Potential Effects of Accumulating Environmental Policies on Dutch Dairy Farms

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ABSTRACT

Consequences for farm management, environment, and economics of environmental policies for Dutch dairy farms were examined through modeling with two policies applied successively to typical dairy farms. Both policies aim to decrease nutrient losses in the soil. The first policy, the Mineral Accounting System (MINAS), is a farm gate balance approach that was introduced in 1998. Acceptable surpluses and levies are gradually tightened in this system until final standards are used in 2003. The second policy was developed to comply with the European Union Nitrate Directive and is called the Manure Transfer Agreement System (MTAS). This system links production and use of animal manure. Farms that produce more manure than the amount that can be applied on their own land according to standards are obliged to have a contract with a farmer who is willing to apply the surplus of manure on his farm. This system will be first applied in 2002 and final standards will be used in 2003. Results of the MINAS policy show fine-tuning of protein feeding especially by replacing grass in summer rations by maize silage and low protein concentrate. Another general result of MINAS is decreased use of N-fertilizer on grassland. As a consequence, division of the area between maize silage and grassland is adjusted. Income drop ranges from €1400 to 4800 (5 to 18%). Mineral Accounting System N surpluses drop by 45 to 113 kg/ha (23 to 37%). Adding MTAS is an incentive for more grassland as grassland has a higher manure application standard. Particularly for intensive farms, MTAS leads to high extra costs (€2600). However, expected environmental improvement is negligible. Therefore, from an environmental point of view there is no logic in adding the MTAS.

(**Key words:** environment, economy, policy)

Abbreviation key: MINAS = Mineral Accounting System, MTAS = Manure Transfer Agreement System, $N_{\min}$ = mineral nitrogen.

INTRODUCTION

Animal density in the Netherlands is high compared with other western countries because of historically low prices of concentrates and inorganic fertilizers (Ketelaars and van der Meer, 1998) leading to high amounts of imported feed. In the early nineties the dairy sector in the Netherlands imported 45% of the feed requirements (Tamminga, 1992). The result is high levels of undigested and unutilized feed residues entering the environment through fecal and urinary excretion. This has led to leaching of nitrates and phosphates, which affects ground water quality and surface water quality (Oenema and Roest, 1998; Oenema et al., 1998).

To tackle these problems, the Dutch government developed policies from 1987 to the present. Until 1998, excessive use of animal manure was regulated by application standards. In 1998, the Mineral Accounting System (MINAS) was introduced to reduce surpluses of nitrogen (N) and phosphate (P_2O_5) (Aarts et al., 2000). Starting in 2002 the Manure Transfer Agreement System (MTAS) was added as an additional policy to avoid leaching of nutrients from animal manure.

Normative modeling at farm level is one way to determine the effects of management measures on the environment. The effect of management measures on the environment was studied by Rotz et al. (1999), Dunlap et al. (2000), and Kohn et al. (1997). Policy-oriented studies are especially prevalent in EU countries where the EU pressure on national governments to decrease nitrate leaching to ground water is high (Berentsen et al., 1992; Rigby and Young, 1996; Van der Ven, 1996; Van Huylenbroek et al., 2000). Because strict environmental policies that apply to agriculture are relatively new, empirical research on the effect of policies on farm management and the environment is relatively scarce. For Dutch dairy farming an in-depth analysis of the first years' effects of MINAS was reported by Ondersteijn (2002).

Received July 1, 2002.

Accepted August 22, 2002.

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The objective of this modeling study was to determine the effects of adapting to current environmental policies for dairy farms that differ in intensity. Moreover, the environmental effectiveness of applying two policies in order to achieve one goal is examined.

