A Path Toward Sustainable Management of Nitrogen in U.S. Dairy Production Systems

Josh Gamble, Gary Feyereisen, Deborah Samac, John Baker, USDA-ARS

Modern dairy farms are increasingly challenged to produce more and minimize off-site impacts of nitrogen (N) on air and water quality. To help meet these challenges, the dairy industry needs novel, low-cost, and easily implemented and maintained solutions for reducing N losses. However, this represents a significant challenge in a complex dairy system where N enters and leaves the production system through many pathways and in many forms and undergoes numerous transformations as it passes from feed to animal to milk or manure and back again. Research by the USDA-Agricultural Research Service (USDA-ARS) Dairy Agroecosystems Working Group (DAWG) seeks to develop bold innovations addressing these common regional and industry-wide challenges.

The USDA-ARS-DAWG is a multi-location research collaboration established in 2014 to support efforts to improve the productivity, competitiveness, and environmental sustainability of U.S. dairy farming systems. The group includes research teams focused on the major U.S. dairy-producing regions: the West (California, Idaho, Texas), Midwest (Minnesota, Wisconsin), and East (New York, Pennsylvania). As noted above, one of the major goals of the DAWG group is to develop new solutions to reduce N losses from U.S. dairy systems, focused mostly on nitrate (NO_3) leaching from soil, and nitrous oxide (N_2O) and ammonia (NH_3) greenhouse gas emissions from the field, barn, and manure handling. This overall goal is guided by the USDA-ARS Grand Challenge which calls for a transformation in U.S. agriculture resulting in a 20% increase in quality production with a 20% reduction in environmental resource impacts by 2025.

Figure 1. Location of DAWG research teams & research projects.

Thus far, research from DAWG members has provided insight into the scope of nutrient management concerns on dairy operations, including feeding strategies to better balance nutrients and improve dietary nutrient use efficiency; farmstead management to control greenhouse gas emissions and discharges of nutrients; and agronomic management to improve crop nutrient recovery, reduce environmental losses, and sequester carbon. The Minnesota DAWG group has focused on a collaboration with a large confinement dairy in west-central Minnesota to evaluate the environmental impacts of manured corn silage and alfalfa production on two adjacent fields. On-farm studies included evaluating: tile drainage N and phosphorus (P) losses from silage corn with and without a rye cover crop; sediment and P losses in tile drainage before and after replacing open surface tile inlets with fine gravel inlets; soil nitrate accumulation and tile drainage N losses with summer fertigation vs. fall injection of dairy manure; changes in soil organic carbon related to agronomic management and terrain; and long-term carbon balances of forage production systems.

In addition, the data collected from the on-farm collaboration was used to support whole-farm simulation modeling with all DAWG locations. The goal was to evaluate trade-offs among nutrient loss pathways for dairy operations and quantify key nutrient management challenges facing farmers across the country. Ten farms were modeled, highlighting common dairy farming strategies, from the top seven milk-producing states (CA, WI, MN, ID, NY, PA, TX). Results were used to highlight current nutrient use inefficiencies on representative dairy farms and were published in the *Journal of Dairy Science*.

Moving forward, a central focus of the DAWG group is to develop a common experiment across all locations. Starting in 2017, multiple DAWG locations initiated the "manure priming study" with the objective of determining long-term effects (economic, environmental, soil chemical, biological, and physical) of a one-time or short-term manure application. The study idea originated at the USDA-ARS Northwest Irrigation and Soils Lab in Kimberly, ID, where researchers observed improved crop yields from plots that received manure nearly a decade ago, but now receive only mineral fertilizer, compared to plots that only ever received mineral fertilizer. Their findings suggest even short-term or single manure applications can influence soil properties, and likely soil microbes, to the benefit of crops for years following application. However, the mechanisms responsible for this benefit are unknown. Quantifying the true benefits of manure to long-term soil health and crop production could enhance its value and improve economic feasibility of longer distance manure hauling. This will expand acreage available for land application, reduce the likelihood of overloading soils near livestock operations, and, therefore, reduce the risk of N and P losses. The manure priming study has been initiated at Kimberly, ID; and University Park, PA; and plans are in place to begin in Bushland, TX; Fort Collins, CO; Madison, WI; and St. Paul, MN.