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Implementation of GHG mitigation on intensive dairy farms: Farmers' preferences and variation in cost effectiveness

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ABSTRACT

The need for mitigation of greenhouse gas (GHG) emissions from dairy farms has been widely acknowledged. However, there is barely any knowledge on GHG emissions and mitigation options on commercial dairy farms. Most of the farmers are not aware of the GHG emissions on their farms and their attitude towards suggested mitigation measures is largely unknown. This study aims to provide insight in the variation of GHG emissions on commercial dairy farms and in the farmers' preferences for mitigation options and to investigate the effects of these options on GHG emissions and farm economy. The average GHG emission on the commercial farms was 1.08 kg CO_2-equivalents per kg milk. The variation in emissions could be attributed to a combination of factors as soil type, fertilizer input, grazing system and feeding management. The preferred mitigation options were an increase of the milk production per cow, replacement of concentrates with single by-products, the use of more maize in animal feeding, the use of a heat pump and heat re-use from milk and reduction of the fertilizer N input. Farmers tend to choose mitigation options that are relatively simple and either cost effective or with only relatively small additional costs. The most promising mitigation options with respect to cost effectiveness are less replacement of dairy cattle and replacement of concentrates by single by-products grown in the vicinity of the farm. Other mitigation options which lead to land use change might be less effective due to possible trade offs. Overall, a total mitigation of 310 to 360 g CO_2-equivalents per kg milk is achievable. This is a reduction of 25 to 30% compared to 1990. It is expected that this reduction can be achieved with relatively little costs.

1. Introduction

Livestock production is a significant source of greenhouse gas (GHG) emissions, its contribution has been estimated at 18%, based on a food chain approach (Steinfeld et al., 2006). Therefore their figure is higher than the IPCC approach of total agriculture, which is about 14% (IPCC, 2007). In The Netherlands, the contribution of agriculture, following the IPCC approach, is calculated at 9%, of which the dairy sector is a significant contributor. E.g. 50% of the national total of nitrous oxide (N_2O) and methane (CH_4) emissions comes from livestock (Van der Maas et al., 2009).

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Over the past decades, research has focused on quantifying emissions and on defining emission factors for N_2O, CH_4 and carbon dioxide (CO_2). An important result is the tiered set emission factors of the IPCC Guidelines (IPCC, 2006). Emission factors have been incorporated in a wide range of models to calculate emissions from agriculture. The models range from field level (Vuichard et al., 2007), via farm level (Schils et al., 2005; 2007a; Del Prado and Scholefield, 2008) to regional level (Velthof et al., 2009).

The need for mitigation of emissions has been acknowledged widely and also in The Netherlands mitigation policy has been defined by the government (VROM, 2007). Many mitigation options have been defined in the last years (Smith et al., 2008). Reducing N_2O losses have been categorized (Oenema et al., 2001) increasing the nitrogen use efficiency and reducing the N_2O emissions per kg of N output. This can be realized by optimizing methods and timing of N application, reducing fertilizer inputs, using ammonium based fertilizers, using nitrification inhibitors, improving drainage, preventing soil compaction and reducing grazing time. Reduction of CH_4 emissions can be realized by increasing the maize fraction of rations (Beauchemin et al., 2008), using starch and additives (Shibata and Terada, 2010) and by manure digestion (Amon et al., 2007). Improving milk production per cow and reducing the number of young stock reduce emissions of both CH_4 and N_2O (Schils et al., 2005). CO_2 emissions can be reduced by changing grassland renovation or no renovation at all (Davies et al., 2001; Mori and Hojito, 2007); increasing the area of permanent grassland, reduced energy use and other energy sources in farm and field activities (Smith et al., 2008). It has been emphasized that due to the many interactions in a livestock system, trade offs can occur. For instance, reduced grazing time will reduce N_2O emissions, but this can partly be offset by more CH_4 due to changes in the animals' ration and more CO_2 due to a higher energy use (Schils et al., 2005).

