LARGE VARIATION IN NITROGEN EFFICENCY AMONG ORGANIC AND NON-ORGANIC DAIRY FARMS

Sissel Hansen[1], Matthias Koesling[2], Maximilian Schüler[3], Gustav Fystro[4], Marina A. Bleken[5] *[1]Norwegian Centre for Organic Agriculture (NORSØK), Tingvoll, Norway, [2]Norwegian Institute for Bioeconomy Research (NIBIO), Tingvoll, Norway, [3]Thünen-Institut für Ökologischen Landbau Trenthorst, Westerau, Germany, [4]Øystre Slidre Kommune, Heggenes, Norway, [5]Norwegian University of Life Sciences, Ås, Norway*

Objectives

Agricultural production is requested to be environmental friendly and resource efficient. A literature review of farm surveys and prototype farm studies found that increasing use of N fertilizer and imported feed increased the yields and the productivity of dairy farms, but also increased the N-surplus [1]. We studied the N-efficiency and cause of variation in organic and non-organic commercial dairy farms.

Hypotheses:

- Increasing amount of nitrogen in purchased fertilizer or feed per ha farmland, will decrease the N-efficiency and increase the N-surplus per ha, and per unit produce.
- The variation in estimated N-efficiencies are larger within organic and non-organic farm management than the between the averages of the two groups.

Method

Data were gathered for the years 2010 to 2012 from 10 organic and 10 non-organic dairy farms. They were typical farms on the Norwegian west coast (Møre og Romsdal County), but the selected farms differed both in cattle numbers, milking yield, farm area, fertilization intensity and share of concentrates. Most of the roughage were produced on the farms, with some import in cold years. All farms imported the feed concentrates. The dairy herds were grazing in summer time, either on fully cultivated land, in fenced uncultivated pastures (pasture), or in forest or mountain area outside the farmland (rangeland). **Farmland** is defined as fully cultivated land plus pasture area weighted by 0.3. Grazed rangeland is not included in the farmland.

We used the following definitions: **Dairy system**: the sum of the dairy farm plus area and N-input for production of purchased feed. Thus, the total N-input to the dairy system includes the N-surplus at the site of production of imported feed; **N-produce:** N in delivered milk plus net edible meat gain; **N-purchase**: purchased feed, fertilizer, manure and litter; **N-surplus**: net N-purchase plus biological nitrogen fixation (BNF) plus atmospheric deposition minus net N-produce; **N-Surplus of purchased N**: net N-purchase minus net N-produce; **N-efficiency farm:** net N-produce / net N-purchase; **N-surplus per unit of N-produce:** (total N-surplus of the dairy system) / N-produce

We used data from the Norwegian agricultural authority, the Norwegian Dairy Herd Recording System, farm advisors and farm accounts to collect data of farms N-input and produce. Farmers contributed with detailed information on fertilization, estimates of clover content at harvest, grazing and soil conditions.

The estimated clover content was used to calculate the BNF by clover according to Høgh-Jensen et al. [2]. The gross roughage yields used for estimating BNF included 40 % estimated loss from the standing plants to the net roughage intake by the herd, calculated as the herd’s demand of metabolic energy.

Results

The N-purchased per ha farmland on the organic dairy farms was on average 68 kg N/ha (Range 41- 102), and on the non-organic dairy farms 233 kg N/ha (range 151 - 401). The net N-produce was 26 kg N/ha (range 17- 36) on organic dairy farms, and 42 kg N/ha (range 21 - 63) on non-organic dairy farms. The corresponding surpluses of purchased N were 42 and 191 kg N/ha. As expected there was a close linear correlation between the purchased N and the N-surplus of purchased N per ha (R^2=0.99). This was consistent for organic and non-organic farms. The average N-surplus increased to 85 kg N/ha on organic farms when BNF and atmospheric deposition was included.

The N-efficiency of purchased N by the dairy farm decreased on the 20 farms, as expected, with increasing purchased N (R^2=0.62). However, this was not so evident within the farm groups ($R^2_{\text{organic farms}}$ =0.46, $R^2_{\text{non-organic farms}}$ =0.06). A similar trend was observed for the N-efficiency when N surplus from imported feed was included (dairy system, R^2=0.63, $R^2_{\text{organic farms}}$ =0.43, $R^2_{\text{non-organic farms}}$ =0.07). On average, the N-efficiency of purchased N on the organic dairy systems was 0.32 (range 0.20-0.42) and on the non-organic dairy systems 0.16 (range 0.12 - 0.24).

The N-surplus per unit of produce increased slightly with increased N-purchase (R^2=0.39 all farms), but not within the farm groups ($R^2_{\text{organic farms}}$ =0.17, $R^2_{\text{non-organic farms}}$ =0.001). This is contradictory to the findings of Bleken et al. [1], and surprising. The average N-surplus per unit of produce was lower on organic dairy farms (4.1 kg N, range 2.7 - 6.5), than on non-organic dairy farms (6.2 kg N, range 4.7 - 7.7).

The main reason for the variation in N-efficiency among the non-organic farms could not be identified with the data available. Neither increased amount of purchased N nor fertilizer N, increased size of the farm or production level, milk yield, share of concentrates, or soil type, showed an evident relation with the N-efficiencies or the N-surplus per unit of produce on the farms within the two farm groups. Some farmers make a large effort to balance feed ratio, improve N-utilization of own manure, to reduce losses from field to feed table, to create optimal conditions for good animal health, improve soil drainage and to reduce soil compaction, but we did not have data on this. These are all factors that will improve N-efficiency. Because all farms are in the rainy western Norway, the variation in farm management is likely more important than variation in soil type and climate for the variation in obtained N-efficiencies.

Conclusions

Increased amount of purchased-N per ha farmland increased the farm N-surplus per ha on organic and non-organic farms. Increased amount of purchased-N tended to decrease N-efficiency, but not on non-organic farms. The correlation between the N-surplus per unit of produce and N-purchase was weak.

The organic farms had lower N-surplus per ha than the conventional farms, had higher efficiency of imported nitrogen and lower N-surplus per unit of produce, leading to an overall better utilization of available N.

Within organic and non-organic farm management, the variation in estimated N-efficiencies is larger than the differences between the averages of these two groups.

References

[1] Bleken, M. A., Steinshamn, H., & Hansen, S. 2005. High nitrogen costs of dairy production in Europe: worsened by intensification. *AMBIO: A Journal of the Human Environment, 34*, 598-606.

[2] Høgh-Jensen, H., Loges, R., Jørgensen, F. V., Vinther, F. P., & Jensen, E. S. 2004. An empirical model for quantification of symbiotic nitrogen fixation in grass-clover mixtures. Agricultural Systems, 82, 181-194.

Acknowledgements

Funding for this work was provided by The Research Council of Norway (Project No.199487)