Proceedings of the World Congress on Genetics Applied to Livestock Production, 11.536

Organic dairy breeding lines? – Possibilities and Requirements

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Summary
Genomic breeding schemes with large cow reference populations will give room for more line division within dairy cattle breeding and therefore also for organic breeding lines. The reason is that different economic values between organic and conventional production systems are expected in the future and the existence of genotype by environment interaction will presumably be even more recognized. Therefore, correlations between organic and conventional breeding goals are expected to be significantly lower than one. This in combination with increased future "break even" correlations opens up for specific organic breeding lines.
Keywords: breeding strategy, breeding goal, organic dairy farming

Introduction
Organic farming is expected to be an important part of future animal production. However, until now, improvements in the efficiency of organic dairy production have mainly occurred through better management, feeding and production strategies, using the same dairy cattle breeds and breeding material as in conventional production systems. In the pre-genomic era, there have been many good arguments for doing this. Genetic progress was strongly dependent on a substantial number of tested young bulls per year, which required many daughters sired by young bulls. Therefore, quite large populations were required to provide enough genetic progress. Now, in the genomic era, progeny testing is no longer essential to achieve good rates of genetic progress, and therefore there is an opportunity to use smaller populations or lines of populations. This has an impact on the opportunity to establish organic breeding lines. The possibilities and requirements for establishing organic breeding lines will be explored and discussed in this paper.

Why organic breeding lines?
The idea behind organic production, as well as the restrictions set by both national and international regulations for organic production, may result in: 1) different breeding goals for organic dairy cattle as described by Slagboom et al., (2018); 2) genotype by environment interactions (G by E) between conventional and organic production systems, and 3) the need to include new traits in the organic breeding goal, which have little or no value in the conventional production systems. Depending on the differences between breeding goal traits and the extent of the G by E, the optimal solution will be customized indices for organic farmers or establishing real organic breeding lines.

The main reason for absence of organic breeding lines is most likely that the so-called "break even" correlation was too low for separation in lines in most breeding schemes in the pre-genomic era. The "break even" correlation is the correlation, where it is beneficial to divide the population in lines when the actual correlation between breeding goals in two lines is lower than the "break even" correlation. A correlation higher than approximately 0.8 has been shown to cause loss of genetic gain when dividing populations with less than a million cows in lines (Smith and Banos, 1991; Mulder and Bijma, 2006). Where populations are small, the "break even" correlation will be lower. However, this assumption was when progeny testing of bulls was the overall driver of genetic gain as shown in Figure 1.

Figure 1 Illustration of the driving forces for obtaining genetic gain in dairy breeding programs before genomic selection. The accuracy of bull EBVs depend on the balance between the number of registered cows and the number of progeny tested bulls, and the selection intensity of bulls to be selected, depend on the number of progeny tested bulls.

In the future, the number of genotyped cows with phenotypes will be the overall driver of genetic gain as illustrated in Figure 2. So, dependent on: 1) the level of genotyping within the population, 2) the traits of importance in the breeding goal (low or high heritability traits), and 3) the possibilities for sharing reference populations with other lines or populations, it will be possible to obtain genetic gain at an acceptable level in small and medium sized populations. In larger populations the use of cows in the reference population opens up for having different lines with different breeding goals, as illustrated in Figure 2. Therefore, the "break even" correlation between breeding goals is likely higher in breeding schemes using genomic selection. This means that the correlation between an organic and conventional breeding goal does not need to be as low as in the pre-genomic era before line division is advisable.

Figure 2 Illustration of the driving forces for obtaining genetic gain in genomic dairy breeding programs. The accuracy of GEBVs depends on the number of cows in the reference populations, and the selection intensity of the selected bulls depends on the number of genotyped bull calves.

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Economic values

As described, mainly two factors affect the "break even" correlation. Firstly, the economic values in the breeding goal for the possible lines and secondly the presence of biological G by E. The breeding goal defines which traits are to be improved and how much weight is given to each trait (Groen et al. 1997). In dairy cattle breeding, the weighting factors are often EV based on modelling. The EV are marginal EV, meaning the EV of one unit improvement of the trait – keeping the remaining traits constant. Therefore the EV, are functions of the production circumstances, depending on differences in productions systems and differences in economic circumstances, e.g. prices of output (milk and meat) and input (primarily feed prices). This creates different EV for different traits in conventional and organic production systems (Kargo et al., 2015). These EV are based on economic models which for some traits, e.g. traits related to welfare and robustness can be difficult to derive. In such cases, one can choose to assign these traits with so-called non-market values (Nielsen et al., 2005). Furthermore, the EV can be adjusted based on farmer preferences, which can be incorporated into the model to calculate EV (Slagboom et al., 2016, Slagboom et al., 2017) or they can be adjusted in accordance with principles for production, e.g. the principles for organic production as shown by Slagboom et al., 2018.

G by E interaction

Looking at Interbull correlations (Interbull, 2017) between countries there is no doubt that G by E exist. Even for simply measured traits like production traits there are correlations below 0.8 between the primarily confinement production systems in West European countries and the grass based production system in New Zealand with minimal feeding of concentrates. This suggests that there may also be G by E between organic grass based productions systems and more indoor based systems with high amount of concentrate and high quality silage in feeding. There are, however, quite few and inconsistent estimates for G by E within literature. In Sweden, G by E between organic and conventional dairy farms were found for fertility traits in second lactation only, and no G by E were found for production traits (Sundberg et al., 2010). In the Netherlands, moderate G by E were found for milk production traits (Nauta et al., 2006). The reason for these many nonsignificant and inconsistent estimates may be due to a low number of registrations in these analyses and in some cases difficulties in assigning the different herds to the right productions classes. Our expectation are, however that dairy cattle breeding in the future will be faced with more diversified production systems, some very intensive and some more extensive systems, and therefore also faced with the existence of G by E.

Conclusion

We have argued that in the future we will have different EV for conventional and organic dairy production systems, and that there is a high probability for the existence of G by E between conventional and organic production systems. The “break even” correlation, measuring how low correlation between breeding goals must before line division is advisable, will go up in genomic breeding schemes with large cow reference populations. All this is in favor of specific lines. Before arguing for organic breeding lines, the correlations between the two environments must therefore be estimated. Furthermore, breeding scheme simulations must be carried out to investigate whether it is economically sound to set up different lines, meaning that the extra gains achieved will be able to pay for the extra costs of running two or more breeding lines instead of one. On top of this the requirements are sound phenotypic registrations and enough genomic tests for females to create reference populations within each production system. In conclusion we expect that organic breeding lines or lines fitting other specific production circumstances will be created in the future.

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