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METHANE EMISSIONS AND MILK YIELDS FROM DAIRY COWS UNDER INTEGRATED SYSTEMS

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ABSTRACT
Integrated systems have been shown to be viable technology for increase agricultural yields and reduce environmental impact. The enteric methane emissions and milk yields were assessed in crossbred grazing cows in the Cerrado region of central Brazil. Treatments were allocated in a completely randomized design and consisted of two dairy production systems based on *Megathyrsus maximus* cv. Mombaça cultivated in Integrated Crop-livestock (ICL) or Integrated Crop-livestock-forestry (ICLF). The treatment means were compared using the F test at 5% probability of error. Mombaça grass presented the same forage yield and 22% more CP (P=0.0105) in ICLF. Treatments did not differ for any enteric methane emission variable; however, the cows' fat milk content and fat corrected milk yield (FCM) were, respectively, 7.3% and 9.7% higher in ICLF (P<0.05). In conclusion, crossbred dairy cows produce more FCM in ICLF, with the same methane intensity and production when grazing Mombaça grass under ICL or ICLF systems.
Key words: cattle; Girolando; greenhouse gas

INTRODUCTION

Integrated/mixed systems has shown to be a viable strategy to increase agricultural yields with more efficient use of natural resources and lower environmental impact. Among the benefits, crop-livestock-forestry (CLF) systems have been indicated for dairy production in order to improve animal welfare and yield, especially in tropical conditions. Some traits may be altered in grasses when cultivated in silvopastoral systems and these changes may affect animal production in pasture-based diets (PACIULLO et al., 2009; SANTOS et al., 2018). The milk yield as well as enteric methane – CH_4 emissions are influenced by the pasture nutritional value (PEDREIRA et al., 2009). Therefore, studies that evaluate ruminant production coupled with greenhouse gases (GHG) emissions, in particularly enteric CH_4, are crucial to better characterized the systems efficiency and sustainability. This work aimed to compare the methane emissions and milk yields from grazing Girolando dairy cows under Integrated Crop-livestock (ICL) and Integrated Crop-livestock-forestry (ICLF) systems in the Cerrado region of central Brazil.

MATERIAL AND METHODS

The work was carried out at the Center for Technologies for Dairy Zebu Breeds (CTZL), located in Brasília – DF at 15°57'09" S, and 48°08'12" W, altitude 998m, in a tropical savanna climate (Aw Köppen-Geiger classification). It was used a completely randomized design, with two treatments. Seventeen lactating Holstein x Zebu cows (mostly 1/2 and 5/8 Holstein × Gyr) with 513 ± 60kg liveweight (LW) and 117.5±49 days in milk (DIM) were used as replications (testers), being eight animals for ICL and nine for ICLF. All experimental procedures were approved beforehand by the Ethics Committee on Animal Use at Embrapa Cerrados (protocol nº 533-2541-1/2017). Treatments consisted of production systems based on guineagrass (*Megathyrsus maximus* syn. *Panicum* *maximum* cv. Mombaça) established in succession after soybean under ICL or ICLF with single lines of *Eucalyptus urograndis* trees (east-west orientation, 25m between rows, 130 trees/ha). The trees were planted in 2013 and the pastures in 2016. In 2019, the average eucalyptus trees height was 28m. The trials took place in February, March and May 2019, comprising the rainy, rain-dry transition and beginning of drought periods in Cerrado region, respectively. Cows were kept on pasture with mean daily herbage allowance (HA) ranging from 12 to 14 kg of dry mass (DM) to 100 kg animal LW. Each experimental unit of 8 ha was divided in 12 paddocks managed using rotational stocking at variable stocking rate, with 2 or 3 days of grazing and 22 or 33 days of rest in the rainy or dry season, respectively. Concentrate with 180 g/kg of crude protein and 760g/kg of total digestive nutrients was offered in the proportion of 1 kg of concentrate for every 3 kg of milk produced above 8 kg of milk per animal per day. The concentrate was supplied during the morning and afternoon milking. Water and mineral mix (90 g/kg of phosphorus) were offered *ad libtum*.

The sulphur hexafluoride - SF6 tracer dilution gas technique (JOHNSON et al., 1994) was used to estimate enteric CH_4 emissions during at least four consecutive days per animal in each experimental period. Individual milk production and milk fat content were measured at least once in every experimental week. The daily milk yield was expressed in fat-corrected milk basis (4%FCM) according to (GAINES*,* 1928). Pre-grazing canopy height was measured in 90 points per paddock in ICL and 120 in ICLF. Pre-grazing forage mass at the soil level was evaluated in 12 points (1 × 1 m) in 3 transects in the ICLF and 9 points (1 × 1 m) in 3 transects in the ICL treatments. Forage hand-plucked were sampled all over the paddock during grazing days for nutritional value analysis. All forage samples were dried at 55º C during 72 h to estimate dry matter. After drying, hand-plucked samples were ground in a 1 mm screen Wiley mill and estimates of crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and *in vitro* dry matter digestibility (IVDMD) were obtained by near infrared reflectance spectroscopy (NIRS). The Proc GLM was used to analyze data from animal performance and PROC MIXED (SAS, 1998) to analyze data from pasture. Type of production system and trial were considered as fixed effects, animal as random effect and pasture traits as repeated measures over time. The treatment means were compared using the F test at 5% probability of error.

