-1}$ to CC and 0.4 Mg ha^{-1} $year^{-1}$ for the ICL. Up to 1 m deep, increasing the C stock with NT was significant in CC system, at a rate 1.51 Mg C ha^{-1} $year^{-1}$; but no increase was observed with ICL. Compared to crop system, ICL did not affect the C or N stocks in 0-20 cm, both your CT and NT. Up to 1 m deep, the same result occurred in NT, but in CT stocks of C and N were higher in the ICL, with C sequestration rates of 1.14 Mg ha^{-1} $year^{-1}$ and N accumulation 0.08 Mg ha^{-1} $year^{-1}$. In conclusion, NT has potential to accumulate C and N in the soil when in continuous crop; however, ICL in NT showed no increase of C and N in relation to the CC.

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Soil C stocks and isotopic signature in integrated crop-livestock-forest systems of the Cerrado-Amazon transition zone

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Introduction

Integrated crop-livestock-forest systems (iCLF) are gaining importance as they are considered promising systems for the mitigation of greenhouse gas emissions and carbon sinks. We investigated if iCLF was able to improve soil C stocks when implemented on an area of pasture showing signs of overgrazing.

Material and Methods

Our study was carried out in the north of Mato Grosso State, in Brazil, a transitional region between the Amazon and Cerrado ecosystems (10º38'13" S, 55º42'32" W). Two areas under iCLF were selected (iCLF1 and iCLF3, systems with one and three rows of *Eucalyptus urograndis* by hedgerow, respectively) and an overgrazed pasture. The soil was a clayey Oxisol (*"Latossolo vermelho-amarelo distrófico", SiBCS*). The climate was Aw, according to Köppen's classification. The areas have been cultivated since 1998, and was converted into iCLF in 2009. Soil samples were collected from 0.00-0.05; 0.05-0.10; 0.10-0.20, 0.20-0.30; 0.30-0.40; 0.40-0.60; 0.60-0.80 and 0.80-1.00 m soil layers to quantify the bulk density, texture, total C content and isotope ratio ($\delta^{13}C$) of the soil. In areas under iCLF samples were taken from the influence zone of the trees to the middle of the pasture zone. Carbon stocks were analyzed for the 0.0 to 0.3 and 0.0 to 1.0 m soil layers.

Results and Conclusions

The isotopic composition of the soil was affected by the implementation of iCLF, and the forestry component was a major important factor in the accumulation of C in the soil. The C accumulation in the soil at all sampling positions was greater in the iCLF3 and in the iCLF1 (in the area under the influence of trees) than in the pasture (Table 1). We concluded that iCLF affected soil C and N stocks in the short term, however, long lasting iCLF deployment would be necessary to elucidate the impact of iCLF in the long-term.

Table 1. Weighted means of carbon stocks (Kg ha^{-1}), based on equivalent soil mass, in a clayey Oxisol under integrated crop-livestock-forestry systems (iCLF) and overgrazed pasture in Nova Canaã do Norte, MT, Brazil

Layer	Pasture	iCLF1[1]		iCLF3[2]	
0.0-0.3	55.76	57.49	NS	61.53	**
0.0-1.0	110.63	123.58	**	128.34	*

[1]iCLF with one line of eucalyptus trees by hedgerow; [2]iCLF with three lines of eucalyptus trees by hedgerow. Comparison between the iCLF and overgrazed pasture means were done using the T-test (nominal significance levels: * p = 0.05, ** p = 0.01, *** p = 0.0001, NS = not significant).

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Soil carbon contents in integrated crop-livestock-forest and crop-livestock system in the Cerrado region

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Introduction

Integrated systems are considered an alternative to improve soil chemical and physical quality aiming the sustainable intensification in the Cerrado (Cordeiro et al., 2015). In this study it was evaluated the evolution of soil carbon (C) contents under integrated crop-livestock-forest (ICLF) and crop-livestock (ICL) systems from 2012 to 2016, after three and five years of adoption.

