Comparing energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands

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Key words: energy use, GHG emissions, organic farming, farming systems.

Abstract

Results are presented of a model study comparing energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. Calculations have been performed for model farms, designed on the basis of current organic and conventional farming practices. Energy use and greenhouse gas emissions per hectare on organic farms are lower than on conventional farms, particularly in dairy farming. Energy use and greenhouse gas emissions per Mg of milk in organic dairy farming is about 80 and 90%, respectively of that in conventional dairy farming. Energy use and greenhouse gas emission per Mg product in organic crop production is 5-40 and 7-17%, respectively higher than in conventional systems. The wide ranges found in crop production reflect large differences among individual crops.

Introduction

In various studies it has been shown that in organic agriculture fossil energy use is lower than in conventional agriculture, both per ha and per unit product (e.g. Grönroos et al. 2006 and Cormack, 2000). Studies comparing greenhouse gas (GHG) emissions in conventional and organic agriculture are lacking. Dutch agriculture is characterized by relatively intensive land use, in both organic and conventional farming. The question thus is whether in Dutch farming practice energy use and GHG emissions are different in organic and conventional farming systems. In this paper results are presented of a model study on energy use and GHG emissions in current Dutch organic and conventional farming practice, covering dairy farming and arable and vegetable cropping.

Materials and methods

In the Netherlands, most farms, whether organic or conventional, are specialised farms, producing either milk, arable crops or vegetable crops. To cover the dairy farming sector, eight organic and six conventional specialised model dairy farms were defined, evenly distributed over sand and clay soils. Feed crops cultivated include grass and maize on the conventional farms and grass/clover mixtures and maize on the organic farms. Farms were classified as ‘intensive’, ‘average’ or ‘extensive’ on the basis of milk production per ha feed crops, covering the range in intensities found in practice. The definition of the model farms is such that the organic dairy farms are less

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intensive and use less concentrates and more grazing than the conventional farms, reflecting current practice. To cover the arable and vegetable farming sectors, four model farms were defined: one organic and one conventional arable farm on clay soil (both growing potato, sugar beet, wheat, carrot, onion and pea) and one organic and one conventional vegetable farm on sandy soil (leek, bean, carrot, strawberry, head lettuce and Chinese cabbage). Rotations in the two pairs of farms were similar, but not entirely equal. Fertilizer doses on the organic farms were defined lower than on the conventional farms, due to lower crop yields and corresponding nutrient requirements. Nutrient management on the organic farms is based on cattle slurry and solid cattle manure. On the conventional farms, pig slurry and mineral fertilizer is used.

Energy use and GHG emissions for all model farms have been quantified based on identical parameters and emission factors, using the model DairyWise (Schils et al. 2006 and Schils et al. 2005) for the dairy farms, and an extended version of the BEA Model (Mombarg et al. 2004 and Schoorlemmer and Krikke 1997) for the arable and vegetable farms. Both models account for direct and indirect energy use and GHG emissions and assume no net accumulation or depletion of soil C stocks. Emissions of CO2, CH4 and N2O are expressed in terms of their 100-year global warming potentials (CO2 equivalents).

Results

Total energy use per ha on the dairy farms varies considerably (30-116 GJ) among the farms (Figure 1) and increases with increasing milk production per ha, as that is associated with stronger dependence on imports and higher animal densities. Energy use per ha averaged over all conventional dairy farms (75 GJ per ha) is almost twice as high as that of all organic farms (39 GJ per ha). Energy use per Mg of milk produced ranges from 3.6 to 4.5 GJ on the organic farms and from 4.3 to 5.5 GJ on the conventional farms (Figure 2). Similarly to energy use per ha, energy use per Mg of milk is positively correlated to milk production per ha. Average energy use per Mg of milk on the organic dairy farms is about 0.9 GJ lower than on the conventional farms, i.e. 19% of the average energy use on the conventional farms. On all dairy farms, indirect energy use is much higher than direct energy use (Figure 1). Concentrates contribute the largest share to total energy use (about 30%).

Similarly to dairy farming, energy use per hectare on the organic arable and vegetable farms is lower than on the corresponding conventional farms (Figure 1). The difference between the organic and conventional arable farms is larger than that between the two vegetable farms, associated with the energy needed for product drying and storage in arable farming. The actual value for this activity depends on yields: higher yields in conventional farming imply higher energy use per hectare. On the arable farms, electricity use for drying and storage of the products consumes about 45% of the total energy consumption and the use of diesel 30%. On both vegetable farms, the most important item is indirect energy associated with the purchase of planting material (35% of total energy consumption). In general, energy use per hectare is high for root crops and planted crops. On average, energy use per Mg product in plant production is higher on organic farms than on conventional farms. The difference between the organic and conventional arable farm is rather small (5%), but larger between the vegetable farms (39%). Energy use per Mg strongly varies among crops (Figure 2). Energy use in growing organic peas, sugar beet and beans is lower than in the corresponding conventional crops. For the other crops (some of which are depicted in Figure 2), energy use in organic crop production is higher than in conventional production. For example, organic carrots require twice as much energy as conventional carrots, mainly because of the energy needed for flaming weeds.

