The carbon footprint of organic dairying in Europe

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Abstract

Dairy farming is the largest agricultural contributor to greenhouse gas emissions in Europe. In this study, the carbon footprint of organic dairying was evaluated by means of a life cycle assessment, based on real farm data from six European countries: Austria, Belgium, Denmark, Finland, Italy and United Kingdom. A total of 34 farms were analysed. The assessment was carried out using an attributional approach with system boundaries from cradle to farm gate. For the dairy production, a functional unit of 1 kg of energy corrected milk was used. The results gave an average of 1.04 ± 0.29 kg CO_2 equivalents per kg of energy corrected milk, which is consistent with recent previous studies. The main contributor to this is enteric fermentation from producing animals, resulting in 43 % of total GHG emissions, which is also consistent with previous studies.

Introduction

Greenhouse gas (GHG) emissions have been of great environmental concern and a focus for life cycle assessment (LCA) studies worldwide. According to Gerber et al. (2013) global cattle farming contributes an annual total of 4.6 Gt CO_2-eq, of which milk production contributes 1.4 Gt CO_2-eq per year. Lesschen et al. (2011) estimated the GHG emissions originated in the dairy sector to be 195 Tg CO_2-eq per year. Hagemann et al. (2011) quantified the carbon footprint of 38 countries ranging from 0.80 to 3.07 kg of CO_2-eq per kg ECM milk. All such previous studies show enteric fermentation to have a large impact on GHG emissions. In this paper, we have assessed the carbon footprint of a variety of organic farms in six countries. GHG emission hot spots in organic dairy production are described. The aim of this study is to evaluate the carbon footprint of organic dairy farming in Europe based on using LCA approach, and to provide details of emission hotspots for use in mitigation design.

Material and methods

LCA approach was used to assess the carbon footprint of organic dairy farming in Europe. The farms included in the study represent a variety of organic farms. Inventory data from farms was collected from six European countries that were considered to give a variable sample of organic dairy farming in Europe. A total of 34 organic dairy farms were included: 8 from the United Kingdom, 8 from Denmark, 7 from Finland, 2 from Belgium, 4 from Italy and 5 from Austria. The farm size varied from 9 dairy cows to 482 and annual production volumes from 40 to 2,230 tonnes. Herd turnover data was corrected using a standard protocol. The parameters included in the calculation were herd parameters including age and weight, feed characteristics, own production of feed, crop yields, fertiliser use, housing systems including manure management, and energy use including traction and air conditioning.

The carbon footprint was calculated using the LCA method described by Schmidt & Dalgaard (2012). An attributional approach based on ISO 14040 standards was used as the basis for the life cycle assessment methodology applied. System boundaries were set from cradle to farm gate. The carbon footprint was calculated per farm and the result was given as weighted average. The calculation model uses the milk yield, weight and ages of the cattle to calculate the feed requirement based on IPCC (2006) and Kristensen (2011). Emissions from plant cultivation, manure management, enteric fermentation and methane were calculated according to IPCC (2006). Using the attributional approach, emissions were economically allocated between milk, beef and energy plus nutrients in manure.

Results

Based on data from six countries and a total of 34 farms, the result for the average European organic milk carbon footprint is presented in Table 1. Emissions are divided between processes.

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Table 1. Average carbon footprint of European[a] organic dairy farming allocated in different processes.

European average	Milking cows	Raising heifers and bulls	Crop cultivation	Total
Direct emissions	[CO_2 –eq]	[CO_2 –eq]	[CO_2 –eq]	[CO_2 –eq]
CH_4 enteric fermentation	0.450101	0.158822		
CH_4 ,manure handling and storage	0.069109	0.018117		
N_2O	0.031963	0.014283	0.032889	0.77484
Emissions outside animal activities				
Feed inputs	0.0390485			
Indirect land use change related to feed	0.0181518			
Manure land application	0.0019600			
Purchased manure and live animals	0.001214			
Fuels	0.029855			
Electricity	0.069349			
Transport	0.002207			
Destruction of fallen cattle	0.000051			
Farm, capital goods and services	0.103624			0.259617
			Total	**1.041343**

[a] Included countries Austria, Belgium, Denmark, Finland, Italy and United Kingdom, n_{farms} = 34.

On farms, emission hotspots mainly consist of methane emissions from the enteric fermentation of dairy cows (58 %) and from raising youngstock (21 %). A considerable proportion of emissions originate in manure management, 9 %. Of emissions from non-animal sources, the largest contributors are capital goods and services and electricity, which account for 40 % and 27 %, respectively. Feed inputs also play a large role, accounting for 15 %. Of the total carbon footprint, enteric fermentation by dairy cows contributes 43 % and raising youngstock contributes 15 %. Farm emissions account for 10 % of the total and manure management and electricity combined contribute 7 %. Feeds contribute 4 % of total GHG emissions. Taken together, the above factors contribute 86 % of all GHG emissions. Of these, the main contributor is therefore enteric fermentation, which accounts for one third of all GHG emissions in total. The total carbon footprint of organic dairy farming in Europe averaged 1.04 kg CO_2 equivalents per kg of ECM milk, with a standard deviation of 0.25, whereas the averages per country were 1.16 ± 0.17 (AT), 0.96 ± 0.23 (BE), 1.12 ± 0.44 (DK), 1.00 ± 0.14 (FI), 1.04 ± 0.22 (IT) and 0.95 ± 0.10 (UK) kg CO_2 equivalents per kg of ECM milk.

Discussion

The current study reveals variations between organic dairy farms and between countries. This result is consistent with recent studies from the perspective of the overall carbon footprint (Thomassen et al.2008, Yan et al.2013, Kristensen et al.2011, Flysjö et al.2012, Casey and Holden,2005), although methodological variations make a direct comparison difficult.

Here, the enteric fermentation was the largest contributor to the total CF. In mitigating this effect, improving feed quality and the nutrient efficiency of feeds would be beneficial. Feed digestibility could be improved, even if it is already high in Western Europe, at 77 %(Gerber et al. 2013). Housing, energy use and manure management could also be developed in a sustainable direction.

Besides farm activities, the method for calculating the CF could be improved; this calculation does not take account of carbon sequestration– doing so would benefit the farms using more grass-based permanent pastures and it would provide a more complete picture of GHG emissions from organic dairy farms.

Suggestions to tackle with the future challenges of organic animal husbandry

Dairy farming is the largest agricultural contributor to GHG emissions in Europe and organic milk production is responsible for its proportional share. Thus, also for organic milk production, mitigation strategies need to be adapted. It is important that such mitigation strategies do take into account the other important features of organic dairy production like impact on biodiversity and on changes in soil carbon sequestration. Although enteric fermentation is the largest contributor to GHG emissions, development of more sustainable practises should therefore not only be in feed design, but in overall tactical management on farms. Organic dairy farming can lead by example in this.

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