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Methane emissions from ruminants in integrated crop-livestock systems

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Introduction

Ruminant livestock produce ~80 Mt of methane (CH_4) annually, accounting for ~33% of global anthropogenic emissions of CH_4 (Beauchemin et al. 2008). CH_4 is a powerful greenhouse gas, with a global warming potential of 25 (Eckard et al. 2010) and represents a significant loss of dietary energy (2–12% of gross energy of feeds; Patra 2012) in the ruminant production system. Despite greenhouse gas (GHG) emissions having become an increasingly important topic worldwide, there is still high variability in the estimated values of these emissions, mainly those attributable to livestock (range 8–51%; Herrero et al. 2011). This variability creates confusion among researchers, policy makers and the public, particularly in tropical/subtropical regions. Therefore, using rigorous and internationally accepted protocols, a Brazilian national project was established to contribute to improving estimates of GHG emissions attributable to livestock in Brazilian ruminant production systems. Moreover, enteric CH_4 emissions are a major challenge for research, in order to develop technologies and strategies for sustainable ruminant production systems in the future (Eckard et al. 2010).

In recent years, integrated crop-livestock systems (ICLS) have gained interest due to, for example, the potential abatement of methane emissions from livestock production: directly through a reduction in CH_4 per unit of animal product resulting from the increase in feed quality and animal welfare (i.e. improved environmental temperature for ICLSs with trees); and indirectly through reduction of area subjected to land use changes (i.e. leading to loss of soil C stocks).

This paper deals with: the preliminary results from quantifying CH_4 emissions by beef heifers grazing in 2 ICLSs (i.e. production systems that integrate corn or soybean crops during the warm season, and cattle grazing on pasture during the cool season, on the same area and in the same cropping year, with or without trees); and how these findings contribute to determining soil C balance and mitigation measures.

Materials and Methods

A field experiment was carried out at the Agronomic Institute of Paraná, Ponta Grossa, PR (25°07’22” S, 50°03’01” W), in a subtropical area in southern Brazil. The effect of 2 nitrogen (N) fertilization treatments (90 and 180 kg/ha) and 2 ICLS (with and without trees) were investigated in a complete randomized block design, with 4 treatments and 3 replicates each (a total of 12 paddocks of 0.99 ± 0.231 ha each). In 2006, 3 tree species (eucalyptus, *Eucalyptus dunnii;* pink pepper, *Schinus molle*; and silver oak, *Grevillea robusta*) were planted at 3 x 14 m spacing (237 trees/ha), on 6 of the 12 paddocks. In May 2012, a mixture of black oat + ryegrass (*Avena strigosa* + *Lolium multiflorum*) was sown for cattle grazing during the cool season.

The paddocks were managed in order to maintain a target surface sward height of 20 cm by adjusting the number of grazing animals weekly (put-and-take approach). In August 2012, a gas collection campaign was

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performed over 5 days in order to quantify CH_4 emissions by cattle. CH_4 production was estimated by the sulphur hexafluoride (SF_6) tracer technique (Johnson et al. 1994) for 2 animals per paddock (total of 24 Purunã beef breed heifers). Animals were selected based on their live weight (mean LW, 286 ± 6.7 kg), measured prior to the SF_6-campaign, so that CH_4 emissions could be expressed on a LW basis. CH_4 budget per unit ground area was calculated by multiplying the average CH_4 emission rate per kg of LW (CH_4/day/kg LW) x number of days x live weight of animal x animals per area. The data were statistically analyzed using ANOVA with the Statgraphics (Magnugistics, USA) package. Prior to ANOVA, data were normalized using log transformation.

Results and Discussion

There were no significant treatment (i.e. N fertilization levels and ICLS) effects for CH_4 emissions per unit LW ($P>0.05$). CH_4 emissions ranged from 0.32 to 0.93 g CH_4/d/kg LW, but tended to be lower for livestock with tree shelter than without (Figure 1). Variation coefficients were 28 and 35% for the systems with and without trees, respectively; this may explain the limited treatment effect, and underline the need to increase the number of sampled animals equipped with an SF_6 collection device or the number of measurement occasions throughout the year. A range from 0.36 to 0.52 g CH_4/d/kg LW was observed by Allard et al. (2007) over 8 measurement times in temperate semi-natural grassland. Similar values (0.30–0.53 g CH_4/d/kg LW) were reported for beef steers in a recent review (Eckard et al. 2010). These results highlighted likely excessive CH_4 emissions in our system when compared with the values cited above. Since in species-rich grasslands animals cope with diverse combinations of plant species and parts, methane production could be reduced by feeding forage with higher quality than that of plant communities containing only few grass species.

Annual emissions of CH_4 from enteric fermentation, using values per unit ground area (means of 2 years, i.e. 1,030 kg LW/ha), were estimated at 5.54 g CH_4/m^2. However, this value was obtained assuming a grazing period around 100 days per year on areas with ICLS. The ICLS described here can be used for finishing animals. On the other hand, summer pastures, associated with winter species, could be used in order to supply forage throughout the year. Accordingly, a diversity of integrated systems is possible, making it hard to estimate annual CH_4 production by animals. Further, this CH_4 budget per unit ground area was calculated by using the average CH_4 emission rate per kg of LW obtained from a single gas collection campaign, which allows us only an approximative value for the grazing period. Therefore, additional research efforts will be required to make further progress in our current understanding of methane emissions per unit of animal products of such integrated systems.

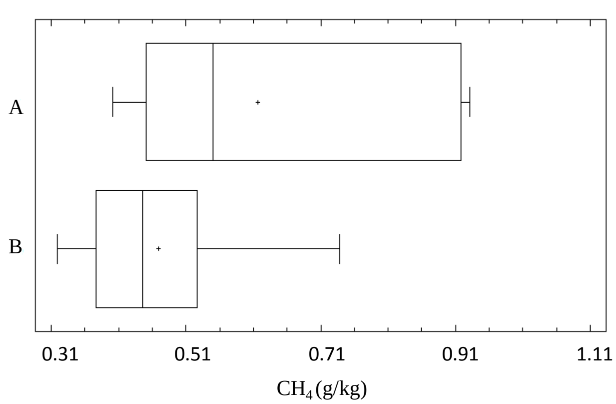

Figure 1. Ranges of CH_4 (g/d/kg of live weight) emissions from ruminants in two integrated crop-livestock systems: A, without trees; and B, with trees.

Conclusions

Presence of trees tended to reduce methane emissions by cattle in integrated crop-livestock systems. Additional methane measurement occasions are planned for the cool-season grazing of 2013 in an attempt to provide more detailed insights into the underlying processes.

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