RESULTS AND DISCUSSIONS

The pasture canopy variables did not differ between treatments (Table 1), pointing that Mombaça grass presented same yield when cultivated both in ICL or ICLF systems. This is a desirable trait when choosing a grass to be cultivated under shading. In some silvopastoral systems pasture intercropping may be not feasible due to the competition with trees for water and nutrients and by low light availability (OLIVEIRA et al., 2007). Therefore, the arrangement and management of trees are of great relevance for animal performance in ICLF systems. According to Santos et al (2016) planting trees in the east-west direction orientation, setting the spacing between rows greater than 22 m and establishing simple lines of trees may favor pasture production. In the present study the ICLF arrangement with a lower density of tress (130 trees/ha) did not impair the pasture production. When it comes to nutritive value, treatments differ only for CP (P=0.0105). Mombaça grass cultivated in ICLF presented 22% more CP than in ICL. Santos et al (2018) founded CP content 28.9% higher for Piatã grass (*Urochloa brizantha, syn. Brachiaria brizantha*) cultivated in ICLF system with 22m between rows and 417 trees/ha. Highest CP contents in pastures under shade compared to ones in full sunlight access are commonly found in literature and can be explained by dilution effect, delay in forage maturity stage and higher nutrient cycling in silvopastoral systems (LEMAIRE; CHARTIER, 1992; PACIULLO et al., 2007; BELESKY et al., 2011).

Table 1. Pre-grazing forage mass and canopy height and nutritive value of *Megathyrsus maximus* cv. Mombaça cultivated in ICL and ICLF systems from December to May 2019, Brasília, DF, Brazil.

Variable	ICL	ICLF[1]	*F Prob*
		Pasture Canopy Variables	
Pre-grazing forage mass (kg/ha)	4,600	4,800	0.7885
Canopy height (cm)	73	66	0.1028
		Forage Nutritive Value	
CP (g/kg)	112	137	0.0105
IVDMD (g/kg)	645	658	0.1265
NDF (g/kg)	621	621	0.9394
ADF (g/kg)	348	344	0.1898

[1] *Eucalyptus urograndis*, single lines, east-west orientation, 25m between rows, 130 trees/ha. CP = crude protein, IVDMD = *in vitro* dry matter digestibility, NDF = neutral detergent fiber, ADF = acid detergent fiber.

The quantity and nutritional value of pasture available can affect feed intake and animal performance. In the present study, either for ICL or ICLF systems, the pre-grazing forage mass with 12% to 14% allowance and the pasture average levels of CP and IVDMD assured adequate conditions to animals express its milk production. Despite the absence of differences in terms of forage fibrous fraction and IVDMD contents, the highest CP and probably better animal welfare may have affected the cow's intake behavior and, consequently, increased 7.3% individual milk fat (P=0.0008) content and 9.7% fat-corrected milk production (P=0.079) in ICLF. The production level affects the enteric CH_4 emissions. In general, the milk yield improvement results in more enteric CH_4 production (g/d) although the CH_4 intensity (g/kg FCM) tends to decrease. Emission intensity may be an indicator of systems efficiency since higher livestock products yields associated to lower CH_4 emissions are desirable. The differences in milk production and composition did not impact (P>0.05) any enteric CH_4 emissions variables (Table 2). Thus, ICL and ICLF did not differ in terms of CH_4 production and intensities. The systems average CH_4 production (438.9 g) was higher than the observed for Primavesi et al. (2004) (331 g/d) and Pedreira et al. (2009) (314g/d) for crossbred cows producing 13.3 and 11.5 L/d and grazing *Urochloa decumbens* and *Megathyrsu maximus* cv. Tanzânia, respectively. These differences might be explained mainly by the highest production level of the cows and the energy content of the forage in the present study. Nevertheless, in terms of CH_4 intensity the average value (27.3 g/L FCM) was close to 25.3 g/L reported by Primavesi et al. (2004) and 27.3g/L by Pedreira et al. (2009).

Table 2. Milk yields, milk fat and enteric methane (CH_4) emissions from crossbred cows grazing *Megathyrsus maximus* cv. Mombaça cultivated in ICL and ICLF systems. Brasília, DF, Brazil.