MATERIALS AND METHODS

Policies for Decreasing Nutrient Losses to the Soil

The introduction of MINAS in 1998 was a logical step in the sequence of environmental policies in the Netherlands aimed at decreasing nutrient losses to the soil. Before MINAS, the environmental impact on the soil was limited by the so-called Phosphate Standards. With phosphate standards, manure production on the farm was linked to application in the soil. Manure production per animal, measured in kilograms of phosphate, was considered fixed in this system. For grassland and fodder crops, different standards determined the maximum use of manure. A surplus of manure had to be transported to farms that could apply this manure within the standards. Although the system was quite rigid, it did not influence specialized dairy farming in the Netherlands much because of the relatively high application standards (Berentsen et al., 1992). The environmental focus shifted towards nitrogen as a result of the Nitrate Directive of the European Union (European Commission, 1991) stating a maximum acceptable level of 50 mg of nitrate (NO_3) per liter ground water to ensure the safety of drinking water. Research in the mid-nineties showed that this level was exceeded in many agricultural areas in the Netherlands (De Walle and Sevenster, 1998; Fraters et al., 1998). The Mineral Accounting System was developed to tackle problems resulting from both nitrogen and phosphate losses to the soil in a more sophisticated way.

The Mineral Accounting System is a farm gate balance approach. Farmers are required to account for nutrient flows that enter and leave the farm through the farm gate. The difference between input and output is the nutrient surplus. As MINAS aims to decrease losses to the soil, the N surplus is corrected for gaseous losses like ammonia emission from stables. The final surplus is expressed per hectare and compared to standards expressing surpluses per hectare that are considered acceptable. The amounts of N and P_2O_5 exceeding the acceptable surpluses are penalized with a levy per kg of N and P_2O_5 respectively. As from the introduction of MINAS in 1998, acceptable surpluses and levies were gradually tightened till final standards will be used in 2003 (Table 1). As can be seen from Table 1, acceptable surpluses differ depending on the use of the land and for N also on the vulnerability of the land concerning leaching. MINAS has a number of shortcomings like not

including atmospheric N deposition, biological fixation of N and P_2O_5 fertilizer as inputs to the system. However, MINAS is considered a step forward in environmental policy because the resulting N surplus is a better indicator for nutrient contamination of ground water than nutrient input via manure (Schröder et al., 2003). A whole-farm balance approach has the advantage of giving autonomy to farmers to determine how and where they will reduce their surpluses (Hanegraaf and Den Boer, 2003), but application standards leave only a very limited number of measures farmers can take to comply with the standards.

Despite the sophisticated system, the EU did not accept MINAS as a system that complies with the European Union's Nitrate Directive. The main reason was that MINAS was considered not to address the application of manure sufficiently (Ondersteijn et al., 2002). To satisfy the EU, the Manure Transfer Agreement System (MTAS) was developed and in 2002 this system was implemented in addition to MINAS. MTAS is based on standards for N production in manure and for N application from manure on land (see Table 1 for the application standards for 2003). If a farm produces more N in manure than can be applied to the farm land according to the standards, the farmer has to have a manure transfer agreement with any farmer with excess "application room," showing that this farmer is willing to apply the surplus of manure on his land. However, there is no direct link between the obligation to have a manure transfer agreement and actual disposal of manure (Ministry of Agriculture, 2001). A farmer is not required to dispose manure and he will not do so as long as he can apply the manure on his own land within the acceptable surpluses of MINAS. As in the Netherlands, many farms have a shortage of "application room", manure transfer agreements are scarce, so manure producers have to pay for agreements. MTAS was introduced in 2002. For 2002, only 85% of the N manure production on farms had to be covered by application of manure on the own farm and, if necessary, by manure transfer agreements. For 2003, the amount increases to 95%. For 2002, manure transfer agreements covered 91 million kg of N, which is 20% of the total N manure production in the Netherlands (Van Staaldunin et al., 2002). A first indication for an average price paid is €0.78 per kg N (Van der Kamp, 2002). This price is paid for the agreement only, not for disposal of manure. The price a manure producer has to pay for disposal of manure varies between €8.50 and €15.50 per metric ton of manure (Philipsen et al., 2001).

The Dairy Farm Model

The model that is used to determine the effects of the environmental policies is a whole farm linear program-

Table 1. Acceptable nutrient surpluses and levies within the Mineral Accounting System and application standards within the Manure Transfer Agreement System (2003).

