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Greenhouse Gas Emissions of organic and conventional dairy farms in Germany

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Abstract

The article presents a model to calculate the greenhouse gas emissions of German dairy farms. The model was tested in 12 organic and 12 conventional farms in Southern and Western Germany. The results show that there is no significant difference between the greenhouse gas emissions per kg milk of the organic and the conventional farms. The lower milk yield of the organic farms is compensated by the lower fossil energy input and the higher carbon sequestration in the fodder production. It can also be seen that a raise of the milk yield from a medium level does not lead to a mitigation of greenhouse gas emissions per kg milk.

Introduction

Dairy farming is an important contributor to the greenhouse gas (GHG) emissions of agriculture (FAO 2010). The mitigation of GHG-emissions from dairy farming requires integrated models for the assessment of GHG-emissions on a single-farm-scale. Up to now there were no methods to assess the emissions of real dairy farms in Germany. We developed a model to calculate complete GHG-balances including the energy-balance of farming systems. The model was tested in 12 organic and 12 conventional dairy farms in Southern and Western Germany.

Material and methods

The model dairy farming (Frank et al. 2013) bases on the model REPRO (Küstermann et al. 2008). It is a process analysis of the farming system that includes all inputs and outputs of energy, nutrients and products and GHG-emissions. The energy balance includes all direct (e.g. fuel, electricity) and indirect (e.g. fertilizer, machinery, buildings, purchase of fodder) energy inputs into the system. The system boundary is the farm. The process steps are defined as the fodder production (on farm fodder production and purchase of fodder), the storage of fodder, the housing system, the storage of manure, the breeding of heifers and the milking process. The inputs are assessed by GHG-equivalents that reflect the GHG-emissions during the production of the inputs. Furthermore we compute the GHG-emissions from land use (N_2O from nitrogen fluxes, CO_2 from carbon-sequestration), CH_4 from enteric fermentation (digestion of ruminants), CH_4 and N_2O from the storage of manure and the emissions from indirect landuse change (iLUC) from the import of soybeans (IPCC 1997, Kirchgessner et al. 1995, FAO 2010). The emissions are allocated by the energy output to the products milk and meat (calves and cows), manure is supposed to stay in the production system.

The model was tested in 12 organic and 12 conventional pilot farms in Southern and Western Germany. Each organic farm has a conventional partner farm nearby. So it can be assumed that organic and conventional farms have comparable site conditions. Farm data are shown in table 1.

Table 1: Management data of the pilot farms

		organic			conventional		
		mean	min	max	mean	min	max
Farm area	ha	73	30	186	57	30	109
Number of cows		42	18	91	50	29	73
milk yield	kg ECM cow^{-1} y^{-1}	6360	4236	7510	8354	6273	10274
first calving age	Months	31	27	35	29	27	33
use time	months	41	29	60	28	24	34

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Results

The computed GHG-emissions from the farms are shown in table 2. The emissions per kg energy-corrected milk (ECM) have no significant difference between organic and conventional farms.

Table 2: GHG-emissions of the pilot farms (g CO_{2eq} (kg ECM)$^{-1}$)

	organic		conventional		
	mean	SD	mean	SD	
Fodder production	121	63	289	62	*
On-farm fodder production	100	60	178	44	*
Energy input	38	12	49	21	n.s.
Nitrous oxide	156	17	121	38	*
C-sequestration	-94	72	8	51	*
Purchase of fodder	21	26	111	61	*
Energy input	7	7	32	15	*
Nitrous oxide	6	9	26	15	*
C-sequestration	8	16	16	15	n.s.
iLUC	0	0	37	39	*
Methane from digestion	419	43	326	18	*
Manure management and storage	130	39	129	30	n.s.
Energy input	14	5	11	2	*
Methane and nitrous oxide	116	39	118	28	n.s
Breeding of heifers	257	85	257	79	n.s.
Storage of fodder, housing system, milking	79	4	66	3	*
Total emissions	1006	157	1067	85	n.s

The results show that the CH_4- emissions from digestion are the biggest source of GHG-emissions in dairy farming. They depend on the feeding strategy and the milk yield. Organic farms have higher CH_4- emissions due to the lower milk yield and the higher content of roughage in the ration. The GHG-emissions from fodder production are per kg milk higher in the conventional farms. The reason is the input of mineral fertilizer (fossil energy input) that is not compensated by the higher yields. The carbon-sequestration is lower than in organic farms. It means that CO_2 from atmosphere is fixed in the soil as humus. The organic farms have a high carbon sequestration due to their positive humus balance by the cropping of clover grass and other legumes. The conventional farms have an equated humus balance. Also the higher purchase of fodder leads to higher emissions in the conventional farms. The breeding of heifers is an important source of GHG-emissions, too; their amount depends on the usage time of cows and the management in breeding. The emissions per kg milk are equal in the organic and conventional farms. The reason is the lower intensity in organic farms with higher breeding time versus the higher intensity and faster growth in conventional farms.

The comparison of the total GHG-emissions with the milk yield of the farms is plotted in figure 1.

