GreenGrass:

Optimising biogas from grass in Ireland

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How did GreenGrass originate?

- **Department of Agriculture** (Dublin) wanted expertise on 'industrial' uses for grass.
- Wanted **agronomy + microbiology + engineering** input
- Questor in Belfast (microbiology)
  University College Cork (engineering) } already linked
  Teagasc (agronomy) - 'introduced'.
- Formed research consortium

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Aims of GreenGrass

Develop grass for sustainable renewable energy generation and value-added products

- **What grasses to use and how to conserve them?**
- **How best to digest grass for biomethane production?**
- **Can the biomethane yield be further boosted?**
- **Any other industrial uses for grass?**
- **What is the cost/economic attractiveness of grass?**

What grasses to use?

GreenGrass


Italian ryegrass


Perennial ryegrass


Cocksfoot


Timothy

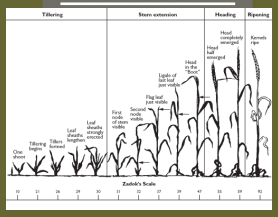

Tall fescue


Red clover

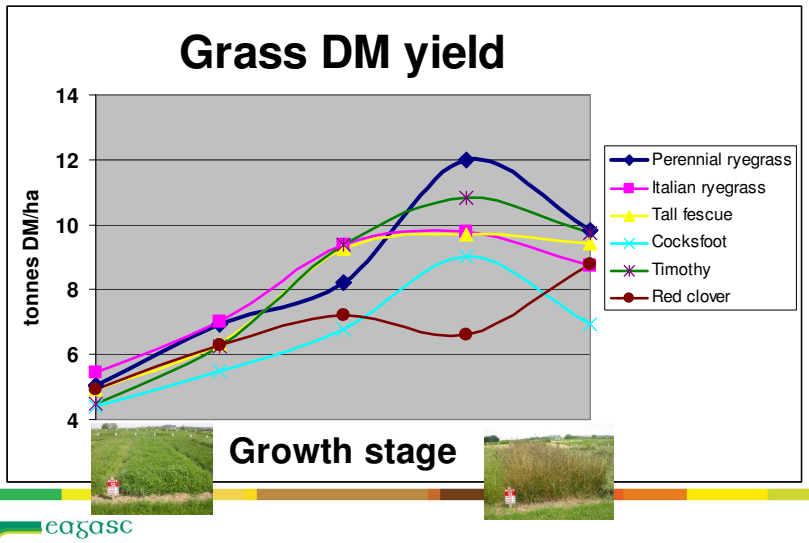
+ old pasture

Nitrogen
0 kg N/ha
120 kg N/ha

Harvest date



What grasses to use?



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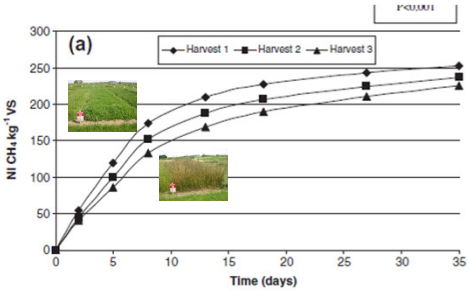
What grasses to use?

Ease of preservation as silage		
Easy	**Moderate**	**Difficult**
Italian ryegrass**	Red clover	Timothy
Perennial ryegrass*		Cocksfoot
Tall fescue		

What grasses to use?

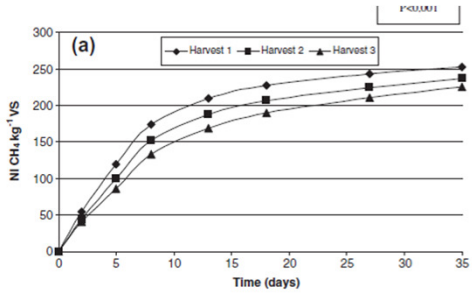
Methane



Grass growth stage has biggest influence on methane output

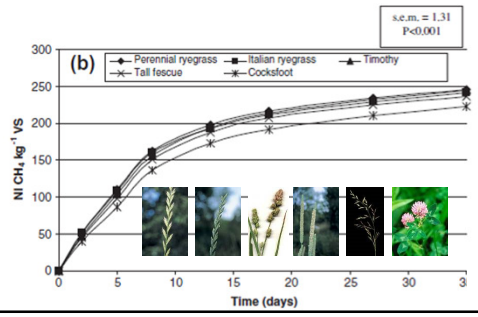
What grasses to use?

Methane



Grass growth stage has biggest influence on methane output

Methane



Grass species has little effect at common growth stage

What grasses to use?