	Phosphate	Nitrogen	
		All soils	Vulnerable sandy soils
Acceptable surpluses (kg/ha)			
Grassland	20	180	140
Arable land	20	100	60
Conservation areas	10	50	50
Levies € ¹ /kg	9	2.30	2.30
Application standards (kg N/ha)			
Grassland		250	250
Arable land		170	170

¹€1 ~ US \$1.

ming model. The objective function maximizes labor income (i.e., the remuneration for family labor and management that is left after all other costs have been paid).

The central element in the model is a dairy cow, calving in February, with a fixed milk production. A minimal ratio is required between the number of young stock and the number of dairy cows to guarantee replacement of dairy cows. Surplus heifers can be sold. The feeding part of the model consists of four parts. The dairy cows and young stock are fed separately, and a division is made between summer, when cows and young stock can graze, and winter, when livestock are kept indoors. For dairy cows, feeding constraints reflect demand and supply of energy and protein, DMI capacity, and demand for fiber in the ration. Milk production, energy requirements and feed intake capacity in the summer and winter periods are determined using formulas of Groen (1988). For protein, the DVE/OEB system is used (Tamminga et al., 1994). Protein requirements are calculated using formulas of the Central Bureau for Livestock Feeding (1995). Because dietary requirements of young stock are usually less complicated, constraints on feeding pertain to only energy and protein. Feed for dairy cows and young stock consists of grazed and conserved grass and maize silage produced on the farm, three types of purchased concentrates that differ in protein content, dried beet pulp, and purchased maize silage.

The land can be used for growing grass or maize silage. Grass can be produced in the model at five rates of mineral nitrogen ($N_{\min}$) from fertilizer and manure (100, 200, 300, 400 and 500 kg per ha per yr) to include decreasing marginal production with increasing $N_{\min}$ rates. Grass can be used either for grazing by dairy cows and young stock or for mowing for silage to be fed to either category of stock. The area of grassland and division between grazing and mowing is dependent on the interactions among animal requirements, season of the year, price of concentrates and price and availability of other forages. These interactions are all considered in the opti-

mization process. To maintain the quality of grass a minimum percentage of mowing is necessary. This is modeled by requiring a minimum amount of grass silage of 2 kg DM per cow per day in the winter ration.

Modeling of maize production is less complex. Above an optimal nutrient rate, production response to nutrients is low (Aarts and Middelkoop, 1990) so that only one nutrient rate is used. Maize silage can be grown as summer or winter feed for dairy cows, or as winter feed for young stock.

Nutrients for plant production can be supplied by fertilizer or by manure. The model estimates MINAS balances for N and P_2O_5 at the farm level based on nutrient inputs and outputs. For a more detailed description of the model see Berentsen and Giesen (1995).

The initial farm situation is specified by the right-hand side values for land, milk quota and family labor and by farm-specific coefficients representing milk production per cow and grass production per hectare.

Typical Farms

Choice of farms is based on a report called Typical Dutch (Reijneveld et al., 2000). In this report specialized dairy farms in the Netherlands are clustered according to region, soil type and intensity. Farm data used for clustering are from 1997 and 1998. More than half of the specialized dairy farms in the Netherlands are located on sandy soil where environmental problems are highest. Consequently, averages of different intensity clusters on sandy soil were chosen as typical farms. The different classes of intensity, based on yearly milk production per hectare, were 10,000 to 12,000 kg/ha, 12,000 to 15,000 kg/ha and > 15,000 kg/ha. Fixed assets and productivity characteristics of the resulting farms are in Table 2. These data were used to model the farms. Because average productivity of maize silage appeared to differ only slightly among the farms, the average gross production of 85,050 MJ NEL was used for all farms.

Table 2. Characteristics of three typical dairy farms on sandy soils, differing in intensity.