GHG emissions per ha on the dairy farms increase with increasing milk production per ha (Figure 1). GHG emissions per ha on the conventional dairy farms are 65% higher than on the organic model farms. Average N2O and CH4 emissions per Mg milk do not differ between the conventional and organic dairy farms (1.1 kg N2O en 25 kg CH4). The absence of any significant difference for N2O is the result of the higher grazing intensity and the more frequent ploughing of grassland on the organic model farms. Moreover, N2O emissions are relatively high on the two organic model farms with deep pit stables. CH4 emission per Mg of milk does not differ, because feed intake per Mg milk, the main determinant of CH4 emission in the DairyWise model, is practically the same. Unlike N2O and CH4, CO2 emissions per Mg of milk strongly differ. This is the consequence of the fact that in DairyWise this emission is calculated directly from energy use, that was 19% lower on the organic farms. Combining the emissions of all three GHGs in terms of CO2 equivalents per Mg milk (Figure 2), yields a difference of 8% between organic and conventional farms. On all dairy farms, CH4 is, with 40-50%, the largest contributor to total GHG emission (Figure 1).

GHG emissions per hectare on the organic arable and vegetable farms are lower than on the conventional farms (Figure 1). Roughly half of the emissions consists of CO2 associated with energy use, the other half consists of N2O. N2O emissions mainly originate from within the farm (use of fertilizers, incorporation of crop residues and nitrogen fixation). GHG emissions per Mg product are on average higher on the organic arable and vegetable farms than on the conventional farms. Similarly to energy use, the difference between the two arable farms is rather small (7%), but larger between the vegetable farms (17%). Again, differences among crops are large (Figure 2). For some organically grown crops emissions are lower than for conventional ones (sugar beet, pea, bean), for some others much higher (leek, carrot, wheat). In general, GHG emissions are high for leguminous crops and crops with high nutrient requirements.

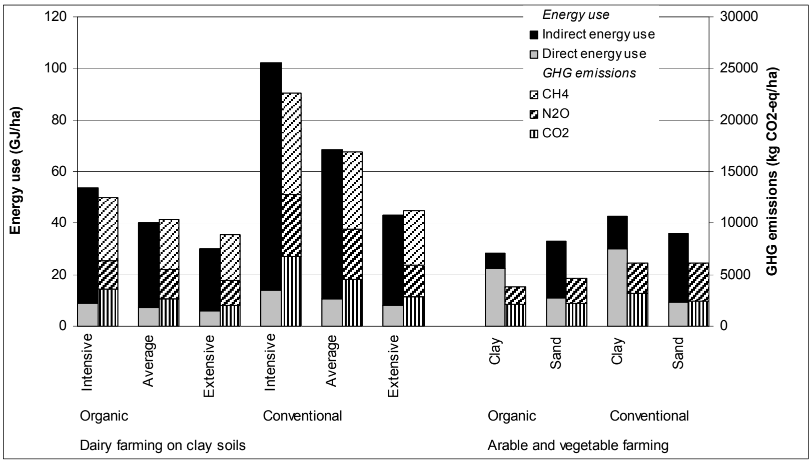

Figure 1: Energy use and GHG emissions per ha on organic and conventional model farms.

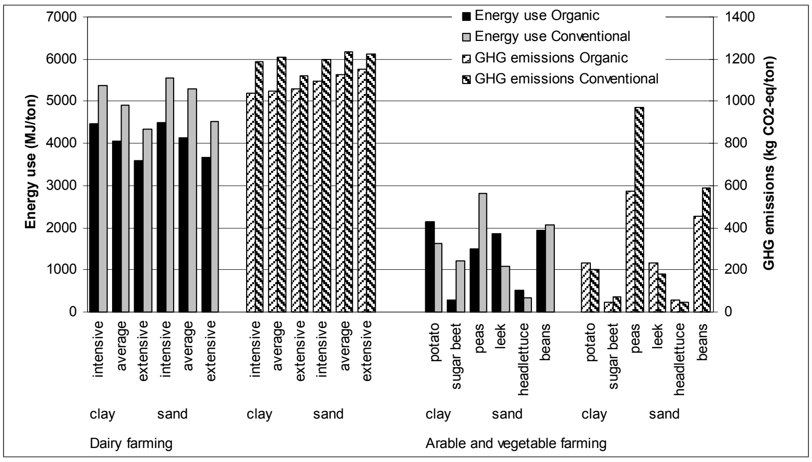

Figure 2: Energy use and GHG emissions per Mg of product on organic and conventional model farms.

Discussion

Energy use and GHG emissions calculated for stylized model farms can not be directly generalized to sector level. That would require careful weighing of the results of the model farms on the basis of their representativeness. As the dairy sector is relatively uniform, we did estimate the 'weights' for the dairy model farms. The results of the weighted averages did not differ from those reported above.

In the present study, energy requirements for imported organic manures were restricted to those for transport and application only. We hence assumed a 'zero energy' price for organic manures themselves. Consequently, energy use is lower for a crop fertilized mainly with organic fertilizers than for a crop fertilized mainly with mineral fertilizers. It is equally justified to assign a non-zero energy value to imported organic manures, for example on the basis of their fertilizer value. That would lead to higher energy use estimates, particularly for organic crops.

Conclusions

Energy use and GHG emissions per hectare on organic farms are lower than on conventional farms, particularly in dairy farming. Energy use and GHG emissions per Mg of milk in organic dairy farming are about 80 and 90%, respectively of that in conventional dairy farming. Energy use and greenhouse gas emissions per Mg of product in organic crop production are 5-40 and 7-17%, respectively higher than in conventional crop production. Based on these results, organic dairy farming performs 'better' and organic crop production 'worse' than their conventional counterparts.

References

Available from the first author upon request.