Changes to cow diets impact N cycling on dairy farms

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Typical dairy cow ration confinement farms USA

Changes to rations

More corn silage
(to reduce production & feed costs, feed more cows)

Less protein
(to reduce feed costs & N emissions)

More grain
(to reduce enteric methane)

- silage
- alfalfa
- corn

Minerals
Vitamins

protein supplement

concentrate (corn grain)
Less protein (soybean meal) reduces N excretion in manure, especially urinary N

<table>
<thead>
<tr>
<th></th>
<th>19.4% CP SBM 16.0% of DMI</th>
<th>13.5% CP SBM 2.4 % of DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excreted N g/cow/d</td>
<td>467</td>
<td>309</td>
</tr>
<tr>
<td>% Urine N</td>
<td>55</td>
<td>37</td>
</tr>
<tr>
<td>% Fecal N</td>
<td>45</td>
<td>63</td>
</tr>
</tbody>
</table>

Adapted from Colmenero and Broderick, 2006
and this decreases NH$_3$ emissions from dairy barns and manured soils

Adapted from Misselbrook et al., 2005
BUT.....less protein decreases manure N availability to plants.

**Slurry manure**

<table>
<thead>
<tr>
<th>Soil inorganic N</th>
<th>LP</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>After cessation of NH$_3$ volatilization (48h)</td>
<td>b</td>
<td>a</td>
</tr>
</tbody>
</table>

**Responses to dung N**

- **Oat DM**
  - LP: b
  - HP: a

- **Oat N**
  - LP: b
  - HP: a

**Tradeoffs in N use and loss**
Substitutions of corn silage, alfalfa silage impact N use and N loss from dairy farms

- reduce production costs
- reduce feed costs
- feed more cows
Typical Wisconsin confinement dairy farm
150 cows plus 130 replacement heifers
annual milk production of 10,120 kg/cow

Modeling
corn-alfalfa silage substitutions

• Cropping system
• Managed N
• N use efficiency
• N loss
Cropping system (ha)

% corn silage of forage dry matter intake
(forage is 60% of dry matter intake)

27% less land

corn silage | alfalfa silage | corn grain

- 20 ha: 15 ha
- 40 ha: 72 ha
- 60 ha: 43 ha

43 ha
72 ha
15 ha
Managed N (kg/ha)

% corn silage of forage dry matter intake
(forage is 60% of dry matter intake)
N loss (kg/ha)

% corn silage of forage dry matter intake
(forage is 60% of dry matter intake)

+ 35 kg/ha

NH₃  NO₃  N₂O

5
33
3
Growing more CS and less AS

- reduces the land requirement for feed production (feeds more cows) (+)
- maintains milk production per cow
- increases herd NUE from 20 to 25% (+)
- decreases manure N excretion from 7.6 to 5.9 g N/kg milk (+)
- increases NO₃ and N₂O loss (-)
- additional fertilizer N also required to offset soil N immobilization by manure from cows fed high levels of CS (-)
$^{15}$N transformations of diet components

Component $^{15}$N labeling → Feed $^{15}$N in TMRs → $^{15}$N in milk, urine, feces → $^{15}$N manure recycled

- Soybean meal
- Silage (alfalfa, corn)
- Corn grain
- Feces
- Milk
- Urine
% $^{15}$N recovery in milk

- Alfalfa silage: 17.1 b
- Corn silage: 19.0 b
- Corn grain: 33.0 a
- Soybean meal: 31.7 a
Urinary $^{15}\text{N} : \text{Milk}^{15}\text{N}$ ratio

Fecal $^{15}\text{N} : \text{Milk}^{15}\text{N}$ ratio

- Alfalfa silage: A
- Corn silage: A
- Corn grain: B
- Soybean meal: B
Mixing feces and urine

$^{15}$N manure application and tillage
Corn silage uptake of $^{15}$N manure

<table>
<thead>
<tr>
<th>Material</th>
<th>1st year corn $^{15}$N uptake</th>
<th>2nd year corn $^{15}$N uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa silage</td>
<td>33.4 ab</td>
<td></td>
</tr>
<tr>
<td>Corn silage</td>
<td>30.5 b</td>
<td></td>
</tr>
<tr>
<td>Corn grain</td>
<td>34.7 ab</td>
<td></td>
</tr>
<tr>
<td>Soybean meal</td>
<td>38.1 a</td>
<td></td>
</tr>
</tbody>
</table>

Manure $^{15}$N applied
Relative NUEs to grow, feed and recycle the manure from the diet components

Percent of soil N input (BFN or fertilizer N) incorporated into milk N plus recycled (as manure N) back into feed supply (corn silage)
Summary

GROWING DIET COMPONENTS
• More CS (less AS) requires more fertilizer N, increases N loss (nitrate, nitrous oxide), and decreases overall NUE (soil-feed-milk-recycled manure N)

FEEDING DIET COMPONENTS
• The $\text{^{15}N in milk}$ (%) were greater for CG and SBM (32.3) than for AS and CS (18.0)
• Manure $\text{^{15}N}$ excretion intensities (g/g milk N) were lower for CG and SBM (2.5) than for AS and CS (4.6).
MANURE N RECYCLED

- Manure $^{15}$NUE (%) was greatest from SBM (38.2), CG (34.7) and AS (33.4) and lowest from CS (30.5). Corroborates importance of legumes in soil-feed-milk-recycled manure N cycle.

TOTAL NUE

- Total $^{15}$NUE (% diet component$^{15}$N secreted in milk and % diet component manure $^{15}$N recycled back to feed) for AS and SBM (51.6) were more than twice total $^{15}$NUE for CS and CG (23.0).
A balance between cereals (corn) and legumes (alfalfa and soybeans) in dairy cropping system enhances NUE in feed and milk production, and captures many other benefits of cereal-legume rotations (e.g., provides BFN to cereals)

Long term environmental impacts (e.g., soil erosion and soil health) associated with land use changes to grow different diet components will likely be more important than the observed short-term impacts of dietary components on cow N use and manure N recycling
Thanks for your attention!
corn-alfalfa rotation
Wisconsin dairy farm