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Introduction

Agriculture contributes 13.5% of global emissions of greenhouse gases (GHG) (IPCC 2007), and about 50% of CH_4 and 60% N_2O from anthropogenic sources, while livestock contributes an additional 18% of global GHG emissions (FAO, 2006). Among the various sources with a potential negative impact on the environment, methane emissions for which livestock are mainly responsible have been highlighted for the agricultural sector. Studies on means to mitigate these emissions, and understand how integrated crop and livestock production systems may contribute to the reduction of greenhouse gases, are essential for the creation of public policies for environmental preservation.

The objective in this study was to evaluate how strategies for grazing management can influence animal production and emission of methane in areas of crop-livestock integration.

Methods

The study was conducted in Southern Brazil (30°05'22"S, 51°39'08'W). The experiment was a component of an integrated crop-livestock system (ICLS) started in 2003 in which summer/autumn soybeans and/or corn are sown in a no-till system. In winter/spring, pastures of Italian ryegrass (*Lolium multiflorum* Lam.) are established by self-seeding. The data presented here was measured during a 114 day grazing period which started in July 11th and ended in November 1st, 2012. Texel x Suffolk lactating ewes were used, all multiparous, with an average live weight of 59.5±6.0 kg.

The experimental design was randomized blocks, with a factorial arrangement (2x2) with three replicates. The treatments consisted of two stocking methods (continuous and rotational) and two grazing intensities: herbage allowance of 2.5 (moderate) and 5 (low) times the potential dry matter (DM) intake of animals. The live weight gain (LWG) was considered the sum of the LWG of the ewes and lambs. To determine the dry matter intake (DMI) three tester animals from each experimental unit were monitored, using the n-alkanes technique. To quantify methane emission (CH_4) the technique of tracer sulfur hexafluoride (SF_6) described by Johnson *et al.* (1994) was used. Statistical analysis was performed using mixed models (SAS Inst. Inc., Cary, NC, USA, 2011) with fixed effects for methods, intensities and blocks and random effect for interaction. When differences between means were detected, the treatments were compared using the Tukey's test at a significance level of 5%.

Results

There was no interaction between stocking methods and grazing intensities (P>0.05) for all variables shown in Table 1. The DMI (g/animal/day) was similar for all treatments (P>0.05). The emission of CH_4 (g/animal/day) did not differ (P>0.05) between treatments. The GEI was higher in continuous stocking method (P<0.05). The amount of methane generated (kg CH_4/ha/day) was affected by grazing intensity, with higher value in the moderate grazing, while the g CH_4/kg/GPV/ day was higher in rotational stocking method, regardless of grazing intensity (P<0.05; Table 1).

Discussion

Phetteplace *et al.* (2001) report values of 8.4, 6.4 and 1.3 kg CO_2 eqv./LWG for beef cows, grazing cattle after weaning and feedlot cattle, respectively. In this study we observed similar or even smaller values, represented by averages of 3.92 kg CO_2 eqv./LWG for continuous stocking and 6.03 kg CO_2 eqv./LWG for rotational stocking. This means that practice of the rotational grazing generates an average emission that is 35% greater than the continuous stocking method. This highlights the importance for farmers to take into account CH_4 emission and not simply select a grazing strategy base on beef output, product quality and impacts on grassland condition.

Conclusion

This study sought to investigate the best production system, in other words, the stocking method and/or grazing intensity in terms of more efficient emission of

Table 1. Dry matter intake (DMI) and methane emission by ewes grazing Italian ryegrass at different stocking methods (continuous and rotational) and grazing intensities (low and moderate).

Variables	Continuous		Rotational		Mean±MSE	P_I	P_M	P_{IxM}
	Low	Moderate	Low	Moderate				
DM intake								
g/animal/day	1476.7	1629.2	1563.5	1919.3	1673.8±83.9	0.143	0.272	0.548
CH_4 emission								
g/animal/day	41.7	41.2	38.7	38.8	39.9±1.3	0.952	0.443	0.913
g/kg DMI	27.7a	26.7a	21.9b	19.3b	23.6±1.1	0.398	0.013	0.682
% GEI	8.6a	8.2a	6.9b	6.1b	7.3±0.3	0.351	0.017	0.826
kg/ha/day	0.540b	0.805a	0.643b	1.00a	0.766±0.05	0.007	0.114	0.590
g/kg LWG/day	164.0b	178.5b	189.5a	215.0a	190.0±6.6	0.092	0.016	0.619

DM=dry matter; %GEI=gross energy intake; LWG=live weight gain; MSE=mean standard error; P_I=probability for grazing intensity; P_M=probability for stocking method; P_{IxM}=probability of interaction between grazing intensity and stocking method. Means followed by lowercase letters on line differ by F test (*P*<0.05).

CH_4 animal in ICLS. The data suggests that even if the moderate grazing intensity has higher methane emissions per area, the continuous stocking system is the most efficient, as it has lower methane emissions per kg of live weight gain, regardless of grazing intensity.

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