As mitigation measures ultimately have to be implemented by farmers themselves, farm models can be used to define successful mitigation options. Schils et al. (2005; 2007b) have defined a number of possible mitigation options and paid special attention to cost effectiveness. Calculations were carried out for a limited number of experimental farms and intensively coached pilot farms, as well as for non existing average farms. However, there is barely any knowledge on GHG emissions and mitigation options on commercial dairy farms. Most of the farmers are not aware of the GHG emissions on their farms and their attitude towards suggested mitigation measures is largely unknown.

To increase the farmers' awareness of GHG emissions extension projects were initiated on commercial dairy farms in The Netherlands. Farmers selected one or more mitigation options for implementation on their farm. For a selection of these farms the baseline GHG emissions and the effect of the preferred mitigation options were calculated with a farm simulation model. The collected data provide insight in the range of GHG emissions on commercial farms, and in the farmers' preferences for mitigation options. Furthermore, the study provided information on the variation in cost effectiveness of the selected mitigation options due to differences in farm structure.

This study aims to provide insight in the variation of GHG emissions on commercial dairy farms, to provide insight in the farmers' preferences for mitigation options and to investigate the effects of these options on GHG emissions and farm economy. We hypothesize that cost-effectiveness is a crucial factor for farmers' decisions.

2. Materials and methods

2.1. Commercial farms

In 2008, about 70 dairy farmers on sand, clay and peat soils in The Netherlands participated in a mitigation project. The participants were divided over four groups with 9 to 20 commercial farms per group. Meetings were organized in each group to inform the farmers on GHG emissions and possible mitigation options. Due to the available budget, a limited number of farms could be analyzed in depth and from each group, 3 to 12 farmers were asked to participate voluntarily in detailed calculations. These farmers received a questionnaire and a predefined list of possible mitigation options.

2.2. Questionnaire for farmers

The selected farmers were requested to answer a questionnaire to determine the farm key parameters that are necessary to calculate GHG emissions. Data were collected on number of dairy cows and young stock, animal production, area of grassland and fodder crops, fertilizer use, grazing system, the use of by-products and concentrates and the use of contractors. A condensed list of all parameters is presented in Table 1. Together with the questionnaire, the farmers received a predefined list of possible mitigation options. The list of options was a selection of the list described in the introduction, based on previous studies by Schils et al. (2005; 2006). Farmers could also suggest new mitigation options. The complete list is shown in Table 2.

Although the issue of GHG was new for most farmers, many mitigation options were actually not new to them. Over the last 15 years, farmers learned about cost effective mitigation options to reduce the nitrogen surpluses (Langeveld et al., 2007).

2.3. Experimental farms

Next to the commercial farms, parameters have been collected of the experimental farm “De Marke,” a frontrunner in high nutrient efficiency where nutrient management has been the main goal in the last 15 years (Langeveld et al., 2007) to see what this means for GHG emissions. Data were also collected of an average farm of the years 1990 and 2007 reflecting the management change in this period. The main influencing factors were technical development, increased milk production per cow and manure legislation. The change

Table 1
A condensed list of parameters in the questionnaire for the farmers.

Parameter	Unit
Name farmer	–
Milk produced	kg
Quota fat content	%
Number of cows, calves, heifers	–
Milk/cow	kg/cow
Milk: fat, protein, urea	%,%, mg/kg
Area grass, maize, other feed crops	ha
Area ownership, rented land, paid rent	ha, ha,(€)
Soil type and drainage	–
Winter feed, share of grass and maize silage	%
Dairy cows: grazing system + supplementation	–, kg/cow
Young stock: grazing system	–
Input of roughage (bought maize and grass silage)	kg DM/farm
Input of by-products	kg DM/farm
Input concentrates per cow incl. young stock	kg/cow
Input/output manure	m^3
Input N, P from chemical fertilizer	kg/farm
Work done by contractor, costs per ha	activities for each ha, €/ha