1. **Use existing sward**
2. **Sow purpose-designed sward**
   - **Ryegrass – <u>Perennial</u> or Italian**
   - **<u>Monoculture</u> or mixture (e.g. + red clover)**
   - **Mixture of varieties**

     <u>Diploid</u> and/or <u>tetraploid</u>

     Early, <u>Intermediate</u> or Late heading-date

     <u>Erect</u> or prostrate

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**

How to conserve the grass?

- Quickly wilt grass to >25%DM

or

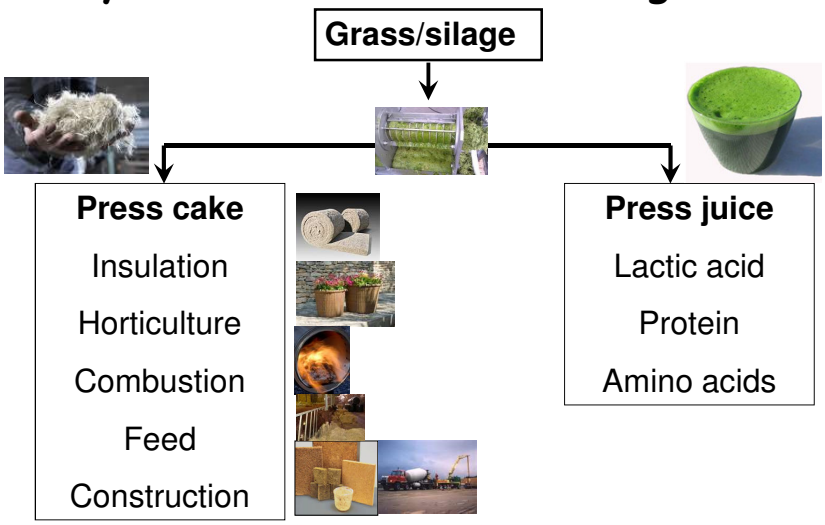
- Apply preservative if sugar content of grass is too low

Cost/economic attractiveness of grass?

- **Intensive 2-cut cheaper than extensive 2-cut or intensive 3-cut systems.**

- **€34/tonne feedstock for intensive 2-cut silage**
  - **~ utilise digestate = -€3/tonne**
  - **~ digest effluent = -€4/tonne**
  - **⟶ €27/tonne**

Any other industrial uses of grass?

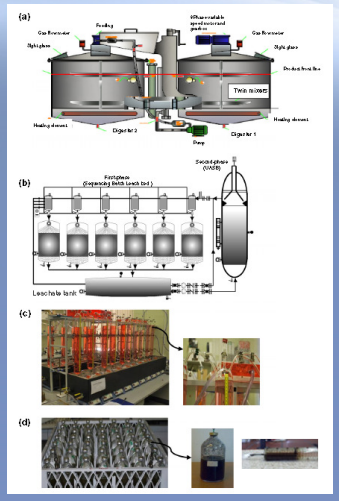


How best to digest grass for biomethane production?

- Digester design and operation (UCC); feedstock conversion optimisation (QUB)

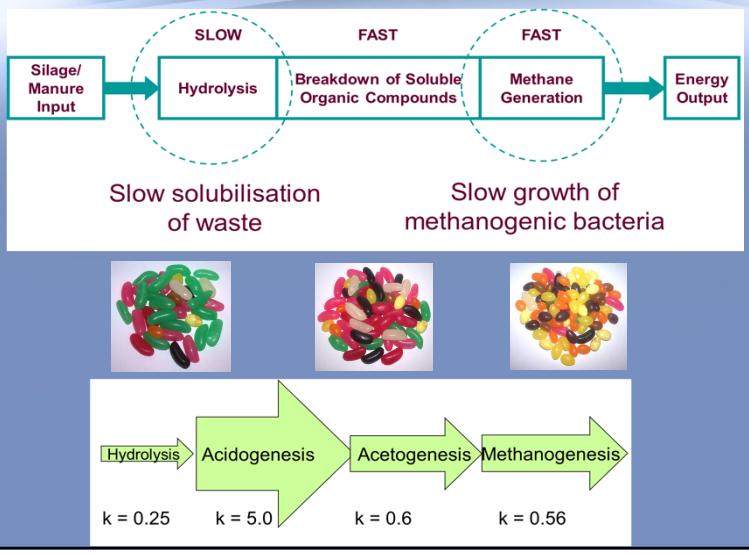
Summary of the results from three various grass digestion systems.

