Biogas research in Teagasc Grange

P.O’Kiely, J.McEniry, C.King & JJ. Lenehan
Animal & Grassland Research and Innovation Centre, Teagasc, Grange, Dunsany, Co. Meath, Ireland

Energy from Biogas: International Energy Agency Task 37 Conference
University College Cork
Thurs. 15 September 2011
Outline

• DAFF-funded ‘GreenGrass’ project
• What do we want from grass for biogas?
• Choices among grasses
• Farm-scale digester
• Future research
Outline

• DAFF-funded ‘GreenGrass’ project
• What do we want from grass for biogas?
• Choices among grasses
• Farm-scale digester
• Future research
GreenGrass project

Aim

Investigate the potential utilisation of grass for the production of bio-based products and biofuels

Teagasc, Grange, Co. Meath

University College Cork/Environmental Research Institute

Questar/Queens University Belfast
GreenGrass project

- Pre-digestion
- Agronomy
- Silage
- Separation
- Liquor
- Fibre
- Digester type
- Digester operation
- System analysis
GreenGrass

Italian ryegrass  Perennial ryegrass  Cocksfoot  Timothy  Tall fescue  Red clover

Nitrogen

0 kg N/ha
120 kg N/ha

Harvest date
12 May
26 May
9 June
23 June
7 July

+ old pasture
**Yield** (dry matter; DM) at two growth stages

<table>
<thead>
<tr>
<th></th>
<th>PRG</th>
<th>IRG</th>
<th>Tall fescue</th>
<th>Cocks foot</th>
<th>Timothy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>7.5</td>
<td>7.0</td>
<td>7.3</td>
<td>5.8</td>
<td>8.0</td>
</tr>
<tr>
<td>2nd</td>
<td>8.0</td>
<td>8.2</td>
<td>8.8</td>
<td>6.9</td>
<td>9.0</td>
</tr>
</tbody>
</table>

**Source:** King *et al.*

**Growth stage at harvest**

- 2.7
- 3.4
Digestibility at two growth stages

2.7  Growth stage at harvest  3.4
Ensilability

'Sugars' at two growth stages

Buffering capacity at two growth stages

Source: King et al.

---

Sugars

Buffers

---

2.7  Growth stage at harvest  3.4
Methane production

**Growth stage of grass at harvest**
Leaky (12 May) through to stemmy (7 July)
- 12 May harvest
- 9 June harvest
- 7 July harvest

**Grass species**
- PRG
- IRG
- Timothy
- Tall Fescue
- Cocksfoot

Source: McEniry et al.
**System analysis**

- Grass silage can be a *cheap* feedstock
- Optimum rather than maximum yield
- Collect and use silage effluent
- Spread digestate on ‘silage land’
- Huge variability in feedstock costs
Outline

• DAFF-funded ‘GreenGrass’ project

• What do we want from grass for biogas?

• Choices among grasses

• Farm-scale digester

• Future research
Why grass in Ireland?

- Widespread availability
- Suited to climate
- High yield potential
- Energy-rich
- Perennial/permanent
- Robust/adaptable (graze/silage/hay/amenity; tolerates ‘abuse’)
- Pest/disease ‘free’
- Synergy with legumes (N fixing)
- Carbon sequestration (in soil)
- ‘Low’ cost of production

“Irish farmers are very familiar and comfortable with grassland management”
Total biomass resource for bioenergy to 2050

Key Point: Grass & wastes can be significant energy resources in the coming decades

Source: Sustainable Energy Authority of Ireland (2010). Bioenergy roadmap to 2050
Why ensile the grass?

• Target harvesting at optimal yield/quality

• Feed supply assured – know what has been saved so can plan ahead

• Feed quality known – so can plan accordingly
  (what you have is homogenous)

• Labour efficiency – fertiliser application, digestate spreading, crop harvesting, etc.

• Reduced dependence on weather
Important technical traits of grass/silage

A) Yield

B) Composition - chemical/physical/microbial

C) Ensilage losses
A) Yield of grass

Cost of silage DM ‘fed’

Cost (€/tonne silage DM ‘fed’)

Grass DM yield (t/ha)
B) Composition of grass/silage

- Digestibility – growth stage
- Ensilability – sugars, buffers, etc.
- Sward canopy structure
- Silage water content and chop length
## C) Ensilage losses

<table>
<thead>
<tr>
<th></th>
<th>% loss of DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Mechanical Respiration</td>
<td>3</td>
</tr>
<tr>
<td>Rain (leaching)</td>
<td></td>
</tr>
<tr>
<td>Silo Air Filling Storage Feedout</td>
<td>10</td>
</tr>
<tr>
<td>Fermentation</td>
<td>3</td>
</tr>
<tr>
<td>Effluent*</td>
<td>6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>20-25%</strong></td>
</tr>
</tbody>
</table>

*If collected, effluent can be fed into the AD reactor thereby avoiding this source of loss.*
Aerobic stability/deterioration

Silage stable in air

Silage unstable in air

Silage very unstable in air

+0°C

Hours exposure to air

Silage stable in air

Silage unstable in air

Silage very unstable in air

+0°C

Hours exposure to air

+0°C

Hours exposure to air

Silage stable in air

Silage unstable in air

Silage very unstable in air
Reducing ensilage losses

Cost of silage DM fed

Cost (€/t silage DM fed) vs % DM losses during ensilage
Silage
– important traits for anaerobic digestion

- **Supply**
- **Digestibility** (energy availability)
- **Preservation** (fermentation)
- **Stability in air** (during feedout)
- **Dry matter content** (water content)
- **Mechanisation system** (chop length; storage system)
- **Cost**
Outline

• DAFF-funded ‘GreenGrass’ project

• What do we want from grass for biogas?

• Choices among grasses

• Farm-scale digester

• Future research
Choices among grasses

1. Use existing sward

2. Sow purpose-designed sward
   - Ryegrass – Perennial or Italian
   - Monoculture or mixture (e.g. + red clover)
   - Mixture of varieties
     - Diploid and/or tetraploid
     - Early, Intermediate or Late heading-date
     - Erect or prostrate
Outline

• DAFF-funded ‘GreenGrass’ project
• What do we want from grass for biogas?
• Choices among grasses
• Farm-scale digester
• Future research
Outline

• DAFF-funded ‘GreenGrass’ project

• What do we want from grass for biogas?

• Choices among grasses

• Farm-scale digester

• Future research
Go raibh maith agaibh!