# An LCA based comparison of two different dairy breeds in an organic farm

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## Abstract

*In the experimental station of the Thünen-Institute of Organic Farming the dairy breeds Black Holstein (BH) and Red Holstein double usage (DU) are kept in separate herds under identical conditions. By means of a material flow FARM-Model, designed with the life cycle assessment (LCA) and material flow software Umberto, an assessment from cradle to farm gate of standard environmental impact categories was undertaken. As the model reflects real farming conditions the effects of changes in animal husbandry such as varying milk yield and herd structure can be assessed. But also the effects of changes in the crop yields or even crop failures can be shown in respect to their product related environmental impact. Therefore it is possible to express the environmental impact of a product as a range of the variable farming conditions and practices. For the three assessed years product related climate impacts vary as much as 11% which is more than the difference between the two breeds. Under identical management milk from BH, the breed which has the higher milk production potential, showed a preferable environmental performance in all studied impact categories.*

*Key words: milk production, farm-model, emissions, environmental performance*

## Introduction

Efficiency in terms of nutrients and production methods is one key aspect in reducing the environmental burdens associated with organic farming systems. Higher efficiency on the farm itself may however lead to offsetting mechanisms along the production chain, for example by the production of concentrate feed in other parts of the world or by increased energy demand. Therefore tools are needed to analyze the efficiency of farming practices and their off-site effects to evaluate change and development in farming conditions on a farm specific level.

In order to improve existing agricultural systems they must be analyzed in regard to their overall performance as well as to the individual performance of the different farm parts. Via a LCA-FARM-Model developed at the Thünen-Institute of Organic Farming the environmental burdens associated with the production of sellable products such as milk and also the environmental performance of e. g. self-produced fodder on the local level can be assessed.

## Material and methodology

The FARM-Model is based on the flow-software Umberto, structured hierarchically and controlled by parameters. These input parameters are data that can easily be obtained in real farming conditions such as crop yields, crop rotation schemes, manure management practices and additional inputs with a market value like mineral fodder, fuel and electricity or special materials for silage making. The parameters for the animal husbandry include the herd size and structure, milk yields and feeding regime.

In order to evaluate emissions from farming practices common assessment schemes from published sources have been used. Green house gas emissions have been calculated according to the rules in IPCC (2006) and Rösemann et al. (2011). Emissions from manure management have been calcu-

lated with the formulas published by Amon et al. (2006). Emissions from the combustion of fuels were calculated based on the GEMIS database (Fritsche, 1999). To assess processes upstream the production chain datasets from the ecoinvent database v2.2 (Hischier et al., 2010) have been used. Effects on common impact categories are addressed by e. g. global warming potential (GWP), photochemical ozone creation potential (POCP), euthrophication potential (EP) and acidification potential (AP). The methodology of the assessment is based on the requirements and guidelines of the international standards ISO 14040 and ISO 14044 (ISO, 2006a, ISO, 2006b).

**Table 1. Crop yields in the experimental station of the Thünen-Institute of Organic Farming in the dairy cattle section [t ha-1, cerals 86 % DM, forage crops ~35% DM)**

| Crop | 2008 | 2009 | 2010 |
|---|---|---|---|
| Pea/Spring barley | 3.01 | - | - |
| Oat/Bean | 2.24 | 1.66 | 1.4 |
| Clover/Grass (1st & 2nd year) | 32.1 | 35.6 | 28.2 |
| Maize | - | 18.1 | 11.7 |
| Triticale | 2.6 | 3.09 | 1.83 |
| Wheat | 3.1 | 1.65 | 2.83 |

The experimental station of the Thünen-Institute of Organic Farming is located in Schleswig-Holstein, North Germany. The dairy breeds Black Holstein (BH) and Red Holstein double usage (DU) are kept in two separate herds under identical conditions. The fodder production is conducted in the experimental station on the same acreage with a 6-year crop rotation scheme that was changed in the crop year 2009. Table 1 shows the crop yields for the years 2008-2010. Fluctuating low yields are apparent.