	SLBR–UASB	CSTR	Micro BMP	Small BMP	Large BMP
HRT (Days)	30	50	35	22	26
CH_4 content (% CH_4 in Biogas)	71	52	51	54	70
CH_4 production (L CH_4 kg^{-1} VS added)	341	451	350	355–419	483–493



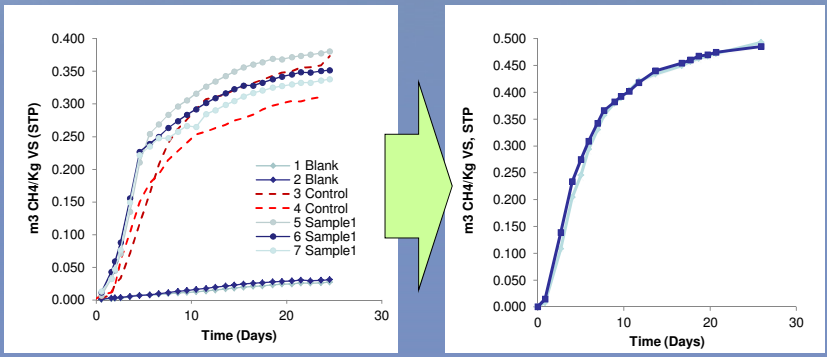
- Perennial rye grass – most consistent and best yield
- European Average for comparison: 298-467 m^3 CH_4/t VS (Braun et al (2009) Biogas from energy crop digestion IEA Task 37)

Can the biomethane yield be further boosted?



Testing Methane Potential

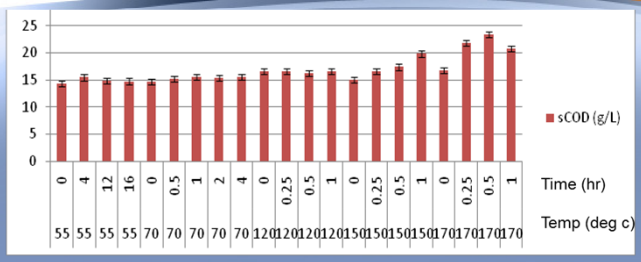
- Emerging standards at EU level
- Examination of all variables – developing accuracy

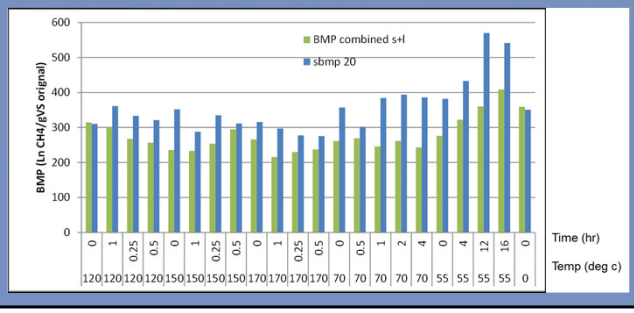


Pre-treatments

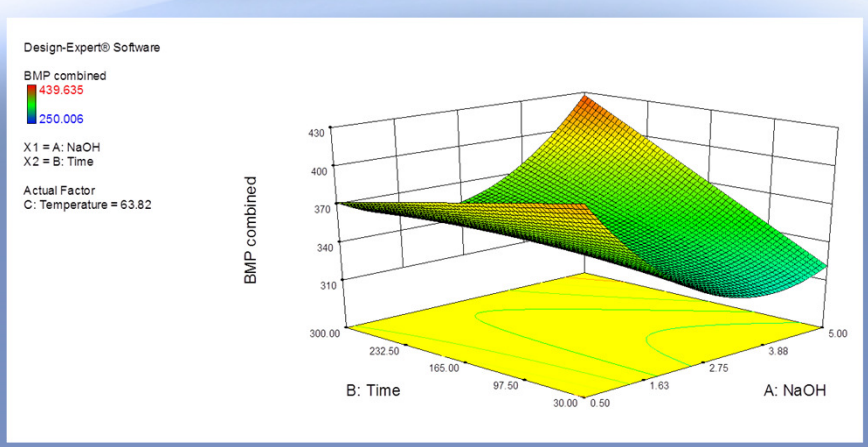
- Thermal hydrolysis – 55-70°C, 120-170°C
- ~~Acidification~~
- Alkali
- Thermal & Alkali
- ~~External enzyme addition~~
- Hydrolytic enzyme production stimulation
  - Test various Hydraulic Retention Times (HRT)
  - Test various Organic Loading Rates (OLR)

Thermal Hydrolysis (Hot Water)

