Implementation of greenhouse gas mitigation strategies on organic, grazing and conventional dairy farms

Victor E. Cabrera and Marion Dutreuil
University of Wisconsin-Madison

Project Supported by USDA National Institute of Food and Agriculture Organic Agriculture Research and Extension Initiative Grant No. 2010-51300-20534

IFSA - Europe, Berlin, 1-4 April 2014
Introduction

GHG emissions need to be reduced

Milk production
- Estimated to be responsible of 4% of anthropogenic GHG

Livestock operations
- One of largest sources of agricultural GHG

Whole farm system approach
- High interaction among system components
Introduction

Simulation is a powerful tool

Feasible research enterprise
- Field trials are unpractical or impossible

Scenario analysis
- Allows to respond “what-if” questions

Projections and trends
- More valid than precise numbers
Objectives

Can GHG emissions be economically reduced?

Compare GHG emissions and economics among dairy farm systems
- Organic
- Grazing
- Conventional

Asses the impact of management strategies on GHG emissions and net return
- Feeding strategies
- Manure management
Materials and methods

Surveying

Interdisciplinary and comprehensive questionnaire (year 2010)

- Farm structure
- Labor
- Herd management
- Feeding
- Cropping
- Economics

Wisconsin official lists of dairy cattle milk producers

- Organic = certified
- Grazing >30% DMI pasture
- Conventional = others
Materials and methods

Surveyed farms (Wisconsin)

Farms used for defining representative farms
- 69 organic
- 30 grazing
- 27 conventional
Materials and methods

Scaled farms

All farms in a system were scaled to averages
- 127 ha
  - 79 ha owned
  - 48 ha rented
- 85 adult cows (milking and dry)

<table>
<thead>
<tr>
<th></th>
<th>Scaled</th>
<th>CON</th>
<th>GRA</th>
<th>ORG</th>
</tr>
</thead>
<tbody>
<tr>
<td># cows</td>
<td>85</td>
<td>128</td>
<td>94</td>
<td>74</td>
</tr>
<tr>
<td>Hectares</td>
<td>127</td>
<td>162</td>
<td>121</td>
<td>119</td>
</tr>
</tbody>
</table>
Materials and methods

Simulated farms

CONVENTIONAL

- Alfalfa: 42.6%
- Grass: 22.4%
- Corn: 12.2%
- Oats: 2.4%

GRAZING

- Alfalfa: 61.9%
- Grass: 37.7%
- Corn: 5%
- Oats: 6.1%

ORGANIC

- Alfalfa: 43.1%
- Grass: 45.5%
- Corn: 16.8%
- Oats: 16%
## Materials and methods

### Simulated farms

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>GRA</th>
<th>ORG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First lactation cows (%)</strong></td>
<td>36</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td><strong>Milk production (L/cow per year)</strong></td>
<td>9,820</td>
<td>7,256</td>
<td>6,159</td>
</tr>
<tr>
<td><strong>Milk price ($/hL)</strong></td>
<td>35.99</td>
<td>37.52</td>
<td>56.20</td>
</tr>
<tr>
<td><strong>Grazing strategy</strong></td>
<td>Older heifers and dry cows</td>
<td>All weaned animals</td>
<td>All weaned animals</td>
</tr>
<tr>
<td><strong>Housing facilities</strong></td>
<td>Free stall barn</td>
<td>Tie stall barn</td>
<td>Tie stall barn</td>
</tr>
<tr>
<td><strong>Manure storage</strong></td>
<td>Top-loaded lined earthen basin</td>
<td>No storage (daily haul)</td>
<td>No storage (daily haul)</td>
</tr>
</tbody>
</table>
Materials and methods

Management strategies for CONVENTIONAL

**Scenarios**

1. Grazing to lactating with no decrease in milk production
2. Grazing offered to lactating cows with 5% decrease in milk production
3. Incorporation of manure the same day of application and addition of a 12-month covered tank
4. Combination of scenarios 1 and 3
5. Combination of scenarios 2 and 3
Materials and methods

Strategies for ORGANIC and GRAZING

Scenarios

6. Decrease forage to grain ratio with a 5% increase in milk production
7. Decrease forage to grain ratio with a 10% increase in milk production
8. Incorporation of manure the same day of application and addition of a 12-month covered tank
9. Combination of scenarios 6 and 8
10. Combination of scenarios 7 and 8
Materials and methods

Integrated Farm System Model (IFSM)

Integrates major biophysical processes in a dairy farm
1. Livestock
2. Crops
3. Grazing
4. Weather
5. Machinery
6. Feed storage
7. Soils
8. Manure and nutrient
9. Economics
10. Tillage and planting

GHG sink and sources at the farm level
- Housing
- Manure storage
- Feed production
- Grazing
- Fuel combustion
- Secondary sources
Integrated Farm System Model

1. Start
2. Read input
3. Initialization
4. Setup machinery
5. Read weather data
6. Spring operations
   - Crop growth
   - Crop harvest
6. Storage
6. Cow feeding
6. Cow management
6. Manure handling
6. Fall operations
   - Economic analysis
7. Yes: another year?
8. No: results
## Results

