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Carbon footprint in different beef production systems on a southern Brazilian farm: a case study

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ABSTRACT

The carbon footprint (CF) of beef production is one of the most widely discussed environmental issues within the current agricultural community due to its association with climate change. Because of these relevant and serious concerns, the beef cattle industry is under increasing pressure to reduce production or implement technological changes with significant consequences in terms of beef marketing. The goals of this study were to evaluate the CF per 1 kg of live weight gain (LWG) at the farm gate for different beef production systems in the southern part of Brazil. Aberdeen Angus beef-bred cattle were assigned to one of seven categories: natural grass; improved natural grass; natural grass plus ryegrass; improved natural grass plus sorghum; cultivated ryegrass and sorghum; natural grass supplemented with protein mineralised salt; and natural grass supplemented with protein-energetic mineralised salt. Monte Carlo analysis was employed to analyse the effect of variations of dry matter intake digestibility (DMID), total digestible nutrients (TDN) and crude protein (CP) parameters in methane (CH_4) enteric, CH_4 manure, nitrous oxide (N_2O) manure and N_2O N-fertiliser. The method used was a comparative life cycle assessment (LCA) centred on the CF. The CF varied from 18.3 kg CO_2 equivalent/kg LWG for the ryegrass and sorghum pasture system to 42.6 kg CO_2 equivalent/kg LWG for the natural grass system, including the contributions of cows, calves and steers. Among all grassland-based cattle farms, production systems with DMID from 52 to 59% achieved the lowest CO_2 emissions and the highest feed conversion rate, thereby generating lower CH_4 and N_2O emissions per production system. Because the feed intake and feed conversion rate are one of the most important production parameters in beef cattle production with an obvious risk of data uncertainty, accurate feed data, which include quantity and quality, are important in estimates of CF for LWG. The choice of adequate feeding strategies to mitigate greenhouse gas (GHG) emissions may result in better environmental advantages.

1. Introduction

Beef cattle production is one of the most important agricultural activities in Brazil and is characterised by a large number of animals and extensive pasture. The Brazilian beef industry is under considerable pressure from national and international communities concerned with global warming based upon the notion that cattle production is responsible for over 50% of national greenhouse gas (GHG) emissions, which are directly related to the agricultural sector. From these emissions, 45% are caused by cattle enteric fermentation (methane, CH_4), as well as urine and faeces decomposition, which releases nitrous oxide (N_2O), and other less relevant gases (Bungenstab, 2012). The Brazilian herd has approximately 205 million heads occupying 170 million hectares of pasture according to a census of the Brazilian Institute of Geography and Statistics (IBGE, 2008).

In the southern Brazilian state of Rio Grande do Sul, there are approximately 13.2 million heads of cattle in 11.7 million hectares,

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which is approximately 53.7% of the total area of this state (IBGE, 2008). In this region, beef production relies on the management of natural pasture as the main source of animal feed. These grasslands exhibit high biodiversity and are characterised by high production and high nutritional quality during spring and summer but low production and low nutritional quality during autumn and winter when it is necessary to use cultivated pastures or supplementation as feed support. The regional pastures show more than 450 species of native grasses and approximately 150 species of legumes. Local biodiversity losses could affect the potential for sustainable animal and plant production in this region due to the loss of valuable species of natural forages, feed, food, ornamental and medicinal species and the reduction of environmental services provided by grassland vegetation, such as erosion control and soil carbon sequestration, which can mitigate climate change (Pillar et al., 2009). Thus, the local cattle industry is under scrutiny from both producers and the public.

In Brazil, approximately 70% of CH_4 emissions are derived from cattle production (MCT, 2010). Most of the CH_4 has its origin in enteric fermentation and is a physiological result of digestion in ruminant animals. These emissions represent, in part, the natural inefficient capture of energy contained in animal feed. The use of such techniques as the intensification of activity via the appropriate management of pastures and improved quality of food supplied to animals mitigates the production of GHG (Bungenstab, 2012; Harper et al., 1999; McAllister et al., 2011; O'Hara et al., 2003).

Thus, better pasture management, supplementary feeding practices, substitution of forage for food containing less fibre, adequate sanitary control, integrated management of animal wastes and the genetic improvement of animals are techniques that may improve livestock productivity and reduce emissions linked to beef cattle production (Barioni et al., 2007; Boadi et al., 2004; Iqbal et al., 2008; Oliveira et al., 2007; Pedreira et al., 2004; Segnini et al., 2007; Wilkins and Hump, 2003).

