Changes in land use resulting from diet modifications related to increasing milk yields

Wolf P., Prochnow A. and Berg W.
Leibniz Institute for Agricultural Engineering Potsdam-Bornim e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany

Abstract

Milk yields in Germany are still increasing for economic and other reasons. Cows with higher yields need diets with higher protein and energy content. This necessitates changes in the amounts of individual feedstuffs within the diets. Accordingly, these changes result in a shift in land use from grassland to cropland. The relationship between the diets of dairy cows (including replacement) and the associated use of grassland and cropland was studied. For this purpose, the fixed amount of the annual milk production in Germany was set as a basis. The milk yield was varied from 4,000 to 12,000 kg energy corrected milk (ECM) cow^{-1} $year^{-1}$, in steps of 2,000 kg ECM cow^{-1} $year^{-1}$. The results show a decreasing use of utilised agricultural area (UAA), especially grassland, with increasing milk yield. The total use of UAA is similar for the higher milk yields. Thus, the lowest use of the resource land (UAA and grassland) associated with a defined amount of produced milk occurs at milk yields of 10,000 and 12,000 kg ECM cow^{-1} $year^{-1}$. The use of cropland is growing with milk yields increasing over the whole investigated scope.

Keywords: grassland, dairy cow diets, land use, milk yield

Introduction

The increasing global human population, with resulting increases in food demand accompanied by changing consumption patterns, as well as the finite availability of agricultural land, presents an urgent need for more efficient farm output. In Germany farmers are under pressure to increase the milk yield per cow for economic reasons. The number of cows is decreasing accordingly (cf. BLE, 2012, Table 138).

To ensure higher milk yields, the protein and energy contents of the diets have to be increased (cf. GfE, 2001). Achieving this dietary change means that a modification of the proportions single feedstuffs is unavoidable. This development leads to a shift from the provision of grassland-based feed to cropland-based feedstuffs, and therefore to changes in the relative land use of grassland and arable land.

This paper analyses the acreage needed to supply sufficient feed production to ensure the annual German milk production at different milk yields, divided into grassland and cropland. The aim of the study was to identify how milk yield (between 4,000 and 12,000 kg energy corrected milk (ECM) cow^{-1} $year^{-1}$) and pasture management are related to the extent of land use.

Materials and methods

This paper analyses the demand of utilised agricultural area (UAA), in particular grassland and cropland for production of 31,186,300 Mg ECM with 4% fat and 3.4% protein, which is equal to the level of production of Germany in 2013 (BMELV, 2014b). The system comprises a defined number of dairy cows and their replacements, which depends on the milk yield. The milk yield varies from 4,000 to 12,000 kg ECM cow^{-1} $year^{-1}$, in steps of 2,000 kg ECM cow^{-1} $year^{-1}$. For each milk yield, three diets, based on three different types of pasture management (without, half-day, and full-day pasture) are represented. The replacement rate is defined as the German average of 36.2% (KTBL, 2009) for all milk yields, as well as the loss of calves during the rearing, which is defined as 9.9% (KTBL, 2009). The rearing period for

female calves and first-calf heifers is set at 25 months (Spiekers and Potthast, 2004). No male calves are considered in this study. The lactation period is 305 days with an additional 60-day dry period.

The diets are presented as total mixed ration and based on data from Krauß *et al.* (2015). Only the composition of concentrate is slightly different. In this study it consists of 50% wheat, 26.5% soybean meal, 20% barley, 3% mineral feed and 0.5% rapeseed oil (according to mixture 170/4 from Spiekers and Potthast (2004)).

The use of grassland (corresponding feedstuffs: grass silage, pasture and hay) and cropland (corresponding feedstuffs: fieldgrass silage, maize silage, beet pulp silage, soybean meal, rapeseed meal, triticale (*Triticosecale* Wittm.) and concentrate) was calculated by the amount of feedstuff used for each diet and the corresponding crop yield based on the German average for 2013 (BMELV, 2014a). As the crops of sugar beet, rapeseed and soya produce more than one product (including products used for human nutrition), the yield was allocated to all products, according to Cederberg and Mattson (2000) and Mattson *et al.* (2000).

Results and discussion

Higher milk yields require adapted diets, because the total amount of feed intake is limited. Protein and energy contents of the diet must be raised in order to ensure that the basic needs of the animals and higher milk yields are covered. This requires a shift from grassland-based feedstuff to cropland-based feedstuff. The amount of a feedstuff is directly related to the land used for its production according to the crop yield.

Figure 1 illustrates the land use for the amount of milk produced in Germany in 2013 in relation to the milk yields of 4,000 to 12,000 kg ECM cow^{-1} year^{-1} and the associated pasture management.