### Baseline outcomes: Farm system differences

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>GRA</th>
<th>ORG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>9,735</td>
<td>7,256</td>
<td>6,159</td>
</tr>
<tr>
<td>Feed costs ($)</td>
<td>182,124</td>
<td>134,133</td>
<td>149,744</td>
</tr>
<tr>
<td>Total income ($)</td>
<td>357,151</td>
<td>288,603</td>
<td>350,185</td>
</tr>
<tr>
<td>Net return to management ($)</td>
<td>23,895</td>
<td>14,439</td>
<td>59,120</td>
</tr>
<tr>
<td>Net return to management ($/1,000 kg milk)</td>
<td>28.9</td>
<td>23.4</td>
<td>112.9</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/kg milk)</td>
<td>0.58</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/yr)</td>
<td>476,623</td>
<td>405,565</td>
<td>454,780</td>
</tr>
</tbody>
</table>
## Results

### Management strategies: CONVENTIONAL

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>9,735</td>
<td>0</td>
<td>-406</td>
<td>0</td>
<td>0</td>
<td>-406</td>
</tr>
<tr>
<td>Feed costs ($)</td>
<td>182,124</td>
<td>-994</td>
<td>-1,795</td>
<td>116</td>
<td>-1,425</td>
<td>-1,349</td>
</tr>
<tr>
<td>Total income ($)</td>
<td>357,151</td>
<td>3,668</td>
<td>-7,979</td>
<td>177</td>
<td>3,865</td>
<td>-7,780</td>
</tr>
<tr>
<td>Net return to management ($)</td>
<td>23,895</td>
<td>7,005</td>
<td>-802</td>
<td>-3,536</td>
<td>3,180</td>
<td>-4,641</td>
</tr>
<tr>
<td>Net return to management ($/1,000 kg milk)</td>
<td>28.9</td>
<td>8.4</td>
<td>0.2</td>
<td>-4.3</td>
<td>3.8</td>
<td>-4.6</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/kg milk)</td>
<td>0.58</td>
<td>-0.16</td>
<td>-0.15</td>
<td>-0.08</td>
<td>-0.18</td>
<td>-0.18</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/yr)</td>
<td>476,623</td>
<td>-126,959</td>
<td>136,289</td>
<td>-60,550</td>
<td>-148,829</td>
<td>-157,555</td>
</tr>
</tbody>
</table>
## Results

### Management strategies: GRAZING

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>7,256</td>
<td>362</td>
<td>725</td>
<td>0</td>
<td>362</td>
<td>725</td>
</tr>
<tr>
<td>Feed costs ($)</td>
<td>134,133</td>
<td>34,797</td>
<td>36,670</td>
<td>242</td>
<td>34,994</td>
<td>36,871</td>
</tr>
<tr>
<td>Total income ($)</td>
<td>288,603</td>
<td>21,560</td>
<td>32,627</td>
<td>95</td>
<td>21,614</td>
<td>32,681</td>
</tr>
<tr>
<td>Net return to management ($)</td>
<td>14,439</td>
<td>-12,846</td>
<td>-4,683</td>
<td>-3,565</td>
<td>-16,407</td>
<td>-8,247</td>
</tr>
<tr>
<td>Net return to management ($/1,000 kg milk)</td>
<td>23.4</td>
<td>-20.9</td>
<td>-9.0</td>
<td>-5.8</td>
<td>-26.4</td>
<td><strong>-14.3</strong></td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/kg milk)</td>
<td>0.66</td>
<td>-0.17</td>
<td><strong>-0.18</strong></td>
<td>0.04</td>
<td>-0.13</td>
<td><strong>-0.15</strong></td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/yr)</td>
<td>405,565</td>
<td>-86,729</td>
<td>-81,796</td>
<td>24,506</td>
<td>-65,447</td>
<td>-60,282</td>
</tr>
</tbody>
</table>
# Results

Management strategies: ORGANIC

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>6,159</td>
<td>308</td>
<td>615</td>
<td>0</td>
<td>308</td>
<td>615</td>
</tr>
<tr>
<td>Feed costs ($)</td>
<td>149,744</td>
<td>49,788</td>
<td>52,369</td>
<td>403</td>
<td>49,861</td>
<td>52,465</td>
</tr>
<tr>
<td>Total income ($)</td>
<td>350,185</td>
<td>39,429</td>
<td>53,253</td>
<td>130</td>
<td>39,526</td>
<td>53,322</td>
</tr>
<tr>
<td>Net return to management ($)</td>
<td>59,120</td>
<td>-9,766</td>
<td><strong>605</strong></td>
<td>-4,855</td>
<td>-14,793</td>
<td>-4,403</td>
</tr>
<tr>
<td>Net return to management ($/1,000 kg milk)</td>
<td><strong>112.9</strong></td>
<td>-23.1</td>
<td>-9.2</td>
<td>-9.2</td>
<td>-32.3</td>
<td>-17.9</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/kg milk)</td>
<td>0.87</td>
<td>-0.23</td>
<td><strong>-0.25</strong></td>
<td>0.06</td>
<td>-0.18</td>
<td>-0.20</td>
</tr>
<tr>
<td>Net emission (kg CO₂ eq/yr)</td>
<td>454,780</td>
<td>-<strong>102,405</strong></td>
<td>-97,632</td>
<td>30,728</td>
<td>-76,632</td>
<td>-71,615</td>
</tr>
</tbody>
</table>
Conclusions

Sources of GHG emissions

- Opportunities exist to reduce GHG emissions and still maintain or even increase profitability, regardless of the dairy farm system

- Manure management strategies decreased GHG emissions with a negative impact in profitability

- Implementation of mitigation strategies should be applied according to farm system characteristics

- Other important dairy management strategies (e.g., reproduction, culling) cannot be studied directly within the IFSM framework
Acknowledgment

Project Supported by USDA National Institute of Food and Agriculture Organic Agriculture Research and Extension Initiative Grant No. 2010-51300-20534
Thanks