Genotype Environment Interaction between Organic and Conventional Dairy Production

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***Abstract* – Due to genotype by environment interaction (GxE), conventional bulls might not be suitable for organic production circumstances. Therefore, lactation records from Holstein cows on organic and conventional farms were used to estimate the magnitude of GxE between organic and conventional production circumstances. GxE was quantified by estimating the genetic correlations between production traits in both environments. Genetic correlations for milk and protein yield were between 0.71 and 0.80 and found to be significantly different from unity. For fat yield the correlations were close to 0.90 and not significantly different from unity. It can be concluded that breeding values for yield traits should be adapted to organic production so that the production level of cows fits better to the organic environment resulting in healthier dairy cows.[1]**

Introduction

Animal breeding is still the missing link in the development of the organic food production chain. At present organic farmers world wide use stock that was selected based on information from conventional production systems. Such animals might not be optimally adapted to the organic low input farming system (Weigel et al., 2001). Under organic conditions, feed supply and genetic potential might not be in balance. Hardarson (2000) describes the physiological problems that high productive cows can get under such conditions. Next to the decrease of animal welfare, the need of health treatments may be a risk for food safety.

To minimize these potential problems, it would be better to have animals that are optimally adapted to the organic environment, which is also a principal of organic farming (EU, 1999). The question is how to select animals for organic farming. Within organic dairy farming, which covers 2-3% of the total dairy production in The Netherlands, numbers of animals are small for efficient and cost effective selection strategies. Potentially use can be made of bulls selected for the conventional system However, due to differences between the organic (low-input) and conventional (high input) environment, breeding values of bulls, which are based on conventional production, might show reranking for organic production due to genotype by environment interaction (GxE) (Falconer, 1996). This means that organic farmers can not select breeding bulls adequately for their farms. Especially, the reranking of top bulls might be a problem (Mulder et al., 2003). GxE can be expressed by the estimation of the genetic correlation between two environments (e.g. Calus et al., 2002). To quantify the importance of GxE between conventional and organic production, milk production data of Holstein cows from converted-to-organic and conventional farms were used to estimate the genetic correlation.

Materials and Methods

Estimated 305-day lactation records and pedigree information from cattle from conventional farms and farms that converted to organic between 1990 and 2003 were obtained from the Dutch Herd Book and milk recording organization (NRS). In total 17389 305-day-lactation records of first parity HF cows were available. Records were from before and after conversion to organic farming (see also Nauta et al. 2004). Next to this, a random selection of similar 305-day lactation records from cattle from conventional farms were obtained. Based on the date the farm converted to organic farming, the data of organic farms was divided into three environmental groups; pre-organic, converting-to-organic and organic (see also Nauta et al, 2006a). Data from conventional farms will be referee to as conventional.

The four groups were analyzed simultaneously in a multivariate (quatro) analysis, i.e. a trait recorded on animals in each of the groups were considered as a genetically different trait. In this way information on genotypes could be used over all groups which resulted in a more accurate estimation of correlations. Genetic correlations between the different groups for milk yield, were analyzed in a multivariate analysis using ASREML (Gilmour et al., 1998).

The model used was:

$$Y_{ijkl} = mu + HYS_j + ß_0 * AFC_{ijkl} + ß_1 * (AFC_{ijkl})^2 + ß_3 * DO_{ijkl} + ß_4 * (DO_{ijkl})^2 + Animal_l + e_{ijkl}$$

Results and Discussion

The genetic correlations for kg milk production between conventional and organic production were 0.80 and between pre-organic and organic farms 0.79. The genetic correlations between fat yield in conventional and organic production were closer to 0.90. For protein yield lower correlations were estimated. A likelihood ratio test showed that the

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Table 1: Genetic correlations of milk production traits between the different environmental groups.

	Genetic correlation between environmental groups:					
	conventional and pre-organic	conventional and converting-to-organic	conventional and organic	Pre-organic and converting-to-organic	Pre-organic and organic	Converting-to-organic and organic
Milk yield	0.99[f]	0.92 (0.05)*	0.80 (0.07)	0.96 (0.04)	0.79 (0.09)	0.87 (0.07)
Fat yield**	0.97	0.93	0.88	0.87	0.86	0.99[f]
Protein yield	0.99[f]	0.92 (0.06)	0.78 (0.08)	0.87 (0.08)	0.71 (0.11)	0.90 (0.08)

* standard errors between parenthesis. ** no standard errors could be estimated, [f] correlation was fixed at 0.99.

correlations for milk and protein yield were significantly different from unity.
The correlations are low compared to other studies that estimated correlations between conventional farms that differed to a certain extend (Calus et al, 2002; Mulder et al., 2004). Our findings correspond more to correlations found between New Zealand and North America or European countries, which are about 0.72 for milk yield (Interbull, 2004). This low correlation thought to be due to the differences in feeding systems between those countries. In New Zealand dairy farming is primarily based on grazing with low input of concentrates while in Europe and North America milk production is more based on 'requirement' feeding systems in which besides roughage also concentrated feed is applied based on the milk production level of the cows. Also Weigel et al. (2001) found low correlations between rotational grazing systems and intensive management systems which were between 0.8 and 0.9 (Weigel et al., 2001). Organic dairy farming in the Netherlands can also be described as a more grass based system while the use of concentrates is limited (EU, 1999) and the ration of roughage in the diets is higher then in conventional farming (Nauta et al, 2006b).

Genetic correlations between conventional and organic production of about 0.80 are indicating that there is an effect of GxE on milk and protein yield. However, these results were estimated with data from a time that organic dairy farmers still could use relative large amounts of conventional concentrates to fill the gap of energy supply for the cows. Under the legislation of organic faming from August 2005, feedstuff has to be of 100% organic origin instead of 40% (EU,1999). This will probably lead to lower concentrates use in organic farming resulting in a lower energy supply. This will probably increase the influence of GxE and with correlations below 0.80, the trait milk production in organic farming can be seen as being a different trait from milk production in conventional farming (Falconer and MacKay, 1996). Therefore, in the future it is expected to become increasingly difficult for organic farmers to select breeding bulls based on information collected under conventional production circumstances. To solve this problem breeding values have to be converted to "organic" breeding values or breeding values have to be estimated based on information obtained under organic conditions. Only then organic farmers can optimally select the best breeding bulls for organic production.

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