POLICY OPTIONS FOR DECREASING N AND P_2O_5 LOSSES FROM GRASSLAND BASED DAIRY FARMS

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ABSTRACT
Policy instruments for reducing nutrient losses include extension and education, research, financial incentives such as subsidies and levies, and regulations. The potential of these instruments for reducing nitrogen (N), phosphate (P_2O_5), and ammonia (NH_3) losses is examined for Dutch specialized dairy farms on sandy soils. A linear programming model is used to estimate policy impacts. Results indicate that efficiency improvements through extension, education, and research alone have the potential to decrease total N losses to government target levels in 2005 and to erase 92% of the gap between base and target P_2O_5 losses, but only 24% of the corresponding NH_3 gap. Such efficiency gains in mineral use are accompanied by a 40% increase in farm income. In order to reach all mineral loss targets, the introduction of levies would eliminate two-thirds of these income gains.

KEYWORDS
Dutch dairy farming, environmental-economic modeling, nutrient losses, policy

INTRODUCTION
Animal husbandry contributes substantially to Dutch environmental problems. Eutrophication of the soil and of ground and surface water by nitrogen (N) and phosphate (P_2O_5), is caused for an important part by excessive use of animal manure and fertilizer on land. Volatilization of ammonia (NH_3) from manure is one of the three main sources of acidification in the Netherlands (Heij and Schneider, 1991). For 2005 governmental targets for maximum losses amount to 253 kg N/ha, 27 kg P_2O_5/ha and 25 kg NH_3/ha.

To realize these targets, the government has two main instruments: stimulation and regulation. Desired behavior may be stimulated indirectly by making people aware of a harmful situation and by supplying knowledge about the possibilities for change and the consequences thereof, or directly by rewarding desired behavior and/or discouraging undesired behavior. Obviously, indirect stimulation works only when people may benefit from a change of behavior. Regulation, as an alternative instrument, forbids undesired behavior and penalizes transgressors.

The objective of this paper is to demonstrate the potential impact of different policy instruments like education, extension, research and financial incentives on nutrient losses and income on an average specialized Dutch dairy farm.

METHOD
A linear programming model is used to analyze the dairy farm (Berentsen and Giesen, 1995). The objective function maximizes labor income (i.e. return to labor and management). The basic unit in the model is a dairy cow, calving in February and having a fixed milk production. Feed requirements are determined using formulas of Groen (1988). The land of the farm can be used for growing grass, maize, and fodder beets. Grass can be grown at different input levels of N, and it can be used for grazing in summer or for silage making for winter. In addition to home-grown feed, different types of concentrate (with varying protein content), dried beet pulp, and silage maize can be purchased. The model contains nutrient balances for N, P_2O_5 and K_2O, that register nutrient input and output and consequently nutrient losses.

The LP-model has been validated on the basis of average results of specialized dairy farms on sandy soil for 1992 and the base situation is simulated by the model. Given the state of the art in the base situation (i.e. level of milk production per cow and of plant production per hectare) management on the farm can be improved by means of education and extension leading to higher income and, when output is restricted like in dairy farming in the EU, to lower nutrient losses. This second situation is realized by economic optimization of the base situation. Through time the state of the art is shifted by research. Implementation of the results of research on farms by means of education and extension leads to technical change. Expected technical change in dairy farming is based on analysis of historic data on yields of plant production per hectare and of milk production per cow (Berentsen et al., 1996). For grass production per hectare a yearly increase in gross energy production has been calculated of 1.6% of the gross energy production in 1992 that ranged from 46,300 MJ NEL/ha at a fertilizing level of 100 kg N/ha up to 75,200 MJ NEL/ha at 500 kg N/ha. The yearly increase in gross energy production from silage maize amounts to 770 MJ NEL/ha (0.94% in 1992) and from fodder beets to 690 MJ NEL/ha (0.69% in 1992). The expected yearly increase in milk production per cow amounts to 145 kg fat corrected milk (2% in 1992). In the third situation expected technical change up to 2005 is incorporated in the model. A final difference between nutrient losses of the farm and governmental target losses for 2005 can only be eliminated by means of levies and subsidies or by means of regulation since negative income consequences are the result. In the fourth situation, prohibitive levies on N losses, P_2O_5 losses and on NH_3 emission above the governmental targets are incorporated in the model.

RESULTS AND DISCUSSION
The average specialized dairy farm on sandy soil in 1992/93 had an area of about 27 ha and a milk quota of 330.000 kg. With an average milk production per cow of 6682 kg/year, this results in 49.4 dairy cows in the base situation (Table 1). Most of the land is used for growing grass at an N level of 408 kg/ha (a level that was perceived in reality). In addition to own-produced feed, silage maize and concentrate are purchased. The farm plan results in N losses of 397 kg/ha, P_2O_5 losses of 67 kg/ha and in a labor income of NLG 62,785.

When optimizing the base situation, all land is used for grass production at a lower N level to feed a maximum amount of grass in summer (when grass is the cheapest energy source) and a minimum required amount in winter. The lower production of home-produced fodder results in a much higher amount of silage maize purchased than in the simulated situation; the amount of concentrate purchased, however, is substantially lower. Nutrient inputs decrease because cattle are fed less superfluous protein and phosphorus, because utilization of N by grass is more efficient at a lower N level, and because land is not provided anymore with superfluous P_2O_5. Labor income increases to NLG 72,150.

When technical change is incorporated, higher milk production per cow and the same milk quota results in 39.1 dairy cows. The higher grass and silage maize production per hectare result in a lower area of grassland and in sold silage maize. Higher milk production per cow requires more concentrate. Higher efficiency leads to substantially lower nutrient losses and to a considerable increase of income.

In the final situation the farm plan is restricted by the expected governmental target for NH_3 emission. For N and P_2O_5 losses the targets are over-achieved. The area of grassland and the N level on grassland are chosen such that enough grass is produced while at the same time the NH_3 emission target is not violated. The number of young stock for replacement is decreased to a minimum. Labor income falls back to NLG 69,808.

From the results it can be concluded that a substantial decrease of nutrient losses can be realized by research, education, and extension while income increases. Moreover, governmental target losses for 2005 can be realized without negative income consequences.

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Table 1
Number of cows, land use, feed purchased, environmental results and labor income for four different situations.

	Simulation of the base situation	Optimization of the base situation	Optimization plus technical change	Optimization plus technical change plus levies
Number of dairy cows	49.4	49.4	39.1	39.1
Land use:				
- grassland (ha)	21.6	27.0	18.7	21.3
- N level grassland (kg/ha)	408	320	300	139
- silage maize for own use (ha)	5.4	-	6.9	5.7
- silage maize sold (ha)	-	-	1.4	-
Feed purchased:				
- silage maize (ha)	3.6	8.7	-	-
- concentrate (1000 kg)	115	78	87	82
Nitrogen balance:				
- input (kg N/ha)	480	444	337	218
- output (kg N/ha)	83	83	90	76
- total losses (kg N/ha)	397	361	247	142
- of which ammonia emission (kg NH_3/ha)	69	68	58	25
Phosphate balance:				
- input (kg P_2O_5/ha)	104	76	69	53
- output (kg P_2O_5/ha)	37	37	39	32
- losses (kg P_2O_5/ha)	67	39	30	21
Labor income (NLG/year)	62,785	72,150	87,681	69,808