NITROGEN BALANCE SHEETS ON DAIRY FARMS IN FLANDERS (BELGIUM)

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Abstract

Flemish dairy farming uses intensively N-fertilized grassland, large amounts of slurry for maize cultivation and large amounts of concentrates to support of the daily cow feed intake. Hence, there is a high input of nitrogen in the milk production system. The nitrogen balance $ha^{-1}y^{-1}$ calculation gives a clear idea about the environmental pressure of dairy farms. In this study, conducted from 1991-1995, the nitrogen balance was calculated on 42 dairy farms. Results showed an overall excess of 310 kg N $ha^{-1}y^{-1}$. The NO_3^- content in the soil, at the end of the grazing season in November, accumulated up to 95 kg N $ha^{-1}y^{-1}$, resulting in NO_3^- concentrations in surface water above 50 mg l^{-1}, which is the maximum allowed by the EU Council Directive 676/91 concerning the protection of water against the pollution by nitrates from agrarian sources. The calculation of the N-balance on the farm is a valuable instrument to detect possible N-excess.

Key words: N-fertilization, nitrate residue, grassland, forage crops, dairy farms, N-balance.

INTRODUCTION

Since Flemish agriculture is characterised by intensive farming systems in swine and poultry herds and to a lesser extend in cattle herds, it has to deal with high nitrate residues and consequently pollution of its surface waters (OECD, 2008). Different measurements of the nitrate content in the water of soils and rivers show too high levels in respect to the EU Council Directive 676/91 concerning the protection of water against the pollution by nitrates from agrarian sources

(Council Directive 676/91, 1991). Since 2003 the Flemish and Walloon region are responsible for their agricultural policy. In Flanders a lot of measures were taken to reduce this nitrate content but so far they all failed and therefore the whole Flemish territory was declared as vulnerable zone for nitrate leaching by the EU Commission (Judgment of the Court 2005/296/02, 2005). Once more the Flemish policy makers try to improve the rules and to adapt farming practices more strictly in agreement with this EU Council Directive 676/91, because this is part of Council Regulation 73/2009, establishing common rules for direct support schemes for farmers (Council Regulation (EC) 73/2009, 2009).

The manure supply in Flanders in 2008 was 100 million kg N. The Flemish manure balance represents the difference between the supply of manure and the available land for deposing manure. In 2008 the Flemish manure balance reaffirmed an equilibrium, despite the smaller land area compared to 2007, because of a lesser use of derogation. This is mainly due to a sharp increase in the processing and export of manure, which is a crucial link in maintaining the equilibrium of the Flemish manure balance. Despite the equilibrium in 2008, the quality of surface and groundwater is not satisfying. Meanwhile, there is a balance in demand and supply of manure, but there is no environmental balance (Platteau J., Van Gijseghem D. en Van Bogaert T. (reds.), 2010).

In the autumn of 2010 more than 10.000 soil samples of agricultural land in Flanders were taken for the determination of the amount of nitrate and the Flemish government justifies under the pressure of the European Commission in spring 2011 a severe fertilizer action plan. The use of chemical nitrogen fertilizer will be dramatically reduced (e.g. sugar beets: from 150 kg N ha^{-1} to 35 kg N ha^{-1} on sandy soils) and also for nitrogen from animal manure the norms are tightened (e.g. maïze: from 260 kg total N ha^{-1} to 205 kg total N ha^{-1} on sandy soils) (VILT, 2011).

It is important to convince dairy farmers that their practices are not always in agreement with the

environmental best ones and that the calculation of the N-input and output on their farm is a good instrument to find out where the N-residue can be decreased.

Nowadays in Flanders the fodder crops take 60 % of the total cultivated land area and relate mainly to pasture land and corn. Forage crops include permanent pasture (43,4 %), temporary pasture (14,4 %), maize (40,4 %) and others (1,8 percent). The fodder crops are mainly produced on cattle farms. Due to a declining decreasing number of cattle, as shown in Table 1, the total area of fodder crops did also decrease since 1999 with the largest reduction of grassland area and even a slight increase of forage maize (Platteau J., Van Gijseghem D. en Van Bogaert T. (reds.), 2010).

Table 1

Evolution of the cattle population [n] and evolution of the forage area [ha]in Flanders, 1999-2009

	1999	2009	Change [%]
Suckler cows	201.629	203.463	+1
Dairy cows	349.039	296.951	-15
Veal calves	167.982	142.541	-15
Total cattle	718.650	642.955	-11
Forage maize (excluding dried grain maize)	144.746	150.306	+4
Grassland	244.014	215.622	-12
- Temporary pasture	58.520	53.692	-8
- Permanent pasture	185.494	161.930	-13
Total fodder	395.462	372.494	-6

MATERIAL AND METHODS

The N-balance is defined as the difference between the N-input and N-output on a farm. This instrument was developed based on scientific research during the nineties (Verbruggen I. and Carlier L., 1996 ; Swensson C., 2001). Nutrient balance sheets for 42 Flemish dairy farms have been consecutively calculated between 1991 and 1995. The N-surplus in the nutrient balance is the net result of the total N-input via fertilizers, concentrates, purchased forage and heifers, litter, N-fixation, manure and deposition minus total N output via young calves and old cows, milk, sold forage and manure. At regular intervals samples of various products imported into or exported from the farm were analyzed on their N-content. The average farm characteristics are summarized in Table 2. The effect of the most important parameters, influencing the mineral balance sheet, was calculated by a multiple regression analyses.