	Low intensity farm	Medium intensity farm	High intensity farm
Intensity (kg milk quota/ha)	11,300	13,400	19,000
Total area (ha)	36	31	24.5
of which:			
grassland (ha)	28.2	24.2	15.4
maize (ha)	7.8	6.8	9.1
Milk quota (1000 kg)	406	416	476
Milk production (kg/cow/year)	7000	7600	7500
Grass production (MJ NE _I /ha)	54,250	65,385	66,460
N-fertilizer on grassland (kg/ha)	280	320	325

Additional assumptions used in the model concerned the price of manure transfer agreements (€0.78 per kg N) and of manure disposal (€11.34 per ton of manure). These prices stem from an evaluation study of the Dutch manure policy for 2003 (Van der Kamp, 2002). It was assumed that soils were not especially vulnerable to leaching. It appeared from Typical Dutch that the majority of dairy farms on sandy soils apply only day grazing for dairy cows in summer with maize silage fed in the evening. This feeding arrangement is included in the model by using limited grazing and by requiring a minimum amount of 4 kg DM from maize silage per cow per day in summer.

RESULTS

Farm management, environmental and economic results of the three typical farms for a base situation, the situation with MINAS-2003, and the situation with MINAS-2003 and MTAS-2003 are presented. In the base situation, no environmental policy is assumed.

The Low Intensity Farm (11,300 kg milk quota/ha)

In all situations, the numbers of dairy cows and young stock on this farm are 58 and 44 respectively. These numbers are determined by the available milk quota and milk production per cow and by the fixed replacement rate respectively.

In general, land use and dairy cow rations in the base situation are determined as follows. The amount of grass silage is minimized in the winter ration because costs of ensiling are relatively high and because grass production per ha is lower than silage maize production per ha. The uptake of fresh grass in summer by grazing is maximized because it is a cheap source of energy and protein (no harvesting costs). The maximum is determined by the DMI capacity of the cows and by the minimum requirement of 4 kg DM from maize silage in summer. An additional amount of concentrates fulfils the requirement for

energy. The high amount of grass in the summer ration results in a high surplus of protein in the ration. For the winter ration, requirements for energy, rumen degradable protein, and intestine digestible protein fine-tune the composition of the ration and influence N_{min} use on grassland. Higher use of N_{min} results in higher protein concentrations in grass. N_{min} use is also influenced by the required production of grass and together these factors determine the area of grassland. The rest of the area is used for maize silage.

Table 3 shows the resulting land use and composition of the rations for the 11,300 kg intensity farm. Comparison of the land use with the land use in reality (Table 2) shows a smaller area of grassland in favor of a greater area of maize silage. The MINAS balances show an N-surplus of 197 and a P₂O₅-surplus of 6 kg/ha. Total revenues of €163,001 and total costs of €142,755 result in a labor income of €20,246. Marginal values of land and milk quota show the increase of labor income if one hectare of land respectively 1000 kg of milk quota is added to the farm. Conversely, marginal values show the amount of money that the farm can afford to pay annually to acquire these production factors without decreasing labor income.

When MINAS-2003 is included, the acceptable surplus for N restricts N-input (Table 3). The N input is decreased by decreasing N fertilizer use on grassland. Given the lower marginal productivity at higher N rates, this decreases N surpluses per kg of produced grass. The resulting shortage of feed is replenished by purchasing extra concentrate. This is low protein concentrate as the summer ration is balanced for protein requirements. Furthermore, this fine-tuning results in a greater share of maize silage in the summer ration. The consequence is a greater area of maize silage. MINAS-P₂O₅ is not a problem with this low intensity keeping in mind that P₂O₅ fertilizer is not included as an input. Costs that differ are costs of ensiling roughage (+€1000), concentrate costs (+€1600), and fertilizer costs (–€1000). As a result, labor income decreases by €1600. As MINAS is

Table 3. Farm management, environmental and economic results for the low intensity dairy farm.

