Comparing the cost effectiveness of GHG mitigation options on different Scottish dairy farm groups

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Background

• GHG emissions – one of the challenges faced by farmers
• UK committed to reduce GHG emission by 80% by 2050 (from 1990 levels)
GHG targets in Scotland

‘Farming for a Better Climate’
– cost effective practices to make farms more energy efficient
– Agricultural Resource Efficiency calculator (AgRE calc)
Mitigations

• Mitigation options
  – feed additives, feed rationing, genetic improvement, anaerobic digester, sexed semen, soil management, milking, manure management etc.

• Optimal option – based on farm types

• Balancing act between cost effectiveness and GHG emission
- Concentrated to the south of Scotland
- Among the most efficient and profitable sector
- Data – Scottish National Farm Survey data (FAS)
  - Farm level data from 55 specialist dairy farms
  - Farms are further grouped based on size and characteristics – medium and large dairy farms

<table>
<thead>
<tr>
<th></th>
<th>Grass land</th>
<th>Arable land</th>
<th>Rough grazing</th>
<th>Family labour</th>
<th>Dairy herd</th>
<th>Milk yield</th>
<th>Var costs</th>
<th>Milk price</th>
<th>Stock rate</th>
<th>SFP pay</th>
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</thead>
<tbody>
<tr>
<td>Dairy medium</td>
<td>99.5</td>
<td>11.7</td>
<td>12.1</td>
<td>2.1</td>
<td>150</td>
<td>6735</td>
<td>205.3</td>
<td>0.23</td>
<td>1.3</td>
<td>383.8</td>
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<tr>
<td>Dairy large</td>
<td>227.9</td>
<td>0</td>
<td>88.7</td>
<td>2.3</td>
<td>300</td>
<td>5657</td>
<td>206.8</td>
<td>0.24</td>
<td>1.16</td>
<td>423.5</td>
</tr>
</tbody>
</table>
Models used

• ScotFarm
  – a farm level optimising model
  – optimises farm profits within limiting farm resources such as land, feed and labour
  – consisting a number of modules linked together
    • Dairy, crop, feed and labour
  – Time frame – 15 years
    • activities, decisions taken in a year are based on those taken in the previous year
Mitigation options

Four GHG mitigation scenarios were used;

• Sexed semen
  – decreases proportion of cows for insemination from 70% to 40%
  – decrease the number of ‘by-product’ male calves

• Anaerobic digester
  – an anaerobic digester installed to digest manure collected during in-house period (2-3 months)
  – the installation generates both heat and electricity

• Fat additive in feed
  – 3% linseed added
  – only fed to the in-house cows (2-3 months)

• High clover swards
  – 20% white clover-grass mix
  – constant yield assumed
  – decrease in fertiliser use (50kg N/ha vs 190 kgN/ha)
Economics behind scenarios

• Sexed semen
  – increase in variable costs by £10/straw
  – double the revenue from high value crossbred calves

• Anaerobic digester
  – Initial investment cost (based on capacity ≈ \( C = -0.939 \ln X + 3.1714 \))
  – Operational cost
  – Savings from generating electricity @ £0.10/kWh and heat @ £0.05/kWh

• High clover swards
  – Reduced synthetic fertiliser @ £238/t
  – Increased seed costs @ £10/kg seed (4 kg/ha)

• Fat in feed
  – Added cracked linseed @ £430/t in the feed
GHG savings under scenarios

• Sexed semen
  – reduced ‘by-product’ dairy male calves
  – Increase cross bred beef calves which have higher emission index

• Anaerobic digester
  – reduced CH\(_4\) emissions, GHG emission replaced by electricity and heat, increased CO\(_2\) emission

• Fat in feed
  – the GHG emission savings due to reduced enteric CH\(_4\) production \(\approx Y = 24.65 - 0.103X\)

• High clover sward
  – reduction in direct and indirect soil N\(_2\)O emission
Results - economics

Change in farm profits

![Graph showing change in farm profits for different farm types and fed levels. The graph indicates a comparison between dairy medium and dairy large categories for SS, FatFeed, AD, and Clover categories. The y-axis represents the change in profits, ranging from -0.25 to 0.10.]
Results – GHG emissions

Life cycle assessment included
Results – GHG emissions

GHG emissions savings

When only dairy is considered
Results – cost effectiveness

£/tCO$_2$e

SS   AD   FF   Clover

Medium dairy   Large dairy
Results - farms’ responses

Changes in feed ration

Only manifested in Fat in feed scenario.

Feed pattern changed forcefully as 3% of relatively expensive fat additive is used in feed.

Farmers decreased animal number by up to 26% to reduce costs of production.
Conclusions

• Cost of effectiveness is a useful way to compare different mitigation options.
• Farmers make better decisions when impact on farm profits along with the GHG emissions are provided.
• Including clover in grassland is the most cost effective measure among 4 studied measures.
• Life cycle assessment needs to be included in these types of studies to widen impacts