Variable	ICL	ICLF[1]	*F Prob*
Milk yield (L/d)	16.2±5.1	17.3±5.2	0.1647
Milk fat (%)	4.1±0.6	4.4±0.6	0.0008
Fat corrected (4%) milk yield – FCM (L/d)	16.4±5.0	18.0±4.9	0.0079
CH_4 (g/day)	441.5±196.0	436.4±191.0	0.7026
CH_4 (gCH_4/L FCM/d)	28.5±12.0	26.1±13.7	0.1043

[1] *Eucalyptus urograndis*, single lines, east-west orientation, 25m between rows, 130 trees/ha.

CONCLUSIONS

Data indicated that crossbred dairy cows grazing Mombaça grass produce more FCM in ICLF compared to ICL system, with the same CH_4 production and intensity.

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REFERENCES

BELESKY, D. P.; BURNER, D. M.; RUCKLE, J. M. Tiller production in cocksfoot (*Dactylis glomerata*) and tall fescue (*Festuca arundinacea*) growing along a light gradient. **Grass and Forage Science**, v.66, p.370–380, 2011.

GAINES, W. L. **The energy basis of measuring milk yield in dairy cows.** Report No. 308. Urbana, IL., USA: University of Illinois Agricultural Experiment Station, 1928. p.436-438.

JOHNSON, K.; HUYLER, M.; WESTBERG, H.; LAMB, B.; ZIMMERMAN, P. Measurement of methane emissions from ruminant livestock using a SF6 tracer technique. **Environmental Science and Technology**, v.28, p.359–362, 1994.

LEMAIRE, G.; CHARTIER, M. Relationships between growth dynamics and nitrogen uptake for individual sorghum plants growing at different plant densities. In: LEMAIRE, G. (Ed.) **Diagnosis of the Nitrogen Status in Crops.** Paris: INRA-Station décophysiologie des Plantes Fourragères, 1992. p.3-43.

OLIVEIRA, T. K. D.; MACEDO, R. L. G.; SANTOS, Í. P. A. D.; HIGASHIKAWA, E. M.; ENTURIN, N. Produtividade de *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf cv. Marandu sob diferentes arranjos estruturais de sistema agrossilvipastoril com eucalipto. **Ciência e Agrotecnologia**, v.31, p.748–757, 2007.

PACIULLO, D. S. C.; CARVALHO, C. A. B. D.; AROEIRA, L. J. M.; MORENZ, M. J. F.; LOPES, F. C. F.; ROSSIELLO, R. O. P. Morfofisiologia e valor nutritivo do capim-braquiária sob sombreamento natural e a sol pleno. **Pesquisa Agropecuária Brasileira**, v.42, p.573–579, 2007.

PACIULLO, C. D. S.; LOPES, F. F. C.; MALAQUIAS JR, D. J.; VIANA FILHO, A.; RODRIGUEZ, N. M.; MORENZ, F. M. J.; AROEIRA, M. L. J. Características do pasto e desempenho de novilhas em sistema silvipastoril e pastagem de braquiária em monocultivo. **Pesquisa Agropecuária Brasileira**, v.44, n.11, p.1528-1535, 2009.

PEDREIRA, M. S.; PRIMAVESI, O.; LIMA, M. A.; FRIGHETTO, R. T.; OLIVEIRA, S. G.; BERCHIELLI, T. T. Ruminal methane emission by dairy cattle in southeast Brazil. **Scientia Agricola**, v.66, p.742-750, 2009.

PRIMAVESI, O.; FRIGHETTO, R. T.; PEDREIRA, M. S.; LIMA, M. A.; BERCHIELLI, T. T.; BARBOSA, P. F. DO. Metano entérico de bovinos leiteiros em condições tropicais brasileiras. **Pesquisa Agropecuária Brasileira**, v.39, n.3, p.277-283, 2004.

SANTOS, D. C.; GUIMARAES JUNIOR, R.; VILELA, L.; MACIEL, G. A.; FRANÇA, A. F. DE S. Implementation of silvopastoral systems in Brazil with eucalyptus urograndis and *Brachiaria brizantha*: productivity of forage and an exploratory test of the animal response. **Agriculture Ecosystems & Environment**, v.266, p.174-180, 2018.

SANTOS, D.C., GUIMARÃES JÚNIOR, R., VILELA, L., PULROLNIK, K., BUFON, V.B., FRANÇA, A.F. Forage dry mass accumulation and structural characteristics of Piatã grass in silvopastoral systems in the Brazilian savannah. **Agriculture Ecosystems & Environment**, v.233, 16–24, 2016.

SAS. SAS Institute Inc. **SAS user's guide:** release. 6.03. Cary, 1998. 1028p.