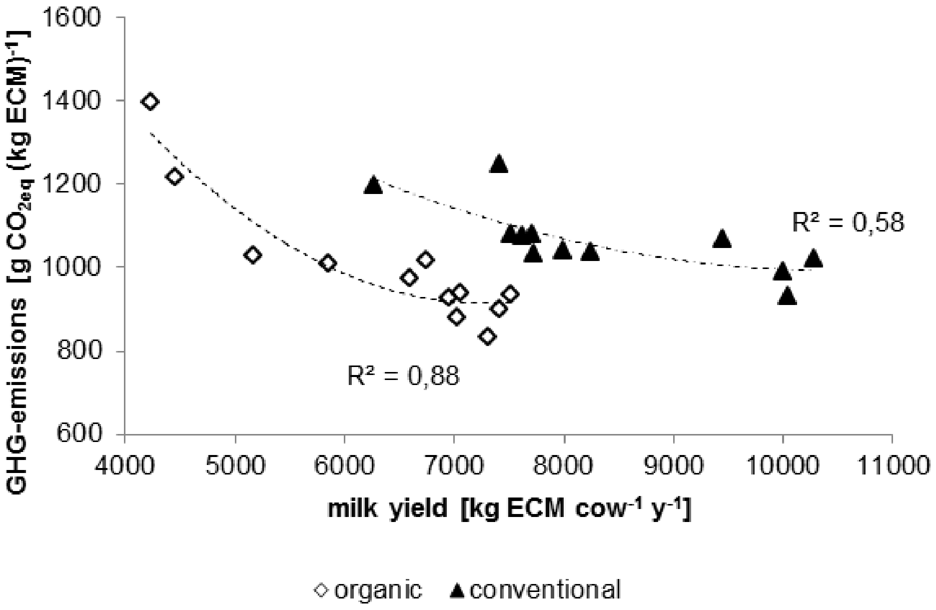

Figure 1: GHG-emissions per kg milk and the milk yield

The rising of the milk yield leads to a reduction of GHG-emissions per kg milk. The rising from 7,500 to 10,000 kg ECM cow^{-1} y^{-1} has no further effect on the mitigation of GHG-emissions. That can be declared by the development of the different emissions sources. The methane emissions from digestion are sinking with rising milk yield, even the emissions from manure management. But the higher milk yield needs higher amounts of concentrates and purchased fodder. Concentrates have usually higher emissions in production than roughage. So there is a raise of the emissions from fodder production with rising milk yield. From a certain point on they are balanced so there is no further mitigation of GHG-emissions with rising milk yield.

Discussion

The new developed model is able to cover a holistic GHG-balance of dairy farms. The view on the complete dairy system shows the great evidence of all emission sources to the carbon footprint of dairy farming. It is necessary to asses all of them to make sure conclusions. This allows a sophisticated view on the comparison of organic and conventional dairy farming.

The results show that organic and conventional dairy farms have comparable emission per unit of product. The reasons are that the lower milk yield of organic farms is compensated by the lower energy input, the lower nitrous oxide emissions and the higher carbon sequestration in fodder production. The interactions between the emissions sources is the reason (Rotz et al. 2010). It can also be seen that the rising of milk yields has no significant effect on the GHG-emissions per kg milk. Under German conditions with comparable high milk yields the rising from 7,500 to 10,000 kg ECM cow^{-1} y^{-1} is expected to have no significant reduction of GHG-emissions in dairy farming.

The model and the results can contribute to develop farm specific GHG-mitigation strategies. It is the basic for the deduction of advisory concepts for more sustainable agriculture.

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References

FAO (Food and Agriculture Organization of the United Nations) (2010): Greenhouse Gas Emissions from the Dairy Sector. A Life Cycle Assessment.

Frank H, Schmid H, Hülsbergen K-J (2013): Energie- und Treibhausgasbilanz milchviehhaltender Landwirtschaftsbetriebe in Süd- und Westdeutschland. Abschlussbericht 2013 „Klimawirkungen und Nachhaltigkeit ökologischer und konventioneller Betriebssysteme - Untersuchungen in einem Netzwerk von Pilotbetrieben“, p. 139-166.

IPCC (International Panel on Climate Change) (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Kirchgessner M, Windisch W, Müller H L (1995): Nutritional factors for the quantification of methane production. In: W Engelhardt, S Leonhard-Marek, G Breves, D Giesecke (ed): Ruminant physiology: Digestion, metabolism, growth and reproduction. Proceedings of the 8th International Symposium on Ruminant Physiology. Enke Verlag, Stuttgart, p. 333-348.

Küstermann B, Kainz M, Hülsbergen K-J (2008): Modelling carbon cycles and estimation of greenhouse gas emissions from organic and conventional farming systems. Renewable Agriculture and Food Systems 23, 38–52.

Rotz, C A, Montes F, Chianese D S (2010): The carbon footprint of dairy production systems through partial life cycle assessment. Journal of Dairy Science 93, 1266-1282.