Reducing GHG emissions and building resilience in dairy production systems

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Bill Gates warns of the dangers of cow farts — and the world should take his words seriously

Climate change mitigation and adaptation

sustainabledairy.org
What are USDA-NIFA CAP grants?

- Prescriptive in nature
  - Measurement
  - Modeling
  - Life Cycle Assessment
  - Education
  - Outreach
- Transdisciplinary
- $10 million in funding across 5 years
What are the strategic advantages of the CAPs?

• Conduct science that connects the parts of the system
• Strategically develop BMP lists for use in
  • Modeling
  • LCA
  • Climate modeling
  • Economic modeling
  • Extension program development
Breakdown of Total GHG emissions, 150-cow farm

- Manure management: 40% - CH₄, 60% - N₂O
- Feed Production: 4% - CH₄, 37% - N₂O, 58% - CO₂

Breakdown of Total GHG emissions, 1,500-cow farm

- Manure management: 32% - N₂O, 68% - CH₄
- Feed production: 5% - CH₄, 47% - CO₂, 48% - N₂O

GHG emissions (kg CO₂-eq/kg FPCM)

- 150-cow: CH₄
- 1,500-cow: CH₄

Bar charts:
- Green: Enteric methane
- Blue: Feed production
- Grey: Manure management
- Black: Animal facilities
- Orange: Fuel use
- Brown: Milking
- Green: Machinery
- Other: Other emissions
Additive effects of feed management and genetic selection

![Bar chart showing potential reduction of methane emissions per unit of milk](chart.png)
Anaerobic digesters result in significant reductions in GHG emissions.
We can follow the GHG emissions through the system
There is complexity in the dairy production system – it’s difficult to study it all
## Beneficial Management Scenarios (abbreviated)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3xCS</td>
<td>Corn silage is increased and alfalfa/grass is reduced to a ratio of 3:1 in animal diets.</td>
</tr>
<tr>
<td>Digester</td>
<td>Anaerobic digester</td>
</tr>
<tr>
<td>Cover Crop</td>
<td>Annual grass cover crop following corn at a seed cost of $50/ha.</td>
</tr>
<tr>
<td>Low Protein</td>
<td>Protein of lactating cows is reduced from 17% to 14%.</td>
</tr>
<tr>
<td>Flare</td>
<td>Covered manure storage is used with a flare to burn the biogas produced converting the CH4 to CO₂ for a lower global warming potential.</td>
</tr>
<tr>
<td>No Till</td>
<td>No-till establishment used for all crops with no incorporation of manure.</td>
</tr>
<tr>
<td>No Till Inj</td>
<td>No-till establishment used for all crops with manure applied through subsurface injection; no N fertilizer used.</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>Low forage rations (~50% of DMI) to lactating cows; ↑ corn silage and ↓ alfalfa/grass in ratio of 3:1; ↑ NDF digestibility 2%; ↑ feed efficiency; ↑ fat to lactating cows; ↓ protein of lactating cows to 14%.</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>↑ corn silage and ↓ alfalfa/grass in ratio of 3:1; ↑ NDF digestibility 2%; ↑ feed efficiency; ↑ fat to lactating cows; ↓ protein of lactating cows to 14%.</td>
</tr>
<tr>
<td>Sep/Digest</td>
<td>Solids are removed post digestion</td>
</tr>
<tr>
<td>Separation</td>
<td>Solid liquid separator before digestion</td>
</tr>
</tbody>
</table>
1,500 cow dairy

Veltman et al, 2018
150 cow dairy
Figure 3. Carbon Footprint (A), Reactive Nitrogen Footprint (B), Phosphorus Losses (C) and Net Return (D) for the 15000 cow farm in New York State showing the contribution of individual flows to the total footprint and the total, on-farm P loss. The whole-farm mitigation strategy consists of 5 individual BMPs: feed mitigation, anaerobic digestion and separation, cover crop, summer application and no-till with injection (see Section 3.6).
Dairy and GHG reduction