Material and Methods

The study area was located at Embrapa Cerrados Research Center, Brasília, DF, Brazil in the central plateau of the Cerrado region. The soil is classified as Oxisol or clayey Typic Dystrophic Red Latosol. The experiment was established in 2009 in a randomized complete block design with three repetitions. The soil samples (0-5, 5-10, 10-20, 20-30, 30-40 cm depth) were collected in 2012 and 2016 from ICL and ICLF systems. The ICLF system has a forest component of *Eucalyptus urograndis* planted in double lines with 2 m spacing between the trees and 22 m between rows. One sorghum crop and three soybean crops were cultivated between the rows on ICLF and in all area on ICL system, from 2009 to 2012. In February of 2012, after soybean harvesting, a mixture of sorghum/*Brachiaria brizantha* cv. BRS Piatã was sown intercropped. After sorghum harvest, the pasture of *Brachiaria brizantha* cv. Piatã was stablished. Two transects, composed by 10 single soil samples per transect were taken and analyzed for total C contents in an elemental analyzer Vario Macro Cube (Elementar).

Results and Conclusions

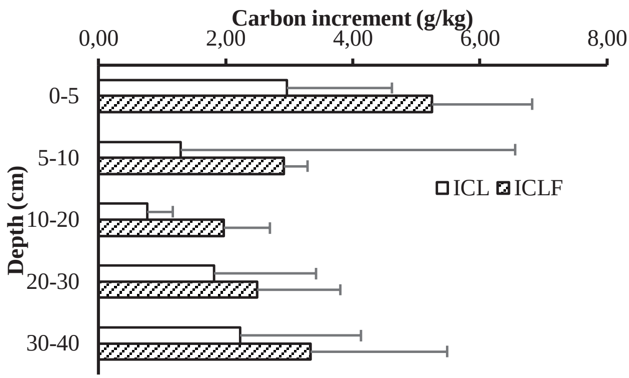

Figure 1. Soil C contents increment to 0-5; 5-10; 10-20; 20-30; 30-40 cm depth under ICLF and ICL between the years of 2012 and 2016.

Considering the increment in C contents between the years of 2012 and 2016, there were no significant differences ($p > 0.05$) between ICL and ICLF systems. However there was a trend where ICLF presented the highest increases in all depths (Figure 1). The ICLF system showed increments in the first three layers 43, 56 and 61 % higher than the ICL system, respectively. The higher carbon content for ICLF probably can be assigned to the contribution of eucalyptus plants litter and first thinning residues, however other factors such as roots and different grazing intensities can affect the soil carbon contents.

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Soil carbon contents in integrated crop-livestock-forest systems

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Introduction.

Pasture and soil degradation in Brazil are the main constraints in conventional systems to animal and grain production. Soil quality in terms of carbon content in these soils is a useful tool to estimate sustainable production. In this study is presented results of 7 years of integrated crop-livestock and crop-livestock-forest systems on soil carbon contents in a clayed Oxisol of the Brazilian Cerrado.

Material and Methods.

The field experiment was carried out in an area of degraded pasture (20^{o} 26′ S, 54^{o} 43′W, 530 m asl) at Embrapa Beef Cattle Research Center, Campo Grande, MS, Brazil since 2008/09. Details are explained in Oliveira et al. (2012), and Pereira et al. (2014). Treatments included ICL (integrated crop-livestock, no trees), ICLF14 (integrated crop-livestock-forest with single line of trees, 14 m apart) and ICLF22 (lines of trees 22m apart). Soybeans were cultivated conventionally in 2008/09 and no-till in 2012/13. Grazed pastures of *Brachiaria brizantha* cv. BRS Piatã were cultivated between eucalyptus trees, after soybeans. Two transects lines, composed by 10 single soil samples/transect, were taken yearly in May-June, to 20 cm depth, and analyzed for total C in an autoanalyser (Sumika/Shimadzu).

Results and Conclusions.

