Climate Change Mitigation and Adaptation in Dairy Production Systems of the Great Lakes

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SUSTAINABLE DAIRY

United States Department of Agriculture — National Institute of Food and Agriculture

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

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Primary project objectives:

- Research, extension and education outputs in the Dairy CAP will lead to mitigation of greenhouse gas emissions from dairy production systems and will allow dairy production systems to adapt to changes in climate.
- Long-term outcomes will be achieved without compromising profit to either the producer or processer while providing consumers with confidence that the dairy products are created in a sustainable manner.
- The outcomes of the project will be achieved through our five research teams: 1) Measurement, 2) Modeling, 3) Life-cycle assessment, 4) Extension, and 5) Education.

Cow, Manure and Soil Research

Potential Use of Milk Urea Nitrogen to Abate Atmospheric Nitrogen Emissions from Wisconsin Dairy Farms

J.M. Powell[1], C.A. Rotz[2], and M.A. Wattiaux[3]

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Measures of Nitrogen Use Efficiency and Nitrogen Loss from Dairy Production Systems

J.M. Powell[1] and C.A. Rotz[2]

Journal of Environmental Quality ❖ Published June 20, 2014

These two studies highlight the complexity and interrelationships of nitrogen transformations on dairy farms. Reductions in dietary crude protein (CP) as part of a CP:energy balanced diet could increase feed N use efficiency so that more N is secreted as milk N, rather than N excreted in manure thus reducing emissions of NH_3 and N_2O. We estimate that 50% of all of Wisconsin's lactating dairy cows are fed CP in excess of requirements. Expanded use of tracking milk urea (MUN) and excretion rates of urinary urea N (UUN) could help enhance dietary N use efficiency, reduce milk production costs and reduce excessive N emissions by as much as 12%.

Long term effects of feeding tannin extracts on lactating cow performance

M.J. Aguerre[3#], B. Duval[1], M.A. Wattiaux[3] and J.M. Powell[1]

Long term effects of feeding tannin extracts on greenhouse gas (GHG) emissions from lactating dairy cows B. Duval[1#], M.J. Aguerre[3#], M.A. Wattiaux[3] and J.M. Powell[1]

The objective of these two studies (above left) was to feed tannins to lactating cows to determine the long-term effect on milk production, milk composition, and enteric CH_4 emissions. Tannins bind and protect protein during silage fermentation which results in higher manure N, and lower urea N. Data was collected in 2014; results are pending.

Land Application of Dairy Manure: Experimental Tannin Trials

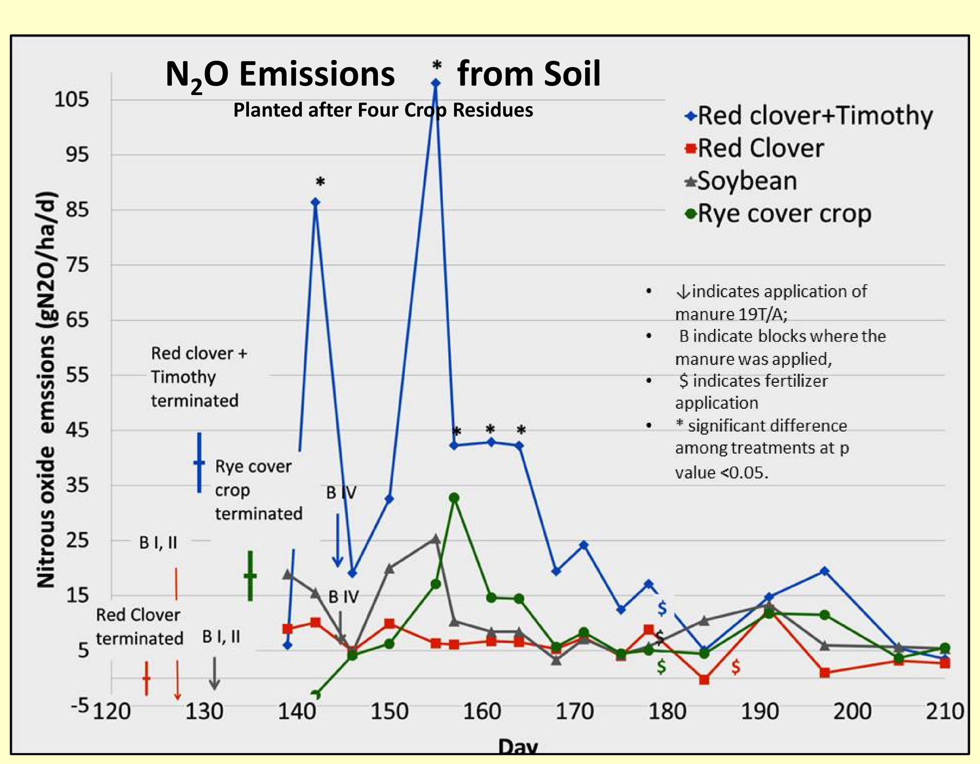
C.A. Campbell[3*] and Matt D. Ruark[3]

