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Conference Abstract

Different manure management methods impact on nitrogen use efficiency - comparison of four dairy farms in Hokkaido Japan

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Abstract

To maintain balanced biogeochemical cycles, minimizing the nutrient wastes from agricultural activities is critically important. Agricultural activities such as dairy farming produce large amounts of nitrogen waste in natural ecosystems. The increased nitrogen waste from dairy farming potentially causes environmental damage, such as eutrophication and greenhouse gas emissions. To accurately assess these changes in nitrogen wastes from dairy farming systems, measurements of variable parameters related to the nitrogen cycle (e.g., nitrogen gas emissions, nitrogen loss to water ecosystems), but these are time-consuming. Instead, calculating farm gate-level nitrogen surplus and nitrogen use efficiency (NUE) is a practical method to estimate the nitrogen waste from dairy farming systems. The nitrogen surplus and NUE are calculated based on the difference and ratio between nitrogen input (such as fertilizer and feed) and nitrogen output (such as milk and meat) on each farm. The data needed to calculate the nitrogen input and output can be obtained by interviewing farmers. Thus it is often easier than directly measuring nitrogen cycle parameters. In addition, it is known that excess nitrogen wastes are often related to improper manure management (i.e., manure is not efficiently collected and returned to the farm as nutrients) on dairy farms. In the dairy farming regions in Japan, particularly in Hokkaido, improper manure management can occur because of the short grass growing

season and long winter, which means a large amount of manure has to be stored for an extended period. However, few previous studies quantitatively linked manure management and NUE in Japan. Thus, a study was needed to assess the link between manure management styles and the farm gate-level nitrogen surplus and NUE. Using the data from several Japanese dairy farms, we clarified the following:

1. Whether nitrogen losses during manure management can be a controlling factor for the NUE of the whole farm or not.

2. Other management options necessary to keep the NUE within an appropriate range.

Interviews were conducted with four small-scale (34–42 milked cows per farm) grazing dairy farmers in Central and Eastern Hokkaido to estimate their nitrogen balance and calculate NUE. The data for the year 2022 was used to calculate the NUE and nitrogen surplus. The data included all the fertilizer and feed information as nitrogen inputs, while milk and meat production as nitrogen outputs. Also, the basic information about the farm (e.g., area and stocking rates) was collected. Then, the total nitrogen and inorganic nitrogen (ammonium-form nitrogen and nitrate-form nitrogen) in excreta samples at various stages from a barn to pre-application in each farm were measured to assess the amount of nitrogen loss and nitrogen forms (e.g., ammonium- and nitrate-nitrogen) during the manure management period. These data were used to calculate manure utilization efficiency (the ratio of applied manure-derived nitrogen to nitrogen in excreta). Many Japanese dairy farmers store the manure for extensive periods (sometimes over a few years) to produce matured compost. Thus it is essential to know the changes in nitrogen status during the storage period. Also, manure processing systems were recorded, such as solid-liquid separation and aeration methods of the slurry.

As a result, surplus nitrogen and NUE ranged from 37.6 to 140 kg/ha/year and 25.6 to 56.3%, respectively. Manure utilization efficiency ranged from 0 to 38.6%. Nitrogen surplus tended to be lower when the manure utilization efficiency was higher. The variability of the manure utilization efficiency was due to the farmers not applying the whole amount of the stored manure and the potential loss of nitrogen during the storage. The proportion of manure-derived nitrogen to total nitrogen fertilizer (the sum of manure-nitrogen, nitrogen chemical fertilizer, and other organic nitrogen fertilizer) ranged from 0 to 100%. It was positively correlated ($P<0.01$) with NUE (Fig. 1). The proportion of manure-derived nitrogen to total nitrogen fertilizer also showed a trend of a negative relationship with the nitrogen surplus (Fig. 2). One of the interviewed farmers was storing the manure compost in one of the paddocks but did not use it during the studied period, showing 0% as the proportion of manure-derived nitrogen to total fertilizer used.

In previous studies, surplus nitrogen was often reported to be positively correlated with milk yield (Gourley et al. 2012, Toda et al. 2020). The present study showed a similar trend, but the Hokkaido dairy systems showed less surplus nitrogen per milk yield than reported in the previous studies. The nitrogen fertilizer application rates for the Hokkaido dairy systems were within the lower range compared to the previous studies, which is one of the

reasons for the low nitrogen surplus values. It could be attributed to the high variability in farm topography, climate, and farming pattern in Hokkaido dairy farming. In Hokkaido, lands are covered by snow for six months of the year. Thus climatic characteristics like this will impact the farmers' inputs to the farms. Also, all of the farms interviewed showed <80 kg N/ha of nitrogen output, and these values were less than the value recommended by the EU Nitrogen Expert Panel to make dairy farming economically viable (EU Nitrogen Expert Panel 2015). We do not intend to suggest farmers increase the nitrogen inputs to the farms due to its potential risks to the biogeochemical cycles. However, many Japanese small dairy farms can aim to increase their milk yield per unit area to become more internationally competitive (or ideally, the milk price has to be increased to support this style of farming). We also note that two of the four interviewed farmers are in the early stages of switching to organic farming. Thus, at this stage, the effect of residual nitrogen derived from chemical fertilizers could impact our estimated nitrogen surplus calculation.

