Improving Dairy Farm Sustainability through Strategic Alternatives to Corn Grain Feeding

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Extension Dairy Specialist
Dairy Science Department

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Introduction

• The dairy industry is struggling to remain economically viable because of skyrocketing corn grain feed prices and uncertain milk price fluctuations.

• Dairy farmers and extension faculty have indicated a need to improve dairy cattle feed efficiency in order for the dairy industry to remain economically sustainable.
Hypothesis

• Effective feeding strategies that include corn grain substitution will improve economic net return in many farm and market situations in Wisconsin. These substitutions will additionally decrease dairy farm environmental impacts and promote more ecologically sustainable production systems.
• Integration of four major components into a bio-economic decision support system, the corn-replacer:

1. Compilation and analyses of data from extensive field research of corn/forage substitution, Tessmann et al. (1991);

2. Development of corn/forage substitution production models, Earleywine (2001);
3. Integration of grazing concentrate supplementation, Soder and Rotz (2001); Bargo et al. (2003); and

4. Development of a Markov-chain, stochastic, dynamic herd simulation model to portray real-life dairy cattle conditions, (Cabrera et al., 2006; 2008)
## Milk Production to Different Diets

<table>
<thead>
<tr>
<th>Diet (TRT)</th>
<th>Alfalfa hay</th>
<th>Corn grain (HMEC)</th>
<th>Soybean meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactation Stage</td>
<td>Early-Mid-Late</td>
<td>Early-Mid-Late</td>
<td>Early-Mid-Late</td>
</tr>
<tr>
<td>Week</td>
<td>(0-12)-(13-26)-(27-44)</td>
<td>(0-12)-(13-26)-(27-44)</td>
<td>(0-12)-(13-26)-(27-44)</td>
</tr>
<tr>
<td>1</td>
<td>38-48-68%</td>
<td>42-40-25%</td>
<td>18-10-05%</td>
</tr>
<tr>
<td>2</td>
<td>48-58-78%</td>
<td>34-33-17%</td>
<td>16-07-03%</td>
</tr>
<tr>
<td>3</td>
<td>58-68-88%</td>
<td>27-25-09%</td>
<td>13-05-01%</td>
</tr>
<tr>
<td>4</td>
<td>68-88-98%</td>
<td>19-09-00%</td>
<td>11-01-00%</td>
</tr>
<tr>
<td>5</td>
<td>98-98-98%</td>
<td>00-00-00%</td>
<td>00-00-00%</td>
</tr>
</tbody>
</table>

Source: Tessmann et al. (1991)
Corn in diet

Lb/cow/day

Week of Lactation

TRT 1
TRT 2
TRT 3
TRT 4
TRT 5
Dry Matter Intake (actual)
Dry Matter Intake (Predicted)

\[ DMI_{1-12} = 24.035 - 7.84 \times AA\% + 0.3577 \times WK - 3.83 \times WK^{-1} \]

\[ DMI_{13-44} = 21.88 - 5.86 \times AA\% - 0.065 \times WK + 0.0087 \times WK^{-1} \]

Source: Earleywine (2001)
Milk Production to Different Diets (actual)
**Milk Production to Different Diets (Pred.)**

\[
MILK_{1-12} = 14.56 + 4.77 \sqrt{AA} - 16.42 \sqrt{AA} \sqrt{Corn} + 10.63 WK^{-1} \\
-5.04 \sqrt{AA} WK^{-1} - 32.35 \sqrt{Corn} WK^{-1} - 0.86 WK - 99.41 \sqrt{SBM} \\
+ 22.21 \sqrt{AA} \sqrt{SBM} + 36.72 \sqrt{SBM} WK^{-1}
\]

\[
MILK_{13-44} = 24.92 - 0.91 \sqrt{Corn} + 3.42 \sqrt{SBM} - 0.27 WK \\
+ 3.26 - 0.091 WK \sqrt{AA} - 97.36 WK^{-1} + 49.76 \sqrt{Corn} WK^{-1}
\]

