Is feeding more maize silage to dairy cows a good strategy to reduce greenhouse gas emissions?

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Background

Livestock sector: 18% global greenhouse gas emissions

How to reduce GHG emissions from milk production?
Background

Feeding strategies for reducing enteric CH$_4$ emission

- Replacing grass silage for maize silage

± 50% of total GHG emissions in milk production
Background

\[ \text{CO}_2 + \text{N}_2\text{O} \]

\[ \text{CO}_2 (1) + \text{CH}_4 (25) + \text{N}_2\text{O} (298) \]
Methods – linear programming

Reference farm
- Average Dutch dairy farm on sandy soil (FADN, 2009)
- Economic optimization

Farm plan reference farm

<table>
<thead>
<tr>
<th>Farm inputs</th>
<th>Dairy farm</th>
<th>Farm outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>purchased feed</td>
<td>maize</td>
<td>milk</td>
</tr>
<tr>
<td>fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gas, water, electricity</td>
<td>grass</td>
<td>meat</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Methods – linear programming

Farm plan reference farm

+ maize silage 1 kg DM/dairy cow/day
- grass 1 kg DM/dairy cow/day

Economic optimization

Increasing maize silage effects farm-plan
- Ploughing grassland for maize land
- Type and amount of concentrates
- Fertilization
- ...

Farm plan farm with maize silage strategy
Methods – calculating emissions

**CO₂ + N₂O**

Mechanistic model for enteric CH₄ emission

Bannink et al., 2006

Life Cycle Assessment

Mechanistic model for CO₂ and N₂O emissions from ploughing grassland

ICBM by Andrén & Kätterer; Vellinga et al., 2004
Results

Reference farm
- 76 dairy cows, 640 ton FPCM/yr
- 46 ha land – 70% grass & 30% maize

- Reference farm → 70% grassland
- Derogation regulation!
- Replacing grass for maize ... NO OPTION!

Reference farm (120% intensified)
- 76 dairy cows, 640 ton FPCM/yr
- 35 ha land – 79% grass & 21% maize
Results – animal perspective

Ration (dairy cow/day)

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grass</strong> (kg DM)</td>
<td>Ref.</td>
<td>Maize</td>
</tr>
<tr>
<td>Grass silage (kg DM)</td>
<td>4.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Maize silage (kg DM)</td>
<td>5.2</td>
<td>6.2</td>
</tr>
<tr>
<td>Concentrates standard (kg)</td>
<td>7.0</td>
<td>5.7</td>
</tr>
<tr>
<td>Concentrates extra protein (kg)</td>
<td>1.0</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Enteric CH$_4$ emission

<table>
<thead>
<tr>
<th>g CH$_4$/dairy cow/day</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>395</td>
<td>380</td>
<td>483</td>
</tr>
</tbody>
</table>

8.4 ton FPCM/dairy cow/yr

Reduction: 0.48 kg CH$_4$/ton FPCM

11 kg CO$_2$-eq/ton FPCM

From an animal perspective feeding more maize silage is an effective strategy to reduce GHG emissions.
### Results – farm perspective

#### Farm plan

<table>
<thead>
<tr>
<th></th>
<th>Ref.</th>
<th>Maize</th>
<th>CO₂-eq/ton FPCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cows (#)</td>
<td>76</td>
<td>76</td>
<td>- 11.2</td>
</tr>
<tr>
<td>FPCM production (ton/yr)</td>
<td>640</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>Grassland (ha)</td>
<td>28</td>
<td>25</td>
<td>- 5.6</td>
</tr>
<tr>
<td>Maize land (ha)</td>
<td>7.5</td>
<td>10.5</td>
<td>+ 4.6</td>
</tr>
</tbody>
</table>

Ploughing grassland for maize land ➔ 32.5 kg N₂O-N/ha ➔ 47.5 ton CO₂-C/ha

Annual emission reduction: 12 kg CO₂-eq/ton FPCM

Total non-recurrent emissions: 845 kg CO₂-eq/ton FPCM
Results – life cycle perspective

Annual emission:
- 17.9 kg CO₂-eq/ton FPCM

Non-recurrent emission:
+ 845 kg CO₂-eq/ton FPCM

Carbon payback-time:
845/17.9 = 47 years

Artificial fertilizer

(kg CO₂-eq/ton FPCM)
Conclusions

Is feeding more maize silage to dairy cows a good strategy to reduce GHG emissions?

- Strategy not feasible in practice for most Dutch dairy farms
- On highly intensified farms, carbon payback-time of strategy is 47 years

→ animal perspective ≠ life cycle perspective!
Thank you for your attention!

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