Improving nitrogen use efficiency through breeding

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Summary

- Genetic differences explain 8% of the variability in the efficiency of how nitrogen is used and 10% of the variability in the quantity of nitrogen excreted.
- A dairy cow in the top 10% of the most nitrogen-efficient cows nationally would be expected to excrete 8.5 kg less nitrogen over a 305-day lactation than an average dairy cow for nitrogen efficiency.

Introduction

Both nitrates in drinking water and nitrous oxide, a powerful greenhouse gas, are of growing concern. Management strategies can be used to reduce the use of nitrogen on farms (e.g. clover) and also increase the efficiency of its use (e.g. targeted use of Low Emission Slurry Spreading). Animal breeding is a proven technology that has clearly demonstrated its ability to deliver sustainable gains in performance. A study was undertaken to examine if genetic differences existed between cows for nitrogen use efficiency, the first undertaken in grazing dairy cows globally.

Nitrogen sources and uses

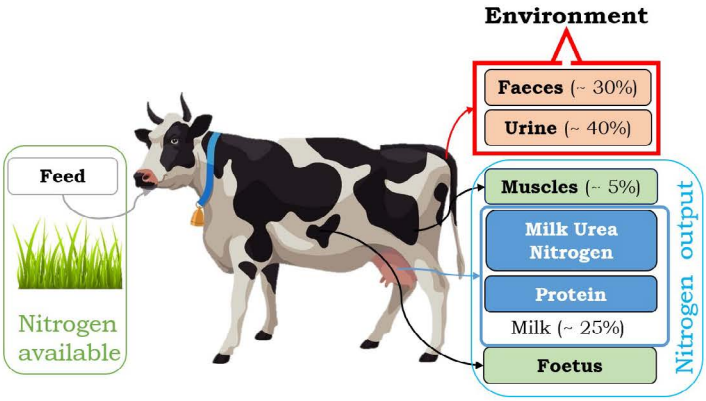

Figure 1. *Different nitrogen sources and sinks for a grazing dairy cow*

The quantity of nitrogen ingested by Irish dairy cows is almost exclusively a function of how much the cow eats and the crude protein (of which nitrogen is a component) of that diet. A small portion of the nitrogen available to the cow can also come from the mobilisation of body muscle reserves. Dairy cows use nitrogen to produce milk protein, milk urea nitrogen, and the protein in the meat (Figure 1). How the nitrogen ingested is portioned into the nitrogen sinks are represented in Figure 2.

Two definitions of nitrogen use efficiency were defined for this study, each on an individual cow basis for different points of the lactation:

- The nitrogen excreted, which was calculated as the nitrogen available to the cow minus the total nitrogen partitioned into the different products, and
- The traditionally used nitrogen use efficiency metric, which was defined as simply all of the nitrogen output into the different products divided by the total nitrogen available to the animal.

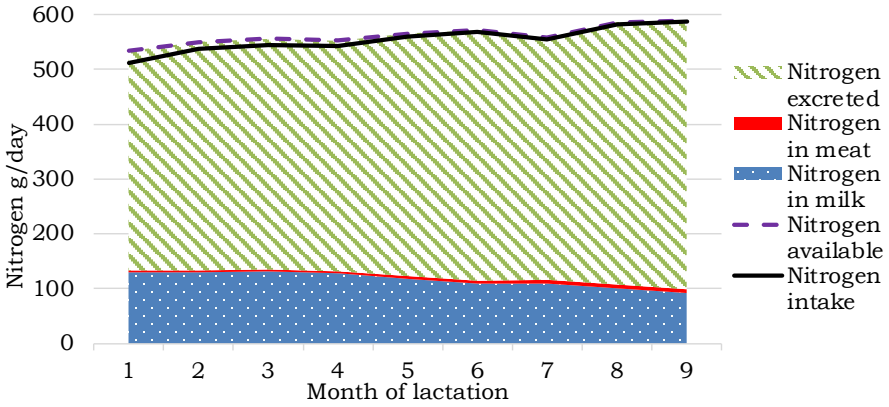

Figure 2. *Nitrogen intake, available and used in product depending on the month of lactation*

Data were available on 1,291 dairy cows from four research farms at the Teagasc, Animal & Grassland Research Centre, Moorepark, Fermoy, Co. Cork. Milk production and composition, body weight, dry matter intake, and crude protein content of the diet were recorded for 2,241 lactations recorded between the years 2008 and 2018.

Potential improvement from breeding

Genetic differences among cows are responsible for 8% and 10% of the variability in nitrogen use efficiency and the quantity of nitrogen excreted, respectively; these values are referred to as the heritability. The best 10% of dairy cows used 1.1% more of their nitrogen intake for milk and meat, and excreted 28 grams less of nitrogen per day than the average cow. Assuming an average herd size of 83 dairy cows, where all dairy cows are in the top 10% for nitrogen-efficiency, that herd would be expected to excrete 709 kg less nitrogen over a 305-day lactation than a herd of cows that are average for nitrogen efficiency.

Relationship between milk production and nitrogen efficiency

The genetic relationship between two traits is a measure of how much one trait might change if the other trait was selected for. For example, the genetic relationship between nitrogen excretion and nitrogen use efficiency was moderately negative; this means that selecting cows with high nitrogen use efficiency could result in lower nitrogen excretion. Nitrogen use efficiency was positively associated with the milk yield, meaning that selecting for high milk production alone could increase nitrogen use efficiency. There was no relationship between either of the definitions of nitrogen use efficiency and milk urea nitrogen, so selecting for high or low milk urea nitrogen concentration would not influence nitrogen use efficiency.

Conclusions

Genetic differences among animals contribute to actual differences in both the amount of nitrogen excreted and also the efficiency by which nitrogen is used. This genetic diversity is a cornerstone to successful breeding programs, however, meaning that, breeding for improved nitrogen use efficiency is possible. This will require measures of nitrogen use efficiency in individual cows, which are difficult to capture.