Source: Earleywine (2001)
Feed Efficiency (actual)

![Graph showing Feed Efficiency](image)

- **Lb Milk/Lb DMI**
- **Week of Lactation**

Legend:
- TRT 1
- TRT 2
- TRT 3
- TRT 4
- TRT 5
## Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price (June 08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$177/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$6/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$358/ton</td>
</tr>
<tr>
<td>Milk</td>
<td>$18/cwt</td>
</tr>
</tbody>
</table>
Milk Revenue

Milk Revenue ($/day)

Week of Lactation

TRT 1
TRT 2
TRT 3
TRT 4
TRT 5
Income Over Feed Cost

Wk 13-44
$4.18/d  
$3.98/d  
$3.77/d  
$3.12/d  
$2.64/d  

Week of Lactation
## Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$172/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$4/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$265/ton</td>
</tr>
<tr>
<td>Milk</td>
<td>$15.5/cwt</td>
</tr>
</tbody>
</table>
Income Over Feed Cost

**Week of Lactation**

- **Wk 13-44**
  - $3.71/d
  - $3.39/d
  - $3.08/d
  - $2.33/d
  - $1.85/d

**IOFC ($/day)**

- **TRT 1**
- **TRT 2**
- **TRT 3**
- **TRT 4**
- **TRT 5**
## Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price (Oct 08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$172/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$8/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$265/ton</td>
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<tr>
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</tbody>
</table>
Income Over Feed Cost

Week of Lactation

IOFC ($/day)

Wk 13-44
- $2.61/d TRT 1
- $2.57/d TRT 2
- $2.54/d TRT 3
- $2.19/d TRT 4
- $1.85/d TRT 5
### Income Over Feed Cost

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$100/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$8/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$265/ton</td>
</tr>
<tr>
<td>Milk</td>
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</table>
Income Over Feed Cost
Optimal Corn Usage (Diminishing returns)

Quantity of output per period of time

Q = f(X₁, X₂, X₃)

Units of variable inputs per period of time

Stage 1  Stage 2  Stage 3

Corn in Diet (lb)

Quantity of Milk (lb)

Marginal Milk/Corn (lb milk/lb corn)
Optimal Corn Usage (Break-even)

- Marginal Value Milk/Corn ($)
- Corn in Diet (lb)

Stage 1, Stage 2, Stage 3

Units of variable inputs per period of time

APP, MPP

X, Y, Z
Milk Production Because of Corn

\[ MPMILK / Corn = (-0.46 \times Corn^{-0.5} + 24.88 \times WK^{-1} \times Corn^{-0.5}) / 0.454 \]

<table>
<thead>
<tr>
<th>Corn in Diet</th>
<th>Marginal Milk/Corn (lb milk/lb corn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>42%</td>
<td></td>
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<tr>
<td>34%</td>
<td></td>
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<tr>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

Feed | Price
-----|------
Corn grain | $6/bu
Milk | $18/cwt
Corn:Milk Price Ratio

Corn($/lb)/Milk($/lb)

Milk:Corn

Corn:Milk

Jan-1970 to Oct-2008
Optimal Corn Usage

Corn in Diet
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%

Feed | Price
---|---
Corn grain | $6/bu
Milk | $18/cwt

Week of Lactation
13 15 17 19 21 23 25 27 29 31 33 35

Marginal Value Milk/Corn ($)
Milk Production Because of Corn

Week of Lactation

<table>
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<tr>
<th>Feed</th>
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Marginal Milk/Corn (lb milk/lb corn)

Corn in Diet (lb)
Optimal Corn Usage

Week of Lactation

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Marginal Value Milk/Corn ($)

Corn in Diet (lb)
Optimal Corn Usage

<table>
<thead>
<tr>
<th>Feed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>$4/bu</td>
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<tr>
<td>Milk</td>
<td>$15.5/cwt</td>
</tr>
</tbody>
</table>

Marginal Value Milk/Corn ($)

Week of Lactation

Corn in Diet
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%
Optimal Corn Usage

<table>
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</tr>
</tbody>
</table>