Over a 7 years period, soil under ICL, showed a positive trend and highest values of total C content as compared with ICLF14 or ICLF22 (Table 1). ICL system (no trees) had less competition for light, water and nutrients, and provided greater source of organic matter for soil carbon, than grass/pasture combined with trees. Availability of total grass biomass in ICL appears to be a better source of organic matter, specially root mass, in order to increase soil carbon contents.

Table 1. Soil C contents to 20 cm depth under different integrated systems 7 years after establishment. Data are means of 8 replicates/treatment/year.

System	Years								
	2008	2009	2010	2011	2012	2013	2014	2015	Means
	g C /100 cm^3								
ICL	2,19a	2,34a	2,39a	2,46a	2,68a	2,57a	2,69a	2,63a	2,51a
ICLF14	1,56b	2,07b	1,88b	1,98b	2,03b	2,08b	2,01b	2,02b	1,98b
ICLF22	1,83c	2,35a	2,21a	2,18b	2,51a	2,30c	2,33c	2,31c	2,28c
Means	**1,86**	**2,26**	**2,16**	**2,21**	**2,41**	**2,31**	**2,35**	**2,32**	**2,26**

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Aboveground biomass availability in native and cultivated pastures in the Pantanal Nhecolandia, Brazil

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Livestock activity in the Pantanal has been the main economic activity. It is based almost exclusively on native pasture, which has generally low biomass availability. From the 90's, the Pantanal farmer's began to introduce exotic grasses species replacing native pastures of low quality, in order to increase the forage mass availability (mixed pastures). Monitoring the forage availability depending on the environmental conditions and human activities is essential to define good management practices. It is known that the indications for reducing methane emissions from livestock are linked to the food management and nutritional strategies. This study aimed to monitor the variation of forage mass availability of Pantanal areas with native and mixed pasture, grazing place for cattle. It is part of PECUS Network - Greenhouse gases (GHG) dynamics in livestock production systems from Brazil. The mixed pasture were composed by three species of *Urochloa* (*brizantha*, *humidicola* and *dictyoneura*). The assessment of the pasture biomass production was held twice during the rainy and dry seasons, respectively in April and September of 2014 and 2015. The yearly precipitation in 2013/14 was 1097.9 mm and in 2014/15 1145.8 mm, within the normal range for the area. Biomass measurement was carried out with the use of 0.5m x 0.5m squares, randomly allocated, in a total of 100 sampling points. There are presented the following results: biomass availability (kgDM.ha^{-1}); botanical composition, which is the percentage of the species present in the biomass availability, and soil cover (%). Taking in account the two areas, a greater biomass availability was found in the native pasture one in the rainy season of the first year (5174 kgDM.ha^{-1} in April/14), noting that this area has been fenced prior to the animals enter. No differences were found out in the others evaluations (2267 kgDM.ha^{-1} in Sep / 14; 2686 kg DM.ha^{-1} in April/15 and 2811 kg DM.ha^{-1} in Sep/15). Two species contributed to the botanical composition: *Cynodon dactylon* and *Urochloa subquadripara*. Since both of them are exotic species, this result indicates a highly disturbed area. In the mixed pasture results of the biomass availability were different between years and seasons. They ranged from 1757 kgDM.ha^{-1}; 2435 kgDM.ha^{-1}; 3541 kgDM.ha^{-1} and 4574 kgDM.ha^{-1}, respectively in Apr/14; Sep/14; Apr/15 and Sep/15. The botanical composition was quite different between the first and second year. In 2014 the dominant species was *U. humidicola* whereas in 2015 it was *U. dictyoneura*. The soil cover in native pasture was 100% during all the sampling, and in the mixed pasture ranged from 90 to 96%, which indicates a good soil protection. These data are important in the assessment of methane emission by cattle, since environmental factors such as botanical composition and biomass forage production interfere in the animal metabolism.