**Table 2. Milk yields and compounds and herd structure for the dairy breeds in the experimental station of the Thuenen-Institute of Organic Farming for the years 2009-2011**

| | DU | | | BH | | |
|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2009 | 2010 | 2011 |
| Milk yield [kg] | 6157 | 5639 | 6364 | 7621 | 6992 | 6833 |
| Fat [%] | 4.52 | 4.42 | 4.42 | 4.35 | 4.32 | 4.26 |
| Protein [%] | 3.31 | 3.28 | 3.38 | 3.07 | 2.99 | 3.07 |
| Avg. Calves | 22.72 | 25.66 | 18.83 | 23.00 | 23.64 | 23.11 |
| Avg. Heifers | 21.51 | 15.65 | 8.04 | 15.85 | 17.59 | 11.53 |
| Avg. Cows | 40.83 | 43.80 | 39.32 | 46.15 | 43.18 | 42.69 |

In order to reflect the feed flow in real farming conditions each crop year was combined with the following milk year. Table 2 presents the yearly herd size and structure for both dairy breeds as well as the respective milk yields and compounds. The reduction in herd size over time is due to experimental management decisions. Any surplus fodder from the dairy cattle section is not included in the environmental impact assessment of the milk production.

## Results

In a product related assessment, in order to produce 1 kg energy-corrected milk (ECM), the BH herd performs better in all assessed impact categories in all years under study. The difference between the herds is highest in the year with the highest environmental impact in milk production (Figure 1). The crop year 2010, shown in Figure 1 for the milk year 2011, was also the year with the highest indicator values for environmental performance. However, as the crop yield from 2010 is fed in 2011 the aggravation in crop performance does not necessarily lead to an aggravation in overall performance in the environmental impact categories under study.