Marginal Value Milk/Corn ($)

Week of Lactation

Corn in Diet (lb)
Optimal Corn Usage

- Feed Price
  - Corn grain: $8/bu
  - Milk: $15.5/cwt

Marginal Value Milk/Corn ($)

Week of Lactation

Corn in Diet:
- 42%
- 34%
- 27%
- 19%
- 17%
- 9%
Optimal Corn Usage

### Feed and Price

<table>
<thead>
<tr>
<th>Feed</th>
<th>Price</th>
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<tbody>
<tr>
<td>Corn grain</td>
<td>$8/bu</td>
</tr>
<tr>
<td>Milk</td>
<td>$15.5/cwt</td>
</tr>
</tbody>
</table>

### Marginal Value Milk/Corn ($)

<table>
<thead>
<tr>
<th>Corn in Diet (lb)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
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### Week of Lactation

- 13
- 18
- 24
- 28
- 32
- 36
Markov-Chains

- **Stage** = Time
- **State** = Characteristics of cow or group of cows
- **Transition** = Probabilities that determine the flow from one state to another state
Markov-Chains

- All potential **states** a cow (or group of cows) can be in a specific **stage**

  - Example: (5,400 states)
    - 9 parities
    - 20 month in milk
    - 10 pregnancy (0-non-preg., 1-9 preg.)
    - 3 production levels
    - 12 months in a year
Markov-Chains

Some Biological Data Needs
Forecast of a dairy herd using Markov Chains

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<td>291</td>
<td>201</td>
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</tbody>
</table>

pregnancy
## Optimal IOFC Using Herd Structure

<table>
<thead>
<tr>
<th></th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>$177/ton</td>
</tr>
<tr>
<td>Corn grain</td>
<td>$7/bu</td>
</tr>
<tr>
<td>SBM</td>
<td>$350/ton</td>
</tr>
<tr>
<td>Milk</td>
<td>$18/cwt</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking cows</td>
<td>1000</td>
</tr>
<tr>
<td>Culling rate</td>
<td>30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Diet</th>
<th>Lactation Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2-20</td>
<td>21-26</td>
</tr>
<tr>
<td>3</td>
<td>27-44</td>
<td></td>
</tr>
</tbody>
</table>

**Total IOFC** $35,463/wk

<table>
<thead>
<tr>
<th></th>
<th>Diet</th>
<th>Lactation Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1-44</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total IOFC</strong></td>
<td>$24,642/wk</td>
</tr>
</tbody>
</table>
Improving dairy farm sustainability through strategic alternatives to corn grain feeding

Feeding Strategies (3 pages, 740 KB)
This spreadsheet application calculates the income over feed cost (IOFC), the marginal value of milk to corn, and the optimal level of corn usage for defined milk price, feed costs, and stage of lactation.

Optimal Alternative Corn Grain Feeding (6 pages, 309 KB)
This PDF document describes the analyses of replacing corn grain by alternative feed strategies.

Optimal Feeding Strategies (SWF file, 762 KB)
This Macromedia Flash application performs analyses in real time directly in the web browser.

Income Over Feed Costs Analyses (SWF file, 918 KB)
This Macromedia Flash application performs analyses in real time directly in the web browser.

Improving Feeding Sustainability (Poster, 320 KB)
This PDF document gives a background of more efficient feeding practices for economic and environmental sustainability.

Victor E. Cabrera, PhD, Assistant Professor and Extension Specialist in Dairy Management, is available to contact for more information.
Limitations and Continued Work

1) Incorporate milk fat and protein,
2) Study and integrate grazing field observations,
3) Incorporate other forages, especially corn silage,
4) Incorporate herd and group feed analyses,
5) Distinction of cow's parity,
6) Incorporate high producing herds, and
7) Account for unintended impacts
Improving Dairy Farm Sustainability through Strategic Alternatives to Corn Grain Feeding

Acknowledgements
Ken Bolton
Randy Shaver
Bruce Jones
Jim Leverich

http://www.uwex.edu/ces/dairymgt/