In conjunction with the feeding trial, the objectives of this 2014 study (above right) were to quantify GHG emissions from field application of tannin-derived manures; to determine if tannin manures can potentially mitigate soil N concentrations during the growing season; and to determine yield response to tannin-enhanced manures. Preliminary results indicate that there are no differences in N_2O emissions based on tannin concentration and that there are no differences in CO_2 emissions based on applied N rate. Yields are also comparable.

Crop Residues and Nitrogen Inputs Affect on N_2O emissions

Maria Alejandra Ponce de Leon[4*], Curtis Dell[2] and Heather Karsten[4]

The study objective is to enhance understanding of how crop residues and nitrogen (N) inputs affect N_2O emissions by measuring N_2O fluxes from corn planted after four crop residues.



Preliminary results:

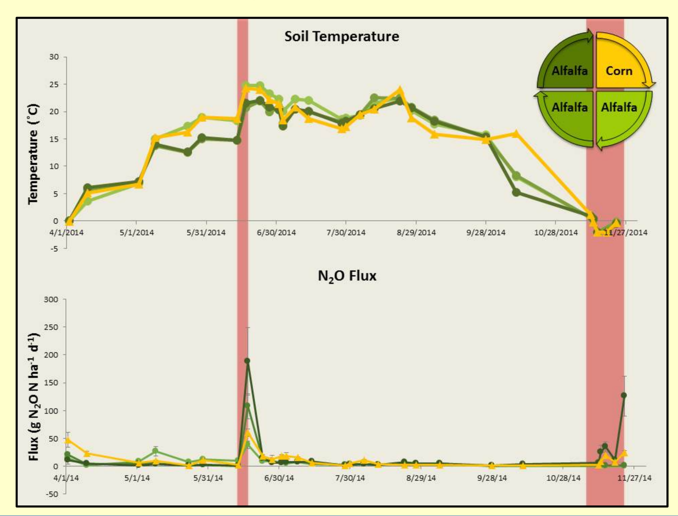
- N_2O emissions tended to peak 5-10 days after manure was applied prior to rapid corn N uptake.
- When side-dress fertilizer N was applied later, N_2O emissions were lower than initial application, since fertilizer N was more rapidly taken up by the actively growing corn, reducing N available for denitrification.
- N_2O emissions in red clover and timothy were greater due to higher biomass and low C:N of the mixture contributing to the enhanced microbial denitrification.

Measurement of Greenhouse Gas Flux from Agricultural Soils Using Static Chambers

Sarah Collier[3#], Matt Ruark[3], Lawrence Oates[3], William Jokela[5] and Curtis Dell[2]

Journal of Visualized Experiments ❖ 8/03/2014, Issue 90

This video journal article showcases the static chamber-based method for measurement of greenhouse gas flux from soil systems (above left). With relatively modest infrastructure investments, measurements may be obtained from multiple treatments/locations and over timeframes ranging from hours to years. These methods are being used at our four field locations: Arlington Research Station and USDA Dairy Forage Research Center in WI; Musgrave Research Farm in Ithaca, NY, and the Penn State Agronomy Farm in Rock Springs, PA.