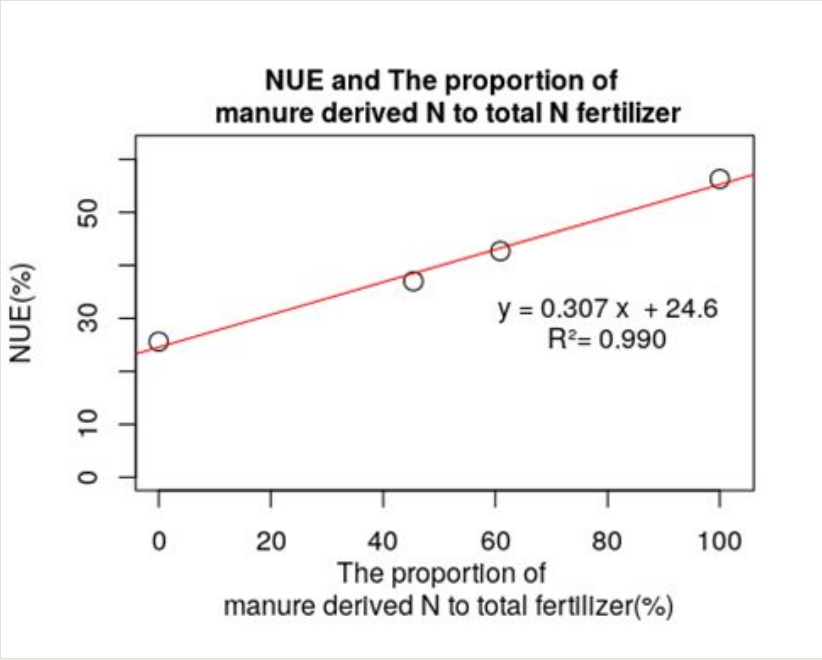

Figure 1. doi

The relationship between the proportion of manure derived nitrogen to total fertilizer and NUE. Open symbols represent four dairy farms that were researched. There was a significant positive correlation ($P < 0.005$).

The result of this study showed that farmers who were able to use manure effectively as fertilizer had a better nitrogen balance. Although more data is needed to confirm this trend, optimizing manure use to minimize the loss of nitrogen and reduce the use of chemical fertilizer will play a significant role in achieving agriculture with a low impact on biogeochemical cycles, particularly the nitrogen cycle.

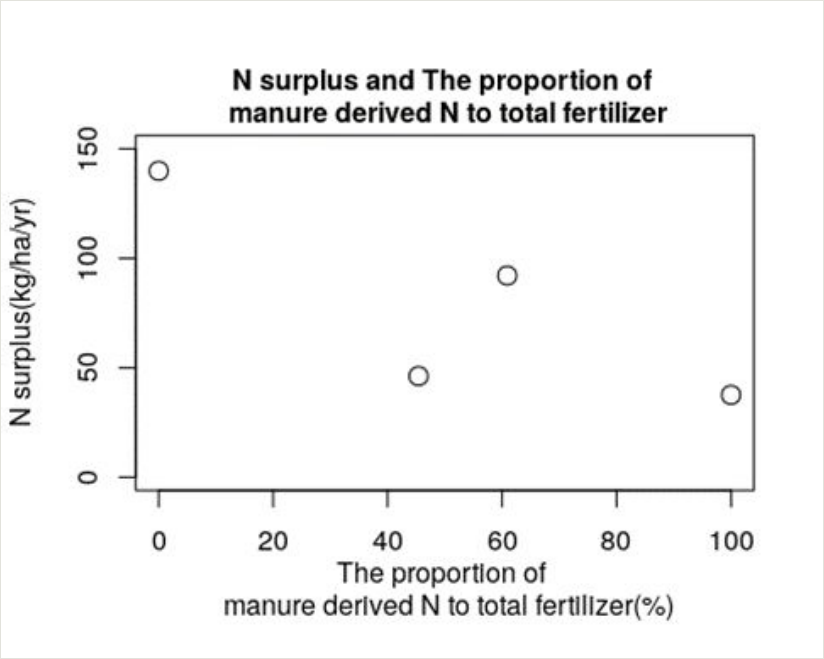

Figure 2. doi

The relationship between the proportion of manure derived nitrogen to total fertilizer and N surplus. Open symbols represent four dairy farms that were researched. The correlation was not significant, but there was a trend of a negative relationship (P = 0.2).

Keywords

Nitrogen surplus, NUE, Nitrogen budget, grazing dairy farm, manure use

Presenting author

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Presented at

poster presentation

Author contributions

Haruka Sato did data collection, interview and data analysis. Yoshitaka Uchida selected the specific farms for the research and planned the experimental set-up.

Conflicts of interest

The authors have declared that no competing interests exist.

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