Observations of the growth and use of energy crops in UK agriculture

Chris Gamble - DLF

BCPC Conference – Changing practices, Improving weed control.
Summary

Some of the Pros and Cons to agriculture and crop rotations of AD plants - experience of farms that traditionally would have been growing wheat, rape, peas and beans in rotation have now been growing maize, hybrid rye, (beet) and high yielding short term grass leys.

The benefit energy crops bring to the rotation - specific links into weed control - cultural and chemistry - changed rotation to manage weed burdens etc. Harvest date challenges vs. grass weed maturity. Value of Digestate and sludge also.

The subsequent effects on soil health, crop rotations and weed management experienced, including the effect of blackgrass seeds in the AD system will be commented on.
Extent and type of plants in the UK

- **Agricultural** - plants that use predominantly agricultural feedstock such as manures, slurries, crops and crop residues

- **Waste** - plants that use predominantly municipal, commercial and industrial waste streams as feedstock

Each is then further categorised by the end-use of the biogas:

- **Heat and/or Power (CHP)** - an anaerobic digester generating biogas which is burned on-site to generate heat, power or both

- **Biomethane to Grid (BtG)** - an anaerobic digester generating and upgrading biogas, to derive biomethane for injection into the national gas grid

Source: NNFCC National Non Food Crop Centre - Anaerobic digestion deployment in the UK. Third report. (April 2016)
Extent and type of plants in the UK

- 316 operational AD plants in the UK outside of the sewage treatment sector, with a further 454 projects currently under development
  - 47 of 316 are BioMethane to grid (14.9%)
- Cropping wise accounting for 2.5% of UK Arable crop acreage
- 1 Mega watt = 1000 acres roughly of arable land
- According to NFU, 1000 medium sized biogas plants are to be built by 2020....So potentially 100 -125K Ha’s of arable land in Maize for Biogas?

A few timelines

- 2005 Kyoto: The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits State Parties to