Table 2

Mean characteristics of 42 Flemish dairy farms during 1991-1995

Farm characteristic	
Grassland [ha]	30.5
Grassland [%]	62.5
Fodder beets [%]	1.0
Maize [%]	36.5
Milk [l cow^{-1} y^{-1}]	6.250
Milk [l ha^{-1} y^{-1}]	11.500
Standard cow units (cows producing 4.000 l) [ha^{-1}]	2.9
Dry concentrates [kg standard cow^{-1}]	915
Dry concentrates [kg cow-1]	1250

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RESULTS AND DISCUSSION

Table 3

Mean input, output and surplus of N on 42 Flemish dairy farms for 1991 to 1995 in kg N ha^{-1}

	1991-1992	1992-1993	1993-1994	1994-1995
Input				
Cattle	1.9	2.3	2.0	1.0
Dry concentrates	91.5	92.0	92.8	99.0
Moist concentrates	16.9	16.2	13.3	16.0
Forages	10.5	8.0	15.5	19.3
Litter (straw)	4.1	3.6	2.3	2.5
Mineral N-fertilizer	223.4	197.6	197.8	177.8
Organic manure	30.9	34.2	35.3	38.9
N-fixation by legumes	2.7	1.0	1.4	2.1
Atmospheric deposition	40.0	40.0	40.0	40.0
Output				
Cattle	15.0	13.7	14.4	16.0
Milk	55.9	57.0	59.5	57.4
Forage	7.5	16.6	9.5	5.7
Organic manure	8.2	7.6	7.0	10.0
Total input	421.0	394.9	381.3	396.6
Total output	86.6	94.9	90.4	89.2
Surplus	334.4	300.0	290.9	307.4

In Table 3 the results of the nutrient balance calculations in terms of N-surplus are shown. Mineral

nitrogen fertilization adds 45-53 % of the N-input and dry and moist concentrates (for example sugar beet pulp, swill, ...) add about 26-29 %.

Of the N-output, milk is far most important and counts for 60 – 66 % of the N-output. Organic manure produced on the farm by cattle excrements are not part of the input or output and have no impact on the balance, but purchasing or selling manure and/or slurry is influencing the final balance sheet.

The grassland and forage production at a dairy farm have a large influence on the N-balance sheet, because they regulate the need to purchase concentrates and forages or to sell forages to other farms. Grass and forage productions fluctuate yearly because of changing weather conditions: dry or wet summer, mild or hard winter, ... (Michiels, J., Verbruggen, I. and Carlier, L.,1996).

The mineral N-fertilization shows a decreasing trend. Since the Flemish territory was declared as vulnerable zone for nitrate leaching by the EU Commission in 2005, grassland may only be fertilized with 150 kg mineral N ha^{-1}, which is 80 kg less than twenty years ago.

In addition, to control ammonia emission, farmers are obliged to incorporate manure in the soil within 24 hours after depositing This strategy enables a more efficient use of N which may result in a reduced application of the mineral nitrogen on the farm. An additional obligation is that farmers must have the capacity to store the manure and the slurry on their farm for at least 180 days. Using storage enables the farmer to deposit the slurry on the land only at the beginning of the growing season in Flanders after February, 15^{th}. (Verbruggen, I., Nevens, F., Mulier, A., Reheul, D. en Hofman, G., 2006)

After performing the multiple regression analysis on the N-input, following regression was found:

$$Y = - 94{,}067 + 0{,}6445\ X_1 + 0{,}0528\ X_2 + 0{,}1945\ X_3 + 1{,}484\ X_4 + 0{,}8886\ X_5$$

Standard error = 48,05
r^2 = 0,84
Y = N-surplus (kg ha^{-1})
X_1 = mineral N fertilized (kg N ha^{-1})
X_2 = purchased dry concentrates (kg cow^{-1})
X_3 = purchased moist concentrates (kg cow^{-1})
X_4 = % grassland from total area
X_5 = purchased organic manure (kg N ha^{-1})
Y = N-surplus (kg ha^{-1})
X = milk production (l ha^{-1})

There was a significant positive relation between the N-surplus and the milk production per ha. An increase/decrease of 1000 liters milk ha^{-1} accounted for 14 kg N in the balance.

In agreement with Van Der Ham (1992) from the results it could be concluded that having more maize land at the expense of grassland has only a small and neglecting influence on the N-surplus. The management of the cows has a much bigger effect. Housing the milking cows during the night, supplementing them with maize silage had no significant influence on the mineral balance sheet. (Van Vuuren, A.M, and Meys, J.A.C., 1987; Carlier and Verbruggen, 1995).

The most important factors are the grassland proportion and its N-fertilization and the organic manure used on the maize land. Performing the multiple regression analysis on the N- output, following regression was found:
Y = 147 + 0,0143 X
Standard error = 103,37
r^2 = 0,24

CONCLUSIONS

Mineral balances are valuable instruments to inform farmers about the N-input and N-output on their farms. Especially on dairy farms large amounts of mineral N-fertilizer are purchased and used to grow grassland in order to feed the milking cows, mineral balance sheets reflect how much N is imported and exported on the farm level and how much N is as a surplus 'lost' on the farm.

Referring to the EU Council Directive 676/91, there is too high nitrate contents in the soil and water at the farm level. The most important factors, influencing the N-surplus on dairy farms are the grassland proportion and its N-fertilization and the organic manure used on the maize land. The direct incorporation of slurry in the soil determines a higher N-efficiency and finally the use of less mineral nitrogen and a better N-balance sheet. Policy makers are obliged to decree the most effective and appropriate rules and laws for the farming practices according to the EU Regulation embedded in an economic and social framework.

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