How can Grass-Based Dairy Farmers reduce the Carbon Footprint of milk?

Donal O’Brien

Livestock Systems Department, AGRIC, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland
Overview

- Grassland and Climate Change Policy
- Carbon footprint of Commercial Farms
- Mitigation opportunities
- Conclusions
Grassland and Climate Change Policy

- Grasslands are a key source of ruminant food products
  - Produce more food energy globally than monogastrics

- Demand for ruminant-based food is growing
  - Population growth
  - Westernization of developing nation diets

- But milk and meat have relatively high greenhouse gas emissions
Grassland and Climate Change Policy

• EU nations have adopted ambitious binding GHG emission targets for 2020 and 2030

• Overall 2030 reduction target set for non-ETS is 30% compared to 05 levels
  • Includes agriculture
    • > 40% of Irish non-ETS emissions

• New Non-ETS targets recognise the important role of agriculture in achieving food security
  • New focus on reducing C footprint
Research objectives

• Grass-based milk production is economically important and growing quickly in Ireland

• Our goals were
  1. To audit C footprint of milk from the main milk production region in Ireland
     • Whole farm system methodology
     • Verify method to a recognised standard

  2. Identify strategies that can be readily applied to mitigate C footprint of milk
Carbon audits

- 62 dairy farms successfully audited for 2014
  - But not representative of Rep. of Ireland
  - Limited to Southern Region

- Livestock inventory and milk production
  - Electronic - DAFM, ICBF, Co-ops

- Monthly on-farm survey
  - Animal feeding plan
  - Fertiliser use and manure management
  - Fuel, Chemical, Water use etc…
Computing Carbon Footprint of Milk

• Life Cycle Assessment (LCA; ISO 14040)
  • Recognised systems approach

• Applied to quantify carbon footprint until milk was sold from the farm
  • On-farm GHG sources
    • Irish National GHG Inventory
    • IPCC (2006)
  • Off-farm GHG sources (e.g. soy meal)
    • Carbon Trust Footprint Expert
    • Ecoinvent (2006)
Certification

• PAS 2050 – British GHG standard
  • More proscriptive than ISO standards
  • Specific emissions for land use change

• Independent Certification
  • Auditing system tested by Carbon Trust
  • Data verified via farm invoices etc…
  • Non-conformities between LCA model and PAS 2050 addressed
  • Certification - Carbon footprint within 5% threshold of PAS 2050
Dairy Farm Carbon Footprints 2014

Carbon footprint
kg CO$_2$e/kg of FPCM

Decile

- No C sink
- Average = 1.26
- Min = 0.92
- Max = 1.73
- SD = 0.16
Dairy Farm Carbon Footprints 2014

Carbon footprint
kg CO$_2$e/kg of FPCM

Decile

C sink
Average = 1.05
Min  = 0.67
Max  = 1.37
SD   = 0.15

The Irish Agriculture and Food Development Authority
Contribution analysis of C footprint

kg CO₂-eq/kg of FPCM

Enteric, Fertilizer, Grazing, Concentrate, Managed manure, Fossil Fuel, Lime, N leaching and deposition
## Farm performance and C footprint

<table>
<thead>
<tr>
<th>Year</th>
<th>Average</th>
<th>Min 10%</th>
<th>Max 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd EBI</td>
<td>148</td>
<td>172</td>
<td>106</td>
</tr>
<tr>
<td>FPCM, kg/cow</td>
<td>5208</td>
<td>5828</td>
<td>4668</td>
</tr>
<tr>
<td>Concentrate feed rate, kg/t FPCM</td>
<td>123</td>
<td>111</td>
<td>193</td>
</tr>
<tr>
<td>Grazing days, turnout to full housing</td>
<td>248</td>
<td>258</td>
<td>221</td>
</tr>
<tr>
<td>Grazed grass, % diet</td>
<td>66</td>
<td>71</td>
<td>57</td>
</tr>
<tr>
<td>N fertilizer, kg/t FPCM</td>
<td>22</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Enteric methane, kg/t FPCM</td>
<td>0.59</td>
<td>0.54</td>
<td>0.65</td>
</tr>
<tr>
<td>C footprint, kg CO$_2$e/kg FPCM</td>
<td>1.26</td>
<td>1.02</td>
<td>1.54</td>
</tr>
<tr>
<td>C footprint with sequestration, kg CO$_2$e/kg FPCM</td>
<td>1.05</td>
<td>0.81</td>
<td>1.26</td>
</tr>
</tbody>
</table>
## Mitigation opportunities

<table>
<thead>
<tr>
<th></th>
<th>CF of milk</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genetic measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herd EBI</td>
<td>-0.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Herd dairy sub-index</td>
<td>-0.38</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Herd fertility sub-index</td>
<td>-0.33</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Non-genetic measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazed grass % diet</td>
<td>-0.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>N fertilizer/unit of milk</td>
<td>-0.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Calving interval</td>
<td>-0.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FPCM yield/cow</td>
<td>-0.44</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Concentrate/unit of milk</td>
<td>0.39</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Mitigation opportunities

- Most variation \( R^2 = 0.82 \) in footprint explained by
  - Cow genetic potential – Herd EBI
  - Nutrient management - N fertiliser response
  - Nutrition – Grazed grass and concentrate

- Strategies are available to improve these farm performance measures
  - Improve cow genetic merit
    - Adopt AI or increase usage
    - Review cow performance
      - Select best team of sires
Mitigation opportunities

- Improve soil fertility
  - Low pH or P levels on some farms
  - Apply lime and soil test
    - Improve N response
    - Potential for legumes - WC

- Precision farming
  - Grazing tools – Pasturebase
    - Greater grass quality control
    - Extend grazing season
    - More pasture in the diet
Conclusions

• Scope to reduce C footprint across all farms
  • Improve productive efficiency
  • No one size fits all approach to increase productivity
    • Region or farm specific

• Modelling knowledge gaps
  • Land quality - Soil types and topography
    • Key determinant of mitigation potential
    • Improve extension advice
    • Refine inventory N emissions estimates
Conclusions

• Modelling knowledge gaps
  • Carbon sequestration
    • Rate and permanence of sequestration
    • Opportunity cost – Time and value

• Improving productivity only part of the solution
  • New technologies required to achieve long-term goals
    • Methane inhibitors
    • Enhanced sequestration
    • Carbon capture and storage
Acknowledgements
DAFM RSF

Thanks for your attention

Look forward to meeting you again at the LCA Food Conference Oct 19-21 in Dublin, Ireland
Life Cycle Assessment

Off-farm
- Fertilizer
- Pesticides
- Feedstuff
- Livestock
- Fuel
- Electricity
- Machinery
- Etc..

On-farm
- Cultivation
- Grazing
- Harvesting
- Housing
- Manure

GHG
NH₃
NO₃

Milk
Meat
GHG
NH₃
NO₃

The Irish Agriculture and Food Development Authority
Effect of Soil Carbon

PAS 2050 footprint

kg CO$_2$e/kg ECM

0.00 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00

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The Irish Agriculture and Food Development Authority
Carbery Carbon Footprints

PAS 2050 footprint

Excl Soil Carbon Soy Emissions

-30%
-12%

The Irish Agriculture and Food Development Authority