REDUCING THE EMISSIONS INTENSITY OF LIVESTOCK PRODUCTION:

CASE STUDIES OF SUCCESS

GLOBAL RESEARCH ALLIANCE
ON AGRICULTURAL GREENHOUSE GASES

USA

Scale: Regional
System: Mixed and Housed
Sector: Dairy

MUN tool reduces nitrogen emissions from US dairy farms

The crude protein consumed by Wisconsin dairy herds greatly impacts urinary urea excretion and nitrogen emissions. More precise feeding of crude protein and energy guided by the milk urea nitrogen (MUN) tool has enhanced feed use and profits, and decreased ammonia and nitrous oxide emissions from dairy farms.

Background

The integration of dairy and crops is a primary source of agricultural production in the US' Midwest. In Wisconsin, 'America's Dairyland', almost all milk is produced on confinement farms (cows fed stored feed in barns). Housed herds are largely fed farm-grown feed from crop rotations comprising alfalfa (lucerne), corn (maize), and soybean (soya) with additional protein and mineral supplementation.

The proportion of dietary crude protein transformed into milk protein typically ranges from 20 to 30% on commercial dairy farms. When dietary crude protein exceeds cow requirements (about 16.5% of dry matter intake for healthy, high-producing dairy cows), dietary nitrogen (N) use efficiency declines and the excess N is excreted mainly as urinary urea. Most of this urea is converted to ammonia gas, which accounts for 60 to 70% of total N loss from Wisconsin dairy farms. Loss is highest from confinement farms and lowest from grazing-based farms. Well over half of Wisconsin dairy cows are housed in free-stall barns (cows move freely among stalls and are fed in alleyways). On these farms, about 35% of ammonia loss occurs from the barn, 20% during manure storage and 45% during and after manure land application.

Key actions & their effects on productivity, income & food security

Over the past 15 years or so, many dairy farmers in the US have adopted precision feed management guided by the MUN tool. The MUN tool was developed to monitor dietary crude protein and energy levels in dairy cow diets. MUN levels between 10 and 12 mg/100 ml usually indicate diets that are balanced in crude protein and energy. MUN levels greater than 12 mg/100ml usually indicate dietary crude protein is being wasted and excreted as urinary urea N.

Wisconsin dairy farmers have been making progress towards the optimum range of MUN, and in doing so have decreased urinary urea excretion. Analyses of about 1.5 million individual cow records over the period 2004–2014 revealed that MUN declined from an average of 13.5 to 12.5 mg/100ml. One-half of the tested cows continued to exceed the optimum MUN range, which means further progress is possible.

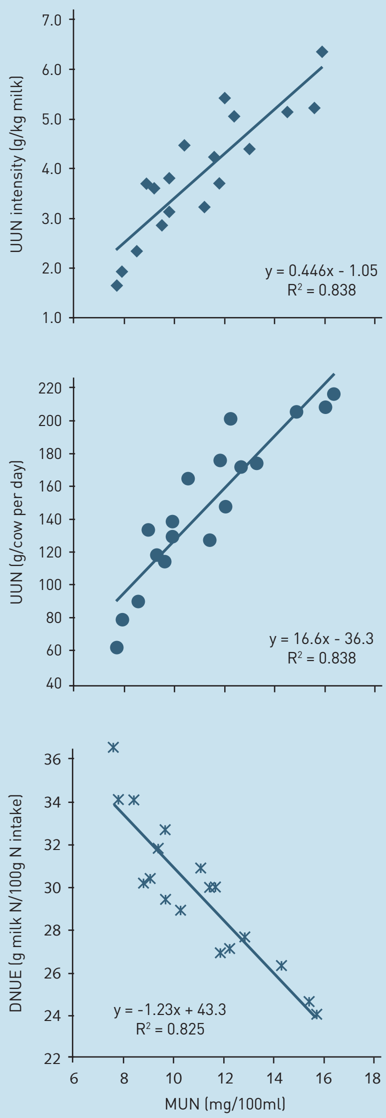
The adoption of MUN as a diet management tool has increased resourcing efficiency and profits, as well as reduced emissions intensity. Sixteen out of 18 studied diets (Figure 1) resulted in no loss or even increases in milk production per cow due to the more balanced crude protein and energy intake.

Strategic feeding of dietary crude protein guided by MUN has reduced the need for protein supplements, which has increased annual farm profits by approximately USD$60–$95 per cow. Additional savings (and reduced environmental impacts) are also accrued from the reduced need to grow unnecessary high protein crops for dairy cattle feed.