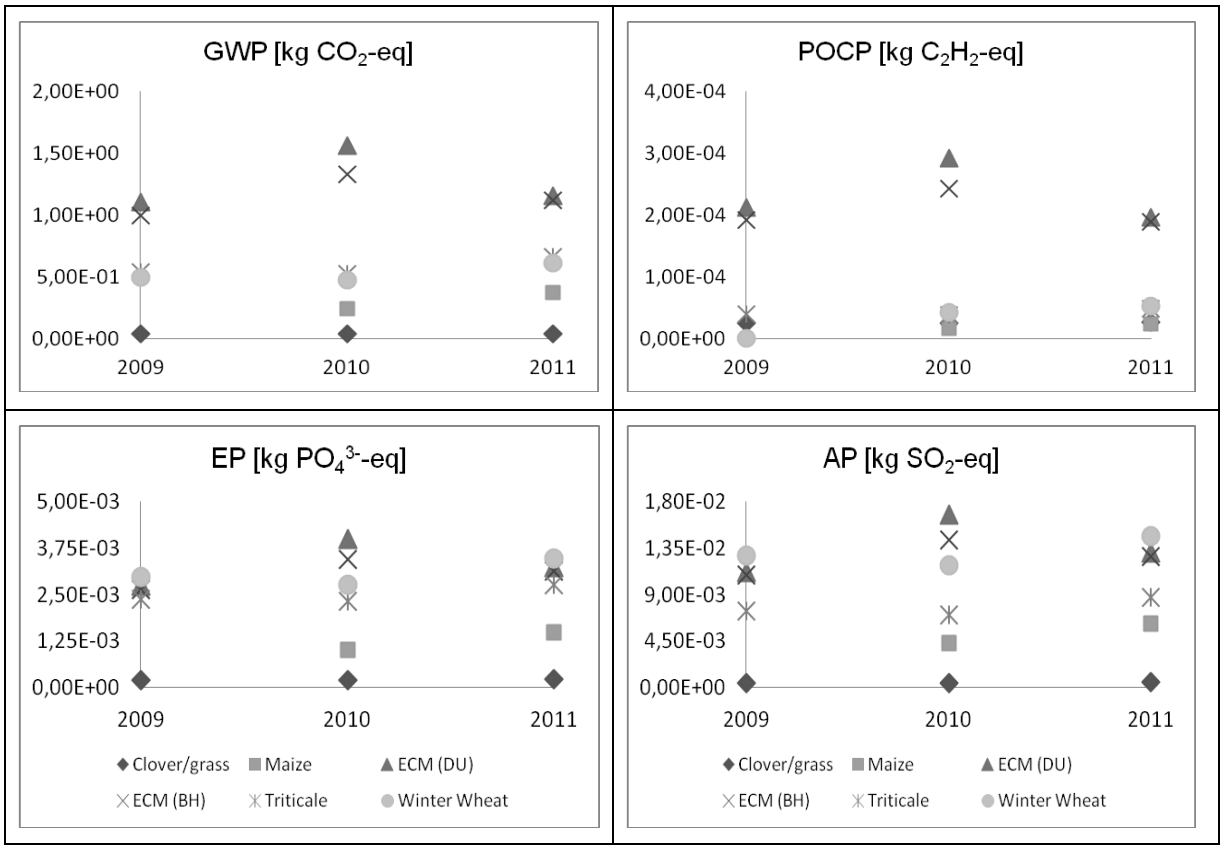


**Figure 1. Associated environmental impacts of milk production of two different dairy breeds per kg ECM and of intermediate products per kg DM in selected impact categories in the cradle-to-gate assessment in the experimental station of the Thuenen-Institute of Organic Farming, 2009-2011.**

In all impact categories the milk year 2010 performs worst. The variation in different milk years is higher than the difference between the two dairy breeds.

In regard to the crop production wheat and triticale show the highest environmental product related impact potential in all categories. This is due to the significantly lower yields compared to maize and clover/grass.

## Discussion

Using the FARM-Model to analyze the dairy section of the Thünen-Institute of Organic Farming over three consecutive years showed a high variation of the potential environmental impacts of farm products and intermediate products. As changes in environmental burdens associated with yield fluctuations of intermediate products did not affect the performance of the milk production as much as anticipated it is probable that a change in herd structure masked this. Herd management may be one starting point for improvement. Further research on the local environmental performance in the different farm parts is needed as management practices towards sustainability and efficiency are developed. For the use of LCA to analyze and communicate the environmental performance of agricultural products, the volatility of the results as an inherent property of farming must be addressed.

## Suggestions to tackle the future challenges of organic animal husbandry

Process and life cycle analyses of farming systems must be undertaken to get a complete view on global and local environmental burdens of their products and the related socio-economical effects of

agricultural production lines. Due to its intensity animal husbandry has inherent energy demands in forage crop production and competes for cropland. Especially in dairy farming it is possible to rely on local feed and material flows and to minimize competition of human and animal nutrition by the use of permanent pastureland and forage legumes that are indispensable in organic crop rotations. In organic dairy systems environmental burdens can probably be reduced further by the minimization of the use of energy intensive forage crops as well as by upholding and improving proper herd management and forage quality. Breed differences in milk yield are determining the product related environmental burdens to a large extent and should be considered in future development of farms.

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**Sonderheft 362**
*Special Issue*

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## 2nd Organic Animal Husbandry Conference Hamburg, Trenthorst, 12-14 September, 2012

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Bundesministerium für
Ernährung, Landwirtschaft
und Verbraucherschutz

***Bibliographic information published by the German National Library***

*The German National Library lists this publication in the German National Bibliography; detailed bibliographic data are available in the internet at http://www.d-nb.de/*

***Bibliografische Information der Deutschen Bibliothek***

*Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://www.d-nb.de/ abrufbar.*


**2012**

**Landbauforschung**
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**Preis / Price 18 €**

**ISSN 0376-0723**
**ISBN 978-3-86576-094-4**