The results show a decreasing use of grassland with increasing milk yield within the same pasture-management group. At the same milk yield, the diet without pasture requires the lowest use of grassland and the highest use of cropland and vice versa for the full-day pasture. Pasture management only slightly influences the total land use for the same milk yield (maximum difference 2.9% at 10,000 kg ECM

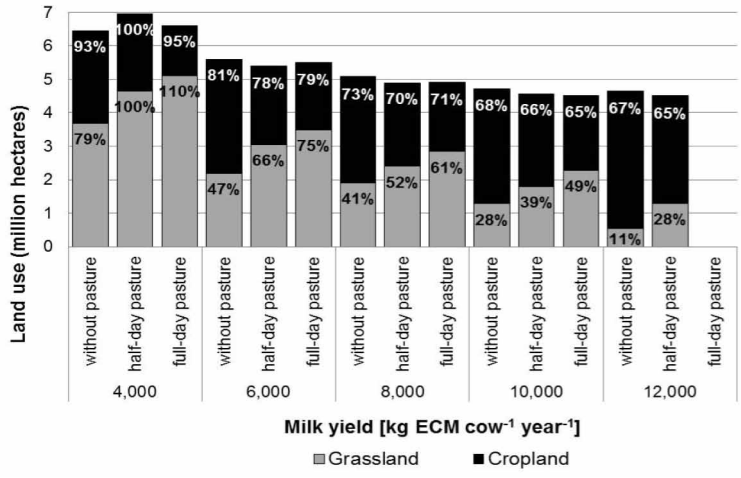

Figure 1. Land use for the production of 31,186,300 Mg ECM, related to milk yields from 4,000 to 12,000 kg ECM cow^{-1} year^{-1}, including three kinds of pasture management; upper percentages: total land use related to total land use at 4,000 kg ECM cow^{-1} year^{-1}, half-day pasture; lower percentages: total grassland use related to total grassland use at 4,000 kg ECM cow^{-1} year^{-1}, half-day pasture.

cow^{-1} year^{-1}, without pasture and full-day pasture), except for a milk yield of 4,000 kg ECM cow^{-1} year^{-1} (maximum difference 7.3%, half-day pasture and without pasture).

The cropland used to produce the diets increases with higher milk yields. However, with increasing milk yields there is a decrease in the amount of UAA needed and in the grassland area. Thus, only 65% of UAA is required if the same amount of milk is produced by cows with a milk yield of 12,000 instead of 4,000 kg ECM cow^{-1} year^{-1} (half-day pasture). While the 4,000 kg ECM cow^{-1} year^{-1} diets do not seem to be efficient regarding the land use, the difference in the use of UAA between the high milk yields of 10,000 and 12,000 kg ECM cow^{-1} year^{-1} becomes negligible (less than 1% for the same pasture management). However, a full-day pasture diet is not practicable at a milk yield of 12,000 kg ECM cow^{-1} year^{-1}. The results imply that the milk yields of 10,000 and 12,000 kg ECM cow^{-1} year^{-1} are the most efficient regarding the use of the resource land (in particular UAA).

Conclusions

The trend towards increasing milk yields results in a decrease in total UAA usage required to produce a certain amount of milk. This effect diminishes considerably at milk yields of more than 10,000 kg ECM cow^{-1} year^{-1}. Looking at the different types of land use, it is obvious that the decrease in grassland is much stronger than the decrease in the total UAA, still at higher milk yields. In contrast, diet modification leads to an increasing use of cropland with increasing milk yields. Surplus grassland would be potentially available for other purposes, e.g. bioenergy production. Further research is needed to estimate the overall environmental impact of decreasing UAA demand but increasing demand for cropland.

References

BLE [Bundesministerium für Ernährung Landwirtschaft und Verbraucherschutz] (2012) *Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland 2012*, 56th edition. Landwirtschaftsverlag, Münster-Hiltrup, Germany.

BMELV [Bundesministerium für Ernährung und Landwirtschaft] (2014a) *Data & Tables: Anbau, Ertrag und Ernte der Feldfrüchte – Endgültiges Ergebnis*, table number MBT-0112090-0000. last update 07.04.2014.

BMELV [Bundesministerium für Ernährung und Landwirtschaft] (2014b) *Data & Tables: Milchwirtschaft auf einen Blick*, table number SBT-0100010-2013. last update 20.11.2014.

Cederberg C. and Mattsson B. (2000) Life cycle assessment of milk production – a comparison of conventional and organic farming. *Journal of Cleaner Production* 8, 49-60.

GfE [Ausschuss für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie] (2001) *Empfehlungen zur Energie- und Nährstoffversorgung der Milchkühe und Aufzuchtrinder*. DLG Verlag, Frankfurt a. Main, Germany.

Krauß M., Kraatz S., Drastig K. and Prochnow A. (2015) The influence of dairy management strategies on water productivity of milk production. *Agricultural Water Management* 147, 175-186.

KTBL [Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V.] (2009) *Faustzahlen für die Landwirtschaft*, 14th edition. KBTL, Darmstadt, Germany.

Mattsson B., Cederberg C. and Blix L. (2000). Agricultural land use in life cycle assessment (LCA): case studies of three vegetable oil crops. *Journal of Cleaner Production* 8, 283-292.

Spiekers H. and Potthast V. (2004) *Erfolgreiche Milchviehfütterung*, 4th edition. DLG Verlag, Frankfurt a. Main, Germany.