	Base situation	MINAS-2003 ²	MINAS-2003 + MTAS-2003 ³
Land use			
Grassland (ha)	24.8	23.0	23.5
Maize silage (ha)	11.2	13.0	12.5
Nmin on grassland (kg/ha)	334	257	255
Concentrate purchased (1000 MJ NE _L)	729	779	797
Winter ration (kg of DM/d per cow)			
Grass silage	2.0	2.0	2.0
Maize silage	5.0	5.2	4.9
Concentrate, standard	7.7	7.3	7.6
Concentrate, high protein	0.1	0.4	0.4
Summer ration (kg of DM/d per cow)			
Grass	10.6	8.1	8.4
Maize silage	4.0	6.0	5.7
Concentrate, standard	2.4	0	0
Concentrate, low protein	0	3.3	0.5
Dried beet pulp	0	0	2.5
Manure transfer agreements (kg N)	...	...	549
MINAS-N (kg/ha)			
Total farm input	269	224	225
Total farm output	67	67	67
Correction gaseous losses	6	6	6
Corrected surplus	197	151	152
Acceptable surplus	...	151	152
Penalized surplus	...	0	0
MINAS-P ₂ O ₅ (kg/ha)			
Total farm input	34	37	31
Total farm output	28	28	28
Surplus	6	9	3
Acceptable surplus	...	20	20
Penalized surplus	...	0	0
Economic results (€ ¹)			
Total revenues	163,000	163,000	163,000
Total costs	142,755	144,353	144,951
Labor income	20,246	18,648	18,050
Marginal value of land (€/ha)	378	667	861
Marginal value of milk quota (€/1000 kg)	123	94	76
Marginal value of acceptable N surplus (€/kg)	...	1.35	1.31

¹€1 = ca. US \$1.²MINAS-2003 = Mineral Accounting System.³MTAS-2003 = Manure Transfer Agreement System.

land based, the intensity becomes more important when including MINAS. This is shown by the marginal values of land and milk quota. Under MINAS, land becomes more valuable while the value of milk quota decreases. The marginal value of the acceptable N surplus shows the marginal cost of realizing the acceptable N surplus. It shows that for this farm it is cheaper to decrease the N surplus than to pay levy. This means that the levy of €2.30 is prohibitive in this case.

Adding MTAS means that manure transfer agreements have to be made for 549 kg of N (Table 3). MTAS pushes the farm plan in the direction of more grassland because MTAS application standards of grassland are higher. To stay within the acceptable N surplus dried beet pulp enters the summer ration. The very low protein content of dried beet pulp compensates for extra

protein supplied with the increase of fresh grass. As the P₂O₅ content of dried beet pulp is also very low, the P₂O₅ surplus decreases. Total costs increase by €600. This is mainly due to manure transfer agreements (€430). The rest is the result of the changes in the farm plan. Finally, like MINAS, MTAS increases marginal value of land and decreases marginal value of milk quota.

The Medium Intensity Farm (13,400 kg milk quota/ha)

Given the area of land, available milk quota, milk production per cow and replacement rates, the numbers of dairy cows and young stock are 55 and 40 respectively. Due to the higher intensity of this farm, more roughage production per hectare is required. This is the reason

Table 4. Farm management, environmental and economic results for the medium intensity dairy farm.

	Base situation	MINAS-2003 ²	MINAS-2003 + MTAS-2003 ³
Land use			
Grassland (ha)	19.8	22.4	22.4
Maize silage (ha)	11.2	8.6	8.6
N _{min} on grassland (kg/ha)	400	254	254
Concentrate purchased (1000 MJ NE _L)	787	814	814
Maize silage purchased (1000 MJ NE _L)	0	192	192
Winter ration (kg of DM/d per cow)			
Grass silage	2.0	2.0	2.0
Maize silage	5.8	5.7	5.7
Concentrate, standard	7.4	7.5	7.5
Concentrate, high protein	0.5	0.5	0.5
Summer ration (kg of DM/d per cow)			
Grass	10.0	9.9	9.9
Maize silage	4.0	4.0	4.0
Concentrate, standard	4.0	0	0
Concentrate, low protein	0	4.3	4.3
Dried beet pulp	0	0	0
Manure transfer agreements (kg N)	...	...	1002
MINAS-N (kg/ha)			
Total farm input	312	249	249
Total farm output	79	79	79
Correction gaseous losses	12	12	12
Corrected surplus	221	158	158
Acceptable surplus	...	158	158
Penalized surplus	...	0	0
MINAS-P ₂ O ₅ (kg/ha)			
Total farm input	45	51	51
Total farm output	33	33	33
Surplus	11	18	18
Acceptable surplus	...	20	20
Penalized surplus	...	0	0
Economic results (€ ¹)			
Total revenues	165,600	165,600	165,600
Total costs	139,273	140,669	141,450
Labor income	26,327	24,931	24,150
Marginal value of land (€/ha)	733	893	1005
Marginal value of milk quota (€/1000 kg)	192	176	167
Marginal value of acceptable N surplus (€/kg)	...	1.32	1.21