Effect of actions on emissions intensity of livestock production

For the typical diets fed to Wisconsin dairy cows, dietary N use efficiency, urinary urea N excretion, and urinary urea N intensity are directly related to MUN (Figure 1). An analysis of data across a wide range of conditions revealed that ammonia emissions from dairy barns decline consistently by about 10 to 35% when MUN falls from 14 to 10 mg/100ml. In Wisconsin, the unit reduction in MUN during 2004–2014 is estimated to have reduced daily urinary urea N excretion by 16.6g/cow, urinary urea N intensity by 446mg UUN/kg milk, and nitrous oxide emissions by 8 to 10% (Figure 2). Further balancing of cow diets to achieve MUN levels of 12 to 10 mg/100ml would reduce state-wide ammonia emissions by an estimated additional 29 to 43%, and nitrous oxide emissions by an additional 15 to 22%.

Figure 1: Relationships between milk urea nitrogen (MUN), dietary nitrogen use efficiency (DNUE), urinary urea nitrogen (UUN), and UNN intensity



Co-benefits and trade-offs

Urinary urea N is the principal source of ammonia and nitrous oxide emissions from dairy farms. As a tactical management tool, dairy farmers use MUN to monitor dietary N use efficiency and to refine the levels of dietary crude protein and energy they feed to their herds. The MUN tool has been used in Wisconsin and elsewhere to predict urinary urea N excretion and subsequent N emissions from dairy farms. Although reductions in dietary crude protein guided by the MUN tool may enhance dietary nitrogen use efficiency, reduce milk production costs, and reduce the negative impacts associated with increases in urinary urea N excretion and the resulting N emissions, this strategy may also decrease the fertilizer N value of manure. If this occurs (which can be monitored through manure testing), it will be slight and can be compensated for with a low amount of fertilizer N.

Implications for adaptation

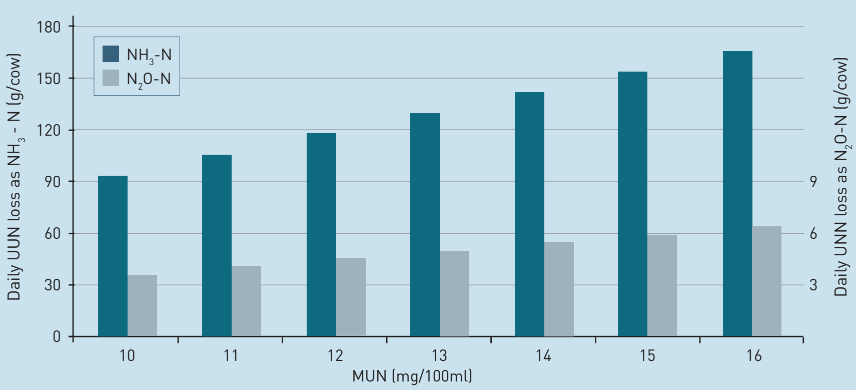
The increase in global demand for food, including milk and other dairy products, is occurring during a period of increasing climate variability. Using MUN to improve feed use efficiency provides multiple pathways to climate change adaptation and mitigation. On most dairy farms, maintaining or increasing milk production with less feed reduces feed costs and enhances overall resource use. Precision feeding guided by the MUN tool should provide savings and therefore create opportunities to invest in technologies, such as more comfortable animal housing and manure storage modifications, which would reduce the effects of projected increases in temperature and fewer but heavier rainfall events.

Challenges to implementation and adoption

Due to variability in pasture quality and intake, grazing-based dairy farms generally have more variable dietary nitrogen use and MUN than confinement-based farms. On grazing-based farms, the scope for using MUN as a day-to-day feed management tool is therefore more challenging, but herd-average MUN may have application as an operational management tool (e.g. sward composition, type and amount of supplemental feed, system designs that maximize overall N use efficiency) even though the ability to influence crude protein levels in the diet is more limited than in housed situations with a more controlled feed supply.

A more widespread implementation of the MUN tool needs to consider possible variations in MUN associated with production systems or animal genetics. Baseline and subsequent target MUN values may need to be established therefore on a per herd basis. Collaboration among producers, nutrition consultants and milk processors are useful in establishing MUN benchmarks and targets. Economic incentives such as price premiums for milk shipped within a desired range of MUN should be explored to nudge the dairy industry toward further reductions in undesirable N emissions.

Figure 2: Relationship between milk urea nitrogen (MUN) and loss of urinary urea nitrogen (UUN) as ammonia (NH_3) and nitrous oxide (N_2O)



Further information

USDA Agricultural Research Service, U.S. Dairy Forage Research Center website

https://www.ars.usda.gov/sp2UserFiles/Place/36553000/EducationalMaterialsMarch2012/DailyNutrition/23%20MUN%20and%20ammonia.pdf

U.S. National eXtension website:

http://www.extension.org/pages/68220/using-milk-urea-nitrogen-to-improve-nitrogen-efficiency-and-reduce-environmental-impact-of-dairy-cow#.Veb7r5d-4sJ

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