Carbon stock on a beef cattle ranch in a savanna woodland area in the Pantanal, Brazil

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The amount and distribution of biomass in agroecosystems expresses the carbon sequestration or mitigation potential of emissions released into the atmosphere. Estimates of total biomass and carbon in vegetation and soil are therefore essential to determine whether an agricultural activity is neutral, a source or a sink for greenhouse gases. The objectives of this study were to estimate the total stock of biomass and carbon contained in the native vegetation and the soil on a beef cattle farm in a savanna woodland area in the Nhecolândia region of Pantanal in Corumbá, state of Mato Grosso do Sul, Brazil. Woody biomass (stems and roots) was estimated from a statistical regression analysis of field data (destructive sampling). The best regression adjustment was obtained with exponential or potential equations, depending on the species. Herbaceous biomass (shoots and roots) was also estimated from field data (destructive sampling). Herbaceous roots and fine roots (of woody species) were collected at depths of 0 to 40 cm, using a zinc box for the former and a soil auger for the latter, both with known volumes. Soil carbon sampling was carried out at seven points according to the plant species under study, at depths of 0-10 cm, 10-20 cm and 20-40 cm. Soil bulk density was estimated based on pedogenetic relationships. The total biomass (above and below ground level) was estimated at 161.34 Mg ha^{-1} and total carbon at 75.42 Mg ha^{-1}. The soil carbon stock was estimated at 17.85 Mg C ha^{-1}, which, added to the total biomass carbon, resulted in 93.27 Mg C ha^{-1}. Unlike what

has been observed in other savanna woodland environments, the data revealed a relatively higher aerial biomass than root biomass, as well as a higher carbon stock in biomass than in soil. Proportionally, the soil was found to store only 19.14% of the total carbon stock of this agroecosystem. (These findings are part of the EMBRAPA PECUS Network - Greenhouse gases dynamics in livestock production systems from Brazil - and partially funded by Conservation International, CI- Brazil).

Carbon stock in areas of pasture and native vegetation

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Introduction

One of the factors that may indicate the quality of soil is the organic matter (SOM), directly linked to structural, biological and chemical soil characteristics, in addition it is stock for carbon (C) and nitrogen (N). For grazing areas, stocks of C and N vary when compared to natural vegetation inventories. Factors such as the type of management adopted, climatic condition and renewal of plants can contribute to stocks become smaller over land use. Thus, the objective of this study was to evaluate the initial and final C stocks in pasture under two types of grazing and native vegetation.

Material and Methods

The experiment was conducted at FZEA / USP in Pirassununga / SP. The experimental area was cultivated with *Brachiaria brizantha* cv. Marandu and evaluations were made in continuous and rotational grazing method with stocking rate as a variable. The period of use of the area was from 01/13/2014 to 10/20/2014 and after the experiment finishing date, samples were collected in continuous and rotated grazing systems and in native vegetation (forest). The samples were collected at depths of 0-5, 5-10, 10-20, 20-40, 40-60, 60-80, 80-100 cm, with four replications each. The quantification of the total content of C and N, were held in the elemental analyzer LECO CN, at Embrapa Meio Ambiente, Jagurariuna-SP. The samples were dried in an air forced circulation oven at 40 °C for 72 hours (or until constant weight) sieved in 100 mesh (0.149 mm). From the concentrations of carbon (C) in soil and densities (obtained from soil samples of volumetric rings at 60 cm depth) C stocks were calculated in each layer and treatments were compared. The results were submitted to analysis of variance and the means compared by Tukey test at the 5% level of probability using SAS software.

Results and Conclusions

The results for the carbon stocks are shown in Table 1.

Table 1. Carbon stock in pasture of Brachiaria brizantha cv. Marandu and native vegetation (forest).

Treatments	Depths (cm)						
	0 to 5	5 to 10	10 to 20	20 to 40	40 to 60	60 to 80	80 to100
Continuo	13.85	10.97	28.322	34.175	27.425	26.187	20.917
Rotational	15.087	11.912	20.205	52.37	29.415	28.465	25.315
Native Veget.	32.11	21.37	36.92	61.11	50.34	41.92	37.02
p <0.05	0.3707	0.3293	0.3339	0.001	0.3458	0.348	0.0056

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