Emissions from cattle have been attributed to production processes that involve inputs (e.g., fertilisers and forage cultivation) and production itself (CO_2, CH_4 and N_2O). Regarding the latter, CH_4 emissions are produced by enteric fermentation and manure, and N_2O emissions are emitted mostly by manure. There is also the potential use of nitrogen fertilisers in pastures emitting N_2O (Luo et al., 2010). Among these GHG, the most important is CH_4, due to the relatively large amount emitted (Beauchemin et al., 2008; Biswas et al., 2010; Steinfeld et al., 2006).

Seasonal changes in cattle production efficiency combined with the constant attention given by the media in highlighting beef cattle as a major source of GHG, has pushed for limitations of the cattle herds in an attempt to minimise their putative, negative and environmental effects. Analysis of the carbon footprint (CF) of cattle production identifies the production procedures or techniques in which emissions may be reduced using improved efficiencies, estimates the amount and breakdown of GHG emissions and provides a mechanism to track efforts in improving efficiencies and reducing emissions (Wiedmann and Minx, 2008).

The aim of this study was to quantify and analyse the variability of emissions, as CF per functional unit (FU), for typical southern Brazilian beef production systems with different options for animal feed intake data obtained from a beef cattle farm, and from Brazilian governmental reports and databases. For this purpose, we required definitions for (a) the typical beef production systems operating in southern Brazil; (b) the system boundary and functional unit to be applied; and (c) the dietary and scenario options to be considered in southern Brazilian beef production that may lead to reduced GHG emissions.

2. Methods

The contribution to climate change associated with seven different production systems was evaluated using a Life Cycle Assessment (LCA) approach (Finnveden et al., 2009; Guinée et al., 2001). This study uses LCA methodology to relate default data provided by Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007) for CO_2, CH_4, and N_2O emissions related to feed and animal manure with data now available from the Brazilian Agricultural Research Corporation (EMBRAPA) (Lima et al., 2012; MCT, 2010).

In the inventory analysis phase, inputs from the environment (resources used) and outputs to the environment (emissions) associated with the product were considered. In the impact assessment phase, inputs and outputs were interpreted in terms of Global Warming Potential (GWP).

2.1. Definition of the production system

This study was performed at a farm in the Western Frontier region of the state of Rio Grande do Sul (Fig. 1), in the Southern part of Brazil (28°56′11.78″S; 55°47′01.68″O).

This Western Frontier region has a large beef cattle herd (ca. 3,300,000 heads), which is approximately 22% of the total cattle herd in this state (IBGE, 2008). The climatic classification of the region is wet subtropic Cfa in Koeppen classification (Koeppen, 1948), and the average precipitation is 1598 mm/year, without periodical dry seasons. The average annual temperature is 19.8 °C. Cattle are bred extensively; the herds forage on natural and cultivated pasture with variable stocking rates, and they are the source for most of the meat production in this region.

In addition to natural grass, other pastures for beef cattle feed include improved natural grass (a mixture of natural grass, ryegrass and clover), and ryegrass and sorghum. In the farm analysed, all farmed animals are of the *Bos taurus* breed (Aberdeen angus). It was assumed that calves are weaned at approximately 180 days and that from this period onwards, the animals graze on grass. From 180 days to when the fattening weight is attained, the animals are allowed to graze on grass according to the scenarios described in Section 2.2. The animal fattening weight was 430 kg live weight for all the scenarios.

The data used in this paper are the average of data collected during six years of observation of 420 animals in different cattle

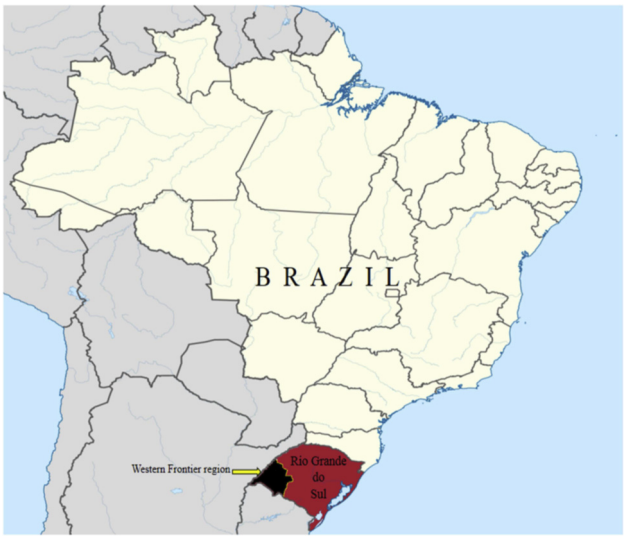

Fig. 1. Geographical position of Rio Grande do Sul. Source: GoogleMaps (2013).

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