• There are several parts of the dairy production systems where GHG can be reduced
• Reductions in GHG are achievable with gains in efficiency!
• Win-win-win-win scenarios are possible (GHG, N, P, profit)
Adding winter rye to corn silage rotations can be beneficial.
Winter rye use has buffered risk of yield loss

- Winter rye cover crop did not affect silage yield ($P>0.05$, all 7 seasons)

- In 3/7 study years where silage yield decreased in Rye forage double crop system, the rye forage yield itself offset silage deficit. (No effect on corn yield in other 4/7 years)
Cover crops take up plant available N

Cover crops build up the N supply in soil

sampling time:
- May
- June
- July
- August
- September

Plant Available N (mg N kg soil \(^{-1}\))

0
2
4
6
8
10
12
14

CC
RF
NC

2016

Potentially Mineralizable N (mg N kg soil \(^{-1}\))

0
20
40
60
80

CC 0-15
RF 0-15
NC 0-15

A
A
B
C

A
A
B
B
C

A
B
C
D

C
C
C
C

A
A
B
A
B

A
A
B
A
B

A
A
B
A
B
Sustainable dairy production systems

- We are expecting that climate change will have a tremendous impact on Midwestern agriculture
- Our soils must be ready to adapt to extreme seasonal conditions
- Dairy production systems that incorporate perennial crops, cover crops following corn silage, and efficient manure use will:
  - Have more soil organic matter
  - Less erosion
  - Enhanced productivity
- Dairy is uniquely positioned to be the leader in agricultural sustainability – and achieve the goals needed for the future.
Thank you
What we feed the cow matters: alfalfa vs. corn silage

Increasing alfalfa in diet:
- Increases excretion of manure, manure-N, and urea-N.
- Did not affect milk production

Figure 1. Grams of methane per kilogram of NDF with increasing percentage of alfalfa silage at the expense of corn silage in a TMR containing 55% forage (DM basis); $Y = 297 - 1.39X$ ($R^2 = 0.97$).
D = Digested
DS = Solid (separated)
DL = Liquid (separated)

L2 = separated liquid
S2 = separated solid
(not digested)

Nitrous Oxide Field
Methane Field
Nitrous Oxide Storage
Methane Storage
Corn and wheat yield gains occur with increases in SOC up to 2%.
Most studies that use organic N sources (animal manure or green manure) show gains in SOC over time, while gains with just inorganic N were minimal.

Fig. 2. Percentage response in soil organic carbon (SOC) and soil organic nitrogen (SON) to N fertilizer input as calculated by time response (TR) ratio and time by fertilizer N response (TNR) ratio using the mixed model and meta-analysis.

Ladha et al., 2012
10 Mg/ha = 10,000 kg/ha = 9,000 lb/ac

37 different studies

Cover cropping leads to gains in SOM, but results across studies have been quite variable.
Figure 2. Projected global mean surface temperature and changes for mitigation scenarios. Changes are relative to corresponding averages for the period 1961-1990.
FIGURE 2. Global estimates of emissions by species*

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Emissions (Million tonnes CO₂-eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle¹</td>
<td>2,495</td>
</tr>
<tr>
<td>Dairy cattle²</td>
<td>2,128</td>
</tr>
<tr>
<td>Pigs</td>
<td>668</td>
</tr>
<tr>
<td>Buffalo</td>
<td>618</td>
</tr>
<tr>
<td>Chickens</td>
<td>612</td>
</tr>
<tr>
<td>Small ruminants</td>
<td>474</td>
</tr>
<tr>
<td>Other poultry</td>
<td>72</td>
</tr>
</tbody>
</table>

*Includes emissions attributed to edible products and to other goods and services, such as draught power and wool.

¹ Producing meat and non-edible outputs.
² Producing milk and meat as well as non-edible outputs.

Source: GLEAM.