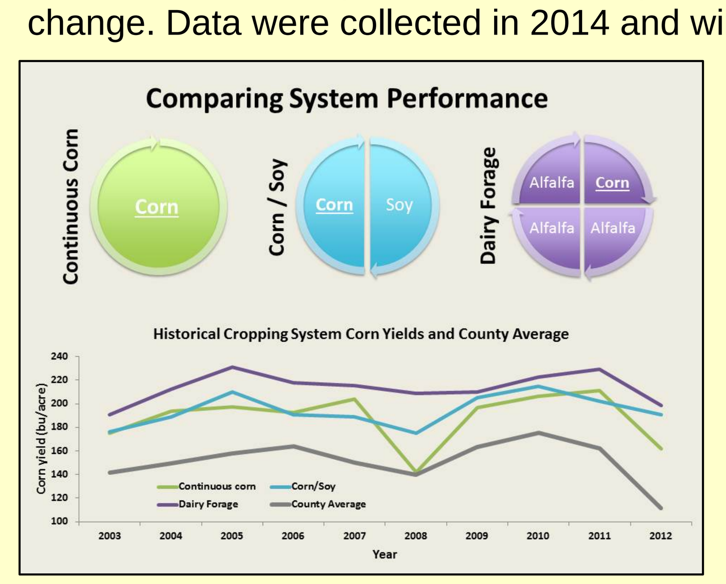


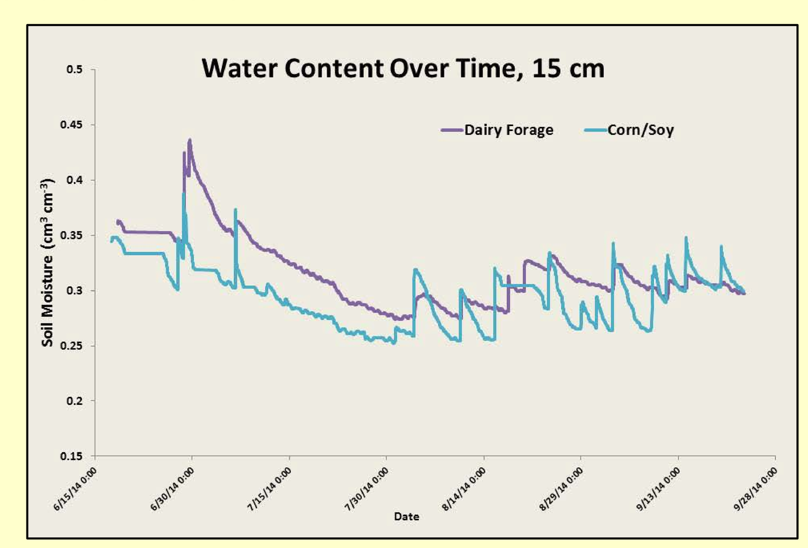
In studies conducted at Arlington Research Station (above right) in 2014 using the static chamber-based method, researchers found that N_2O spiked when both soil temperature and soil moisture were at their highest. An additional spike occurred after liquid manure was applied and injected but before the ground was frozen. Data from these studies will be placed in the CAP's data repository and used to validate process models. The overall goal is to identify where in the dairy production cycle greenhouse gases might be mitigated.

Building resilience: effect of long-term crop rotation on soil water characteristics

Elizabeth McNamee[3*], William Bland[3], Heather Karsten[4] and Sarah Collier[3#]

The study objective is to examine soil moisture dynamics in long-term cropping system studies in Wisconsin and Pennsylvania. Using changing climate projections, we examined which resilient soil water behaviors may become more important as the hydrologic cycle intensifies with climate change. Data were collected in 2014 and will continue in 2015.



