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How Production Intensity Could Affect Sustainability And Milk Quality In Dairy Farm

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Introduction

Increasing food production and quality in a sustainable manner is a key factor to fulfil the needs of global human population growth. Sustainable intensification strategy can reduce environmental impacts, through improvements in the milk production per cow and feed efficiency, as well as by increasing the net primary production of the utilized agricultural area (UAA) and the input efficiency (Gislon et al., 2020). An environmentally sustainable milk production must therefore be achieved through the use of cropping/forage systems and practices that allow the most efficient use of resources and the lowest environmental impacts per unit of product (Capper, 2011). The aim of this work was to evaluate the effects of three different levels of production intensity per unit of UAA on milk quality and sustainability in different farms of Northern Italy.

Materials and Methods

Twenty-four dairy farms in Northern Italy were selected and assigned to three classes of milk production intensity levels: LOW (<15 t fat-protein corrected milk (FPCM)/ha), MEDIUM (from 16 to 30 t FPCM/ha) and HIGH (>31 t FPCM/ha). Data covering herd composition, livestock production systems, livestock feed management, crop cultivation and management were collected through on-farm questionnaires and registered data available on the farms. All the data concerning farm inputs and farm outputs were obtained through the analysis of all the farm invoices. The environmental impacts have been evaluated using the LCA methodology assessing the global warming potential (GWP). The system boundaries concerned a cradle-to-farm gate analysis. The functional unit considered was one kilogram of FPCM. Milk fatty acid profiles were determined by gas-chromatograph. Results were analysed for their statistical significance via analysis of variance utilizing the production intensity as fixed factor, with data from each intensity level pertaining to individual farm as replicates in the statistical model. The Bonferroni post-hoc test was used to interpret any significant differences among the mean values.

Results

Farms belonging to the HIGH group were characterized by lowest farm area and highest stocking rate, whereas, HIGH and MEDIUM groups had daily milk production, dry matter intake (DMI) and dairy efficiency greater than LOW farms (Table 1). LOW and HIGH milk farms were connected to high amount of multiannual forages and maize, respectively. LOW farms showed higher winter soil covering, higher areas without agrochemical inputs, lower plowed areas and lower mineral nitrogen application than HIGH farms. This resulted in lower GWP in LOW and MEDIUM farms than in HIGH farms, with a contrasting dilution effect of CH_4 emissions counteracted by higher emissions linked to purchased feeds. MEDIUM farms showed similar GWP to low farms but with herd performances close to those of HIGH farms. The lower the milk intensity was, the higher the milk quality, in terms of fatty acid profile, confirming that dairy cow diets based on high quality meadow forages showed higher C18:3n-3, CLA, n-3/n-6 ratio. The nitrogen balance showed an increase of input from LOW to HIGH farms, mainly due to inputs related to purchased feeds and mineral fertilizers. This resulted in a surplus of 105, 328 and 792 kg/ha in LOW, MEDIUM and HIGH farms, respectively.

Table 1. Farm and cropping system characteristics, GWP and milk quality of farms with different milk intensity levels.

	Milk Intensity				
	LOW (n = 8)	MEDIUM (n = 8)	HIGH (n = 8)	SEM	*P*-value
Farm characteristics					
Milk Intensity (t FPCM/ha)	6.8^{c}	23.2^{b}	48.5^{a}	3.868	<0.001
Utilized Agricultural Area (UAA) (ha)	94^{a}	95^{a}	43^{b}	8.998	0.018
Stocking rate (LU/ha)	1.71^{c}	3.41^{b}	7.19^{a}	0.526	<0.001
Herd performances					
Milk FPCM per cow (kg/d)	22.1^{b}	34.5^{a}	36.0^{a}	1.521	<0.001
DMI (kg/d)	19.3^{b}	23.8^{a}	24.2^{a}	0.542	<0.001
Dairy efficiency (kg FPCM/kg DMI)	1.14^{b}	1.45^{a}	1.49^{a}	0.044	<0.001
Cropping system characteristics					
Maize (whole plant/ear silage, grain) (% UAA)	16	61	83	-	-
Winter cereals (silage grains) (% UAA)	5	6	9	-	-
Italian ryegrass (% UAA)	7	30	41	-	-
Other forage crops (% UAA)	1	1	1	-	-
Multiannual forages (alfalfa, meadows) (% UAA)	74	30	11	-	-
Double crop (% UAA)	3^{b}	28^{a}	45^{a}	4.7	<0.001
Winter soil covering (% UAA)	83	65	60	4.2	0.073
Plowed area (% UAA)	40^{c}	98^{b}	131^{a}	9.6	<0.001
Area without agrochemical use (% UAA)	73^{a}	31^{b}	13^{b}	6.5	<0.001
Mineral nitrogen inputs (kg N/ha)	28^{c}	110^{b}	159^{a}	14.48	<0.001
GWP					
Total (kg CO_2-eq/kg FPCM)	1.43^{b}	1.53^{b}	1.68^{a}	0.037	0.012
Purchased feeds (kg CO_2-eq/kg FPCM)	0.48^{c}	0.78^{b}	0.96^{a}	0.049	<0.001
CH_4 (kg CO_2-eq/kg FPCM)	0.70^{a}	0.52^{b}	0.52^{b}	0.024	0.001
N_2O (kg CO_2-eq/kg FPCM)	0.14	0.13	0.12	0.006	0.507
Other inputs (kg CO_2-eq/kg FPCM)	0.12^{a}	0.10^{ab}	0.08^{b}	0.007	0.030
Milk quality (g/100 g fat)					
C18:3n-3	0.73^{a}	0.57^{ab}	0.39^{b}	0.046	0.006
CLAc9t11+t7c9+t8c10	0.58^{a}	0.36^{b}	0.41^{b}	0.035	0.020
even_SFA	65.3^{a}	64.1^{ab}	62.9^{b}	0.375	0.021
MUFA	25.8^{b}	26.0^{b}	28.7^{a}	0.418	0.002
PUFA	3.68^{b}	4.76^{a}	4.03^{b}	0.167	0.019
n-3/n-6 ratio	0.64^{a}	0.35^{b}	0.25^{b}	0.055	0.007

CLA = conjugated linoleic acid, DMI = dry matter intake, FPCM = fat protein corrected milk, GWP = global warming potential, LU = livestock units, UAA = Utilized Agricultural Area.

Conclusions

A medium milk production intensity is a good way for a sustainable intensification strategy, by combining high inputs and production efficiencies, while maintaining a capability of recycling nutrients and reducing environmental pressure.

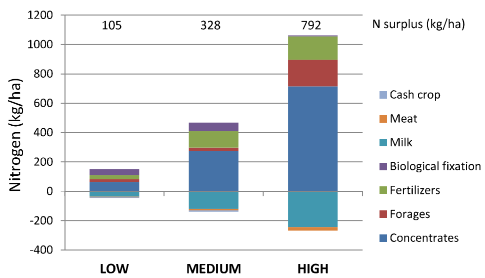

Figure 1. Farm gate nitrogen balance in the studied farms

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