¹€1 ≈ US \$1.²MINAS-2003 = Mineral Accounting System.³MTAS-2003 = Manure Transfer Agreement System.

that the N_{min} level on grassland is as high as 400 kg in the base situation (Table 4). Cow rations are highly comparable with that of the previous farm. Labor income for this farm is €6000 higher. This higher income is the result of a higher total milk production leading to higher revenues. On the costs side the lower number of cows (with a higher production per cow) leads to lower costs directly attributable to the number of animals, like costs of housing, health care, breeding, etc. The smaller land area and the lower numbers of animals results in zero costs for variable, non-family labor. These costs were around €1500 for the previous farm. Finally, due to the smaller land area, costs of purchased feed (concentrates) are higher, but this effect is moderate because productivity of grassland is considerably higher on this farm. Sum-

marizing, the economic effect of higher plant and animal productivity and a 2% higher milk quota outweighs the economic effect of a 14% greater land area by €6000. Both the marginal values for land and quota are higher than on the previous farm. In general, the marginal value for land increases with increasing intensity (land is becoming more scarce) while the marginal value for milk quota decreases. However, due to the higher plant and animal productivity both marginal values are higher in this case.

Inclusion of MINAS-2003 results in a decrease of the N_{min} level on grassland and in a shift to more grassland, which is in contrast with the previous farm. This is due to the higher productivity of grassland on this farm. However, as this farm is more intensive, the shift to

Table 5. Farm management, environmental and economic results for the high intensity dairy farm.

	Base situation	MINAS-2003 ²	MINAS-2003 + MTAS-2003 ³
Land use			
Grassland (ha)	22.8	23.8	23.8
Maize silage (ha)	1.7	0.7	0.7
Nmin on grassland (kg/ha)	400	270	270
Concentrate purchased (1000 MJ NE _L)	925	1012	1012
Maize silage purchased (1000 MJ NE _L)	853	934	934
Winter ration (kg of DM/d per cow)			
Grass silage	2.0	2.0	2.0
Maize silage	5.6	5.7	5.7
Concentrate, standard	7.6	7.5	7.5
Concentrate, high protein	0.4	0.5	0.5
Summer ration (kg of DM/d per cow)			
Grass	9.9	8.9	8.9
Maize silage	4.0	4.0	4.0
Concentrate, standard	4.0	0	0
Concentrate, low protein	0	0	0
Dried beet pulp	0	4.7	4.7
Manure transfer agreements (kg N)	...	...	3284
Manure disposal (metric tons)	0	230	230
MINAS-N (kg/ha)			
Total farm input	467	391	391
Total farm output	114	151	151
Correction gaseous losses	46	46	46
Corrected surplus	307	194	194
Acceptable surplus	...	178	178
Penalized surplus	...	16	16
MINAS-P ₂ O ₅ (kg/ha)			
Total farm input	93	82	82
Total farm output	48	62	62
Surplus	45	20	20
Acceptable surplus	...	20	20
Penalized surplus	...	0	0
Economic results (€ ¹)			
Total revenues	190,627	190,627	190,627
Total costs	163,449	167,313	169,872
Levy	...	906	906
Labor income	27,179	22,408	19,849
Marginal value of land (€/ha)	790	1200	1332
Marginal value of milk quota (€/1000 kg)	107	76	49
Marginal value of acceptable N surplus (€/kg)	...	2.30	2.30

¹€1 ≈ US \$1.²MINAS-2003 = Mineral Accounting System.³MTAS-2003 = Manure Transfer Agreement System.

more grassland and the decrease of the N_{min} level causes shortage of roughage. Consequently, a small amount of maize silage is purchased. Like the previous farm, rations are balanced for protein requirement and the N surplus meets with the acceptable surplus. Labor income decreases by €1400 compared to the base situation.