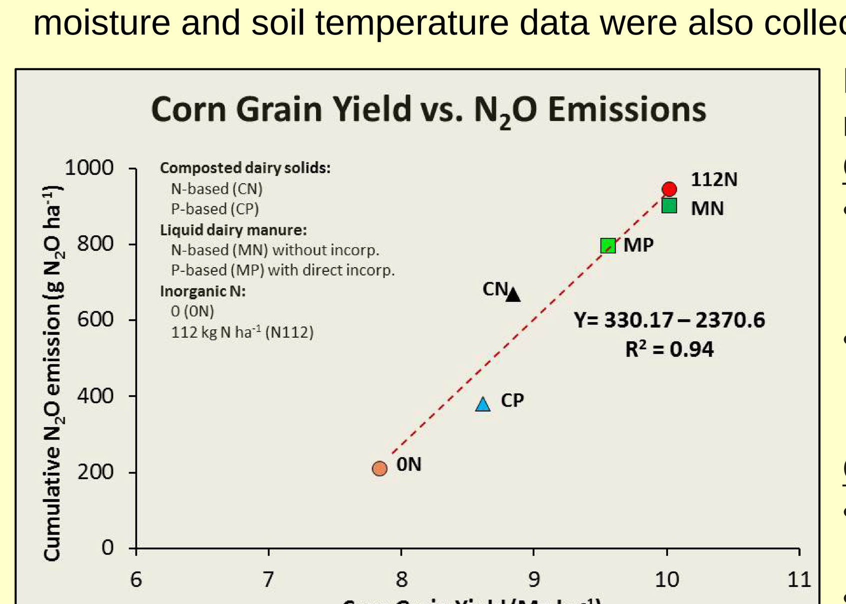


Preliminary results show that corn planted in a four year dairy forage (a-a-a-c rotation) out-yields corn planted in either a continuous corn or a soybean/corn rotation (above left). Soil under the a-a-a-c rotation appears to have better water holding capacity under both flooding (2008) and drought (2012) conditions and shows higher yield. Understanding soil resilient behaviors under different cropping regimes (above right) is one way of developing long-term adaptation strategies to our changing climate.

Nitrous Oxide Emissions from Manure Application to Corn, Grass and Alfalfa

Amir Sadeghpour,[6#] Quirine Ketterings,[6] Greg Godwin,[6] and Karl Czymmek[6]

The study objective was to evaluate changing from unincorporated N-based applications to a P-based (crop-removal) management system with immediate incorporation of manure. In Experiment 1, researchers examined the impacts on corn grain yield while measuring nitrous oxide, carbon dioxide and methane emissions. Experiments 2 and 3 were conducted on alfalfa and grass. Soil moisture and soil temperature data were also collected.



Preliminary results for shifting from N- to P-based management:

On corn

- When composted dairy solids were applied, there was a 3% loss in yield but a 43% reduction in N_2O emissions;
- When liquid manure was applied, there was 4% yield loss, but a 29% reduction in N_2O emissions;

On alfalfa and grass,

- The manure application increased both yield and N_2O emissions;
- There was no difference on N_2O between injected manure and surface application of manure.

Modeling

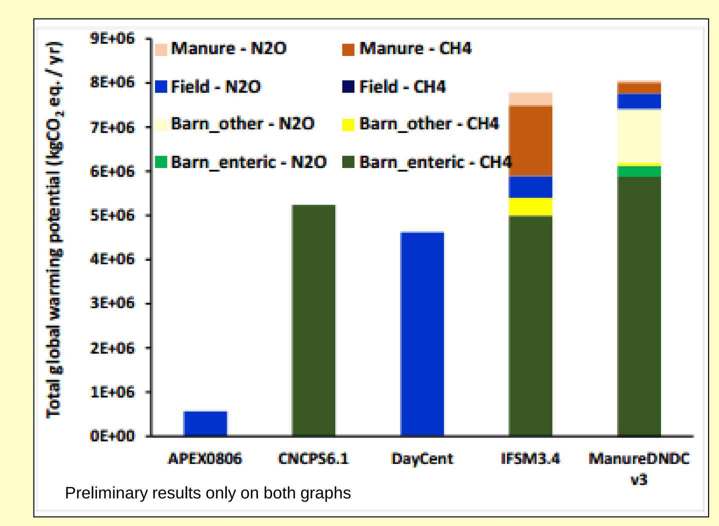
Comparison of Process-Based Models to Quantify Major Nutrient Flows and Greenhouse Gas (GHG) Emissions of Milk Production

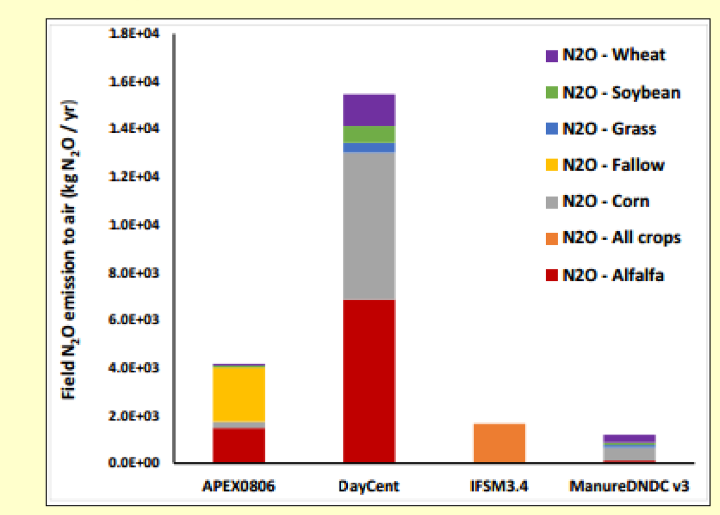
Karin Veltman[7#], Andrew Henderson[8], Anne Asselin-Balencon[7], Larry Chase[6], Ben Duval[1#], Cesar Izaurralde[9], Curtis Jones[9], Changsheng Li[10], Dingsheng Li[7*], William Salas[10], Peter Vadas[1], Olivier Jolliet[7]