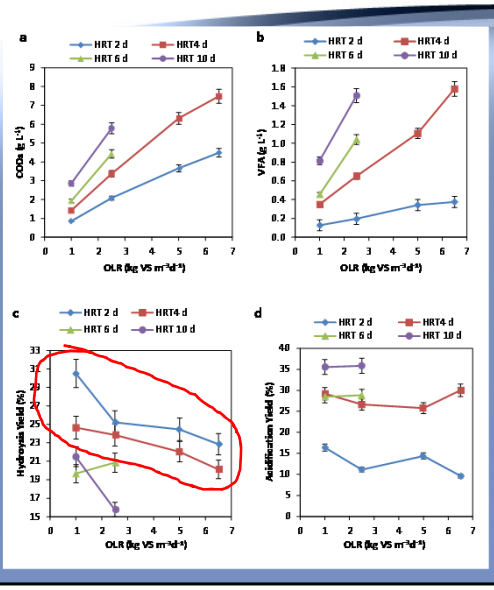




Optimisation of Pre-treatment



Stimulating natural hydrolysis

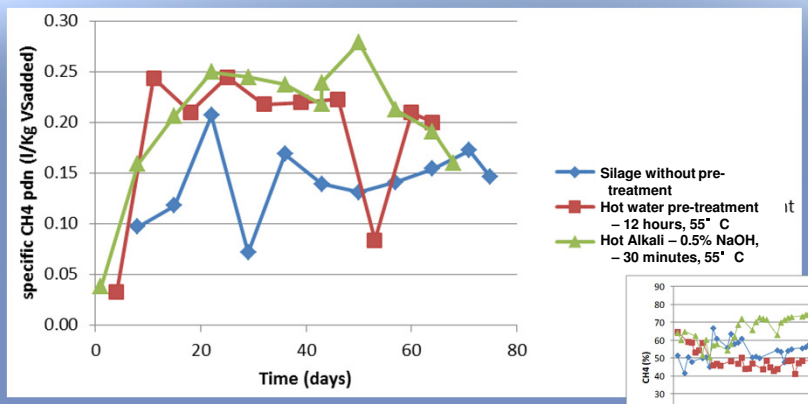


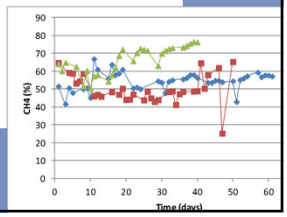
- Effect on solids destruction
- Actual biogas yield

OLR (kg VS $m^{-3}d^{-1}$)	HRT (days)	BMP at 20 d (L_N CH_4 kg^{-1}VS)	Biodegradability (%)
1.0	2	339 ± n/a	68
2.5	2	310 ± 29	62
5.0	2	273 ± 1	55
6.5	2	283 ± 16	57
1.0	4	368 ± 10	74
2.5	4	334 ± 7	67
5.0	4	312 ± n/a	63
6.5	4	309 ± 0	62
1.0	6	308 ± 17	62
2.5	6	270 ± 47	54
1.0	10	307 ± 14	62
GS		282 ± 12	57
Statistical significance			
OLR (kg VS $m^{-3}d^{-1}$)		S	S
HRT (days)		S	S

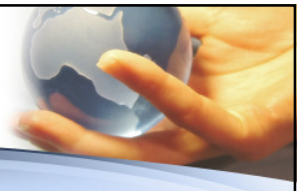
Continuous tests

- Pre-treatment – increased methane yield





Cost-benefit analysis



- **Scenario A – 10% increase in biogas from same feedstock**

	Unit	Business as Usual	With Pre-treatment	Pre-treatment benefit
Electricity Sales				
MWh exported	MWh/year	3642	4007	
Electricity Sales Revenue	£/year	£ 176,032	£ 193,635	£ 17,603
Capacity Payments Revenue	£/year	£ 26,390	£ 29,029	£ 2,639
ROCs revenue	£/year	£ 666,642	£ 733,306	£ 66,664
LECs Revenue	£/year	£ 13,982	£ 15,381	£ 1,398
Biogas yield (silage)	m^3/tonne	150	165	
Silage cost (11712 t/y @£25/t)	£/year	- £ 292,803	- £ 292,803	
Totals		£590,243	£675,495	£ 88,305

- **Scenario B – 10% increase in biogas yield – use 10% less feedstock**

	Unit	Business as Usual	With Pre-treatment	Annual Saving
Biogas yield (silage)	m^3/tonne	150	165	
Silage Used	tonnes/year	11712	10541	
Northern Ireland				
Silage price	£/tonne	25	25	
Silage cost	£/year	£ 292,803	£ 263,520	£29,283

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Department of Agriculture, Food and the Marine
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