Inclusion of both MINAS and MTAS does not change the farm plan or the MINAS-balances. Labor income decreases by €781 due to costs of manure transfer agreements.

The High Intensity Farm (19,000 kg milk quota/ha)

For this farm, the numbers of dairy cows and young stock are 63 and 48 respectively. Due to the high inten-

sity and the high requirement for grass this farm uses the major part of the land as grassland (Table 5). Comparison with the farm characteristics (Table 2) shows that, contrary to the previous farms, this farm has a much smaller area of maize land than in reality. Purchasing some 10 ha of maize silage compensates for the shortage of roughage. Rations are highly comparable with those of the previous farms. The high intensity of the farm results in relatively high MINAS-surpluses. Labor income is comparable with that of the previous farm. Apparently, from an economic point of view a 12% higher milk quota compensates for a 21% smaller area, as animal and plant productivity are almost the same.

Introduction of MINAS-2003 has considerable consequences to the high intensity farm. The MINAS-balances

show that the P_2O_5 surplus is brought down to the acceptable level while the N surplus exceeds the acceptable level. First, surpluses are reduced by minimizing N and P_2O_5 input in the summer ration of the dairy cows. This is done by decreasing the amount of grass in the summer ration and by replacing concentrate with dried beet pulp. Second, the N level on grassland is decreased and third, 230 metric tons of manure are removed from the farm. Labor income decreases by €4771 due to higher costs of concentrates, costs of manure disposal (€2600) and the levy that has to be paid because of the MINAS N surplus. Costs of applying manure on the farm decrease by €700. These results and also marginal values of land and quota show that with MINAS-2003, intensity is becoming a problem on this farm. The marginal value of the acceptable N surplus is €2.30, which means that the levy is not prohibitive for this farm.

Adding MTAS-2003 does not change the farm plan nor the MINAS balances. The only effects are economic. Labor income decreases by €2559, which are the costs of the manure transfer agreements.

Sensitivity Analysis

A number of uncertain factors should be considered. The first one has to do with the location of the farms. So far it was assumed that farms were located on common sandy soil. An alternative, worst case scenario for farms as far as environmental policy is concerned, would be to assume that farms are located on sandy soils vulnerable for leaching of N. Secondly, there is uncertainty about prices of goods and services that are influenced heavily by environmental policy, like prices of manure transfer agreements and of manure disposal. Extra calculations for the situation with MINAS-2003 and MTAS-2003 were done to determine the sensitivity of the results for changes in these factors. New results are compared to those in the final situation of the previous calculations.

Assuming that farms are located on vulnerable sandy soil means that acceptable N surpluses go down (see Table 1). For the high intensity farm there is no effect on farm management and environmental results. This farm was already paying levies and it pays €2200 more levy. Both other farms further decrease the N level on grassland and buy more concentrates and maize silage (the 13,400 kg intensity farm) to stay within the acceptable N surpluses. The effect on labor income is €2500 and €2000 for the low and for the medium intensity farm, respectively. The effect is higher for the first farm because of the lower animal and plant productivity.

If the price of manure transfer contracts would be doubled, there is a higher area of grassland used as the N application standards for grassland are higher than for arable land. However, changing arable land to grass-

land is limited by MINAS that requires fine-tuning of the rations especially with regard to protein requirement and supply. So, all farms slightly increase the area of grassland. On the high intensity farm this is accompanied by a further decrease of the N_{min} level on grassland. The result is a decrease of the amount of N under the manure transfer agreement. Labor income decreases by €230, €700 and €2425 for the three farms respectively. Effects on MINAS surpluses are negligible.

Increasing the price of manure disposal by 20%, which results in the high end of the range of manure disposal prices as given by Philipsen et al. (2001), only influences the high intensity farm as this is the only farm that disposes manure. There is no effect on farm plan. The only effect is an income decrease by €1022 due to the higher costs of manure disposal.

DISCUSSION

Results show that the low and medium intensity dairy farms can cope with MINAS-2003 by fine-tuning feeding and fertilizing without losing more than 8% of their income. The high intensity farm faces an income loss of 18% as this farm depends on the relatively expensive measure of manure disposal. Generally, it can be stated that good nutrient management (i.e., feeding and fertilizing on the edge) can bring down nutrient losses to a certain level at reasonable costs, but given the tight acceptable surpluses in 2003, especially high intensity farms cannot escape from expensive measures.

