COMMUNICATION

A comparison of nitrogen use efficiency and surplus in two dairy farms typologies

Severino Segato, Giorgio Marchesini, Igino Andrighetto

Dipartimento di Scienze Animali. Università di Padova, Italy

Corresponding author: Dr. Severino Segato. Dipartimento di Scienze Animali, Università di Padova. Viale dell'Università 16, 35020 Legnaro (PD), Italy - Tel. +39 0444 228939 - Fax: +39 049 8272669 - Email: severino.segato@unipd.it

ABSTRACT - Referring to the Destra Brenta district (Veneto Region, Italy) two farming systems were considered: grassland-hay (H) vs. arable land-silage maize (M). Manure and crop products belonged to an internal flow, thus an annual farm gate balance of nitrogen (N) was carried out to determine the nutrient use efficiency (NUE) and surplus by using data from a survey. Surplus was determined as difference between inputs (I) and outputs (O) and NUE as ratio between O and I. The main I was represented by purchased concentrate, on the contrary fertilizer accounted only for low amounts. Surplus per surface unit was significantly higher in M-farms group than in H one (269 vs. 369 kg N per ha; P<0.01). Surplus referred to unit of fat corrected milk was significantly lower in M-farms (17.6 vs.15.6 kg of N per ton of FCM; P<0.01) leading to an higher N-NUE (0.260 vs. 0.278; P<0.05).

Key words: Dairy cow, Farming system, NUE, Nitrogen balance.

Introduction – In the dairy area Destra Brenta (Veneto, north-east Italy) farmers raised the productivity of crop and herd of the farming system. In order to increase feed production, most of permanent grassland was substituted by maize cropped arable land. They also purchased high amount of concentrate to satisfy the elevated nutrient requirement of high producing dairy cows. This intensive dairy farming system led to a high production of manure which could cause a serious nitrogen (N) imbalance. This potential pollution was exacerbated by the limited soil N retention capacity, especially of arable land. For this reason there is an increasing demand by Italian policy makers of indicators to assess the environmental consequences of intensive dairy farming system. N-Nutrient Use Efficiency (N-NUE) and surplus, as determined by a farm-gate balance of inputs and outputs, seem to be useful for this purpose (Giustini *et al*., 2007). The aim of this study was a comparison of current N utilization efficiency by two farming systems based on hay or maize as main home-grown crop and primary forage source.

Material and methods – In 2006, a survey was carried out in 44 specialized dairy farms of Destra Brenta district. The database contained information on land use, manure and fertilizer application, feed purchasing, herd, milk production and quality. Farms were

grouped (n=22) in two farming systems according to the feeding method: grassland and a hay based-diet (H) vs. maize and a maize silage based diet (M). The mainly productive characteristics of the two farming systems are given in Table 1.

Table 1. A selection of average characteristics of the two farming systems.

		Hay (H)	Maize (M)
Grassland	ha	15.7	13.6
Arable land	"	3.0	10.2
Stocking density	cows·ha^{-1}	2.6	3.1
Fat correct milk production per cow	kg·year^{-1}	6927	8815

Manure and crop products belonged to an internal flow, thus a farm gate apparent balance of nitrogen (N) was carried out to determine the nutrient use efficiency (NUE) and surplus (Schröder *et al*., 2003). Annual N balance was calculated considering atmospheric deposition, purchased fertilizer and feed as inputs (I), milk and meat as outputs (O). The nutrient surplus was calculated as the difference between I and O and N-NUE as ratio between O and I. Data were submitted to ANOVA according to a monofactorial design (two farming system) by the general linear model procedure of SAS (2002).

Results and conclusions – The effect of the farming system on N balance (kg year^{-1}) and the relative NUE and surplus values are given in Table 2. The main input was purchased feed that was significantly higher in M-farming system; fertilizer application was similar between the two groups. Milk was the main output and it was significantly affected by farming system. The significantly higher N surplus per ha observed in M-farms group was solely due to a major N input as purchased concentrates.

Table 2. Effect of farming system (Hay vs. Maize) on annual nitrogen (N) balance, surplus and N-NUE.

		Hay (H)	Maize (M)	RSD	*P*
Fertilizer	kg·ha^{-1}	83	79	23	ns
Feed	"	256	409	176	**
Total input§	"	360	510	160	**
Milk	kg·ha^{-1}	79	126	37	***
Meat	"	12	14	3	*
Total output	"	91	140	40	***
Surplus per area	kg·ha^{-1}	269	369	121	**
Surplus per milk	kg·10^{-3} kg FCM	17.6	15.6	1.9	**
Surplus per cow	kg·cow^{-1}	101	118	15	***
N-Nutrient Use Efficency		0.260	0.277	0.02	*

*§Including a representative average N atmospheric deposition of 20 kg/year. *: P<0.05; **: P<0.01; ***: P<0.001.*

In H-farming system N surplus per unit of milk resulted significantly higher and N-NUE was significantly lower than in M-farming system. The higher efficiency of M-farms had several reasons. A ration mainly based on concentrates or low N content forage (i.e., maize silage) may result in a much more efficient N retention (Van Keulen *et al*., 2000). Taking into account high productive cows, lower amounts of N per unit of milk were necessary for maintenance and growing up the young stock replacements, even if this N supply also depends on calving rate (Børsting *et al*., 2003). Since maize silage has a higher energy content compared to grass hay or silage, less concentrates are needed, reducing the feeding cost. The use of Italian ryegrass as catch crop after maize could minimize the risk of nitrate leaching during winter and spring. Moreover, this extra roughage production can reduce further the amount of purchased feed. In addition, part of the maize could be harvested as grains or corn-cob mix and used as concentrate replacer. However, grassland stimulated soil organic matter build-up limiting nitrate leaching to groundwater. A reduction of N losses during manure storage and handling and an appropriate crop rotation could improve the utilization of manure N (Nevens *et al.*, 2006).

In conclusion, the eco-efficiency could seem higher in H-farm if related to total amount of surplus per surface unit according to the regional approach, otherwise it seemed higher in M-farm if surplus was related to milk production (ratio between production and potential environmental damage).

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