

Genotype by environment interaction for milk production traits in conventional and organic Dutch dairy farms



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Background

By 2030:

- 25% agricultural land is organic
- Decrease nutrient losses by 50%



Consumers' demand for organic products

+ 31% organic dairy farms in The Netherlands between 2016 and 2021 *

Different practices between organic and conventional farms, e.g. regulations on organic farms:

- > 60% of roughage
- No chemical fertilizer
- Compulsory access to grazing

Genotype by environment interaction (G×E) may lead to a re-ranking of animals between two environments

Objectives

→ Define farm environments more accurately in terms of nitrogen (N) and phosphorus (P) efficiency and ration characteristics.

→ Analyse G×E between first parity Holstein Friesian cows on conventional (CF) and organic (OF) dairy farms in the Netherlands.

Material and methods - Farm characteristics



Conventional **Organic**
1,050 farms
2016 to 2021

Milk yield; N and P efficiency (herd level); Ration composition (concentrate, fresh grass, grass silage, maize silage and others, as % of dry matter (DM) in the ration)	4,971 records	542 records
Permanent grassland	3,282 records	400 records

Results - farm characteristics

	Conventional			Organic		
	Mean	SD	CV	Mean	SD	CV
Milk yield (kg/cow/year)	9031	1088	0.12	7435	1248	0.17
N efficiency (%)	25.2	2.2	0.09	23.5	2.9	0.12
P efficiency (%)	35.2	3.5	0.10	30.3	4.3	0.14
Concentrate (% DM)	26.9	5.5	0.20	20.3	7.2	0.35
Fresh grass (% DM)	9.3	7.8	0.85	27.1	11.9	0.44
Grass silage (% DM)	40.4	9.5	0.23	45.2	10.7	0.24
Maize silage (% DM)	17.7	10.4	0.59	5.2	8.0	1.55
Other (% DM)	5.6	5.6	1.00	2.2	3.8	1.73
Permanent grassland (ha)	36.2	26.8	0.74	58.9	45.0	0.76
Permanent grassland (%)	62.6	30.7	0.49	73.8	33.3	0.45

Table 1. Mean values, standard deviations (SD) and coefficients of variation (CV) of farm characteristics on CF and OF. All variables are significantly different between CF and OF ($P < 0.01$, t-test)

Material and methods – G×E between OF and CF



Conventional **Organic**
(status in 2021)

	852 farms	224 farms
Milk (milk, fat and protein yield)	96,527 records	15,071 records
Somatic Cell Count (SCC)	92,052 records	14,270 records
1 st parity cows, at least 60 % Holstein Friesian		

$$Y_{ijkl} = \mu + HYS_i + Breed_j + LL_k + \beta \cdot AFC_{ijkl} + Animal_{ijkl} + e_{ijkl}$$

Y_{ijkl} : observation on animal l ; μ : overall mean for the trait; HYS_i : Herd-Year-Season (2016 to 2021; 4 seasons; $i = 1$ to 2,126 for OF and 1 to 11,938 for CF); $Breed_j$: Breed combination ($j = 1$ to 14); LL_k : Lactation length ($k = 1$ to 6, grouped as: < 300 d, $300 - 350$ d, $351 - 400$ d, $401 - 450$ d, $451 - 500$ d, > 500 d); AFC_{ijkl} : Age at first calving (in months); β : regression coefficient for linear regression on AFC ; $Animal_{ijkl}$: random additive genetic effect of animal l ; e_{ijkl} : residual

Results - G×E between OF and CF

	h^2		r_g
	Conventional	Organic	
305-d milk (kg)	0.45 (0.01)	0.37 (0.02)	0.96 (0.02)
305-d fat (kg)	0.41 (0.01)	0.36 (0.02)	0.96 (0.02)
305-d protein (kg)	0.37 (0.01)	0.31 (0.02)	0.95 (0.02)
Fat (g/kg)	0.69 (0.01)	0.67 (0.02)	0.99 (0.01)
Protein (g/kg)	0.72 (0.01)	0.67 (0.02)	0.99 (0.01)
SCC	0.04 (0.01)	0.03 (0.01)	0.96 (0.17)

Table 2. Heritability (h^2 , SE) for traits on CF and OF; and genetic correlation (r_g , SE) between the two environments. G×E is considered significant for $r_g < 0.80$.

Conclusions & further research

- With $r_g > 0.80$, no G×E was found between organic and conventional farms for the 6 milk production traits.
- Milk yield, N and P efficiency, ration composition and permanent grassland are significantly different between OF and CF. Moreover, variation is observed within CF and OF, especially regarding ration composition.
- Further analyses will be conducted on G×E interactions between organic and conventional farms, including more farm characteristics, such as ration composition and N and P efficiency.



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