MINAS-2003 is fully effective as far as the two less intensive farms are concerned in the sense that N surpluses are brought down to the acceptable level. Given the intensity of these farms, P_2O_5 surpluses are not a problem. For the high intensity farm, MINAS-2003 is not fully effective as it shows to be economically profitable to pay levies on N surplus instead of further decreasing N surpluses. This conflicts with the basic idea of the government that levies should be prohibitive (Brinkhorst and Pronk, 1999), which means that it should not be economically attractive to pay levies instead of decreasing surpluses. Margin analysis shows that in this particular case with a manure disposal price of €13.00 per metric ton, the levy on unacceptable N surpluses should be 20% higher to become prohibitive.

MTAS-2003 does affect farms, but not in the sense that environmental results improve. On the low intensity farm, the farm plan shifts towards more grassland because the manure application standards for grassland are higher. On the other two farms, the farm plan already shifted towards more grassland as a result of MINAS. For these farms there is only an economic effect. For the high intensity farm, MTAS results in a further decrease of labor income by 9%. As the decrease of income

is not accompanied by better environmental results, MTAS merely functions as a mechanism to transfer income from livestock farmers to arable farmers.

Changing the ration in order to meet herd nutritional requirements with less N-input through purchased feed appears to be helpful to reduce manure N excretion and consequently N surpluses (see also Rotz et al., 1999 and Dou et al., 1996). In the model that was used here, it is assumed that cows could exactly be fed according to protein standards. This can be realized if animals are fed individually. However, if cows are group fed, for example, roughage, it is often impossible to feed exactly according to protein standards. This means that, in practice, generally a surplus of protein is fed as a kind of safety margin. On average, this means extra consumption of protein and consequently higher N surpluses. As a result it will take more effort and more costs to meet the acceptable surpluses. A safety margin of 100 g of intestine digestible protein per day (6 to 7%) and 200 g rumen degradable protein (Berentsen et al., 1996) means that labor income decreases by an extra €1350 and €2584 for the medium and high intensity farms, respectively, as a result of the environmental policies. On the low intensity farm, there is hardly any influence.

The farm data used in this research, including the data on productivity, are from 1997 to 1998. Since then, animal and plant productivities have improved. Productivity improvement means a better input/output ratio and this includes a more efficient use of nutrients and lower surpluses (Tamminga, 1992; Berentsen and Giesen, 1997). The consequences for 2003 calculations will be that it will take lower costs to meet the acceptable surpluses.

CONCLUSIONS

Main farm management effects of MINAS for Dutch dairy farms are (1) fine tuning of protein feeding especially by replacing grass in the summer ration by corn silage and low protein concentrate and (2) a decrease in the N fertilizer use on grassland. This is followed by a change in land use depending on grassland productivity and the drop in N fertilizer use. Low grassland productivity and a moderate drop in N fertilizer use leads to more maize silage at the expense of grassland. Higher grassland productivity and a substantial drop in N fertilizer use leads to more grassland to maintain grass production at a required level. The environmental effects of MINAS are a drop of the MINAS N surplus in amounts of 46 to 113 kg/ha and a drop of the MINAS P_2O_5 surplus of 25 kg/ha on intensive farms. The Mineral Accounting System is fully effective on farms with a lower intensity. On farms with higher intensity, the acceptable N surplus is exceeded, and levy is paid. Con-

sequences for labor income are a decrease of €1400 to €4800.

Contrary to MINAS, the Manure Transfer Agreement System has little effect on farm management. The higher application standard of grassland is an incentive for more grassland. Income effects depend strongly on intensity, measured in animals per hectare. On intensive farms, income decreases by €2600 due to MTAS. There is no benefit to the environment by applying MTAS in addition to MINAS.

ACKNOWLEDGMENTS

The authors would like to thank Christien Onders-teijn and Lisa Holden for valuable comments on an earlier version of this paper.

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