The project aims to quantitatively compare five process-based models for predicted nutrient flows (N, C, P) and GHG emissions associated with milk production at the animal, farm and field-scale; and to improve life cycle inventory databases for milk production in the US by integrating process-based models into LCA data acquisition. Models runs from in 2013 and 2014 will continue to be refined with new data in 2015.

Preliminary Results:

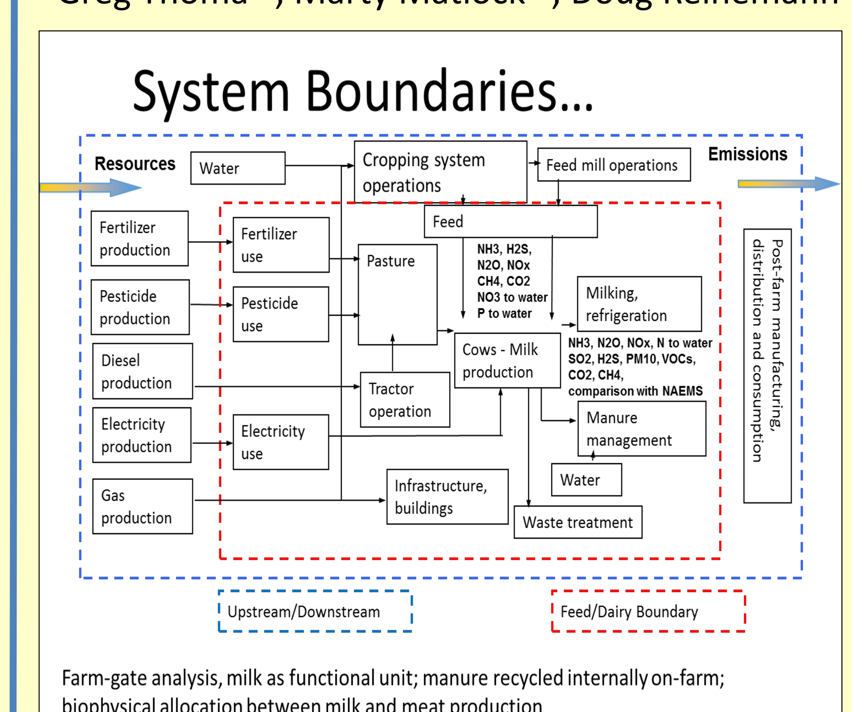
- Enteric CH_4 emissions are dominating global warming potential at the individual farm level
- Model predictions show large differences for field N_2O emissions and manure CH_4 emissions. These will be checked against experimental data to determine the causes of these differences.
- We will extend the model comparison to nitrate (NO_3^-) and phosphate (PO_4^{3-}) in groundwater; we will also establish and compare whole-farm nutrient (N,P) balances.
- Well validated process models are useful for extrapolating from specific experimental results to a broader range of conditions, as an input to LCA studies.





Life Cycle Assessment (LCA)

Greg Thoma[11], Marty Matlock[11], Doug Reinemann[3], Joyce Cooper[12], Olivier Jolliet[7], Peter Vadas[1]



- The LCA will to quantify greenhouse gas emissions at the process level by tracking all inputs and outputs of the dairy production system; the system boundary is the cradle-to-farm gate since most of the GHGs in dairy production systems occur at this level.
- Inputs can be compared using a functional unit, or common denominator measurement, represented as kg CO_2 per kg of fat and protein corrected milk.
- The Life Cycle Inventory provides the data which can be continually updated.
- All data will be stored in the USDA LCA Digital Commons allowing us to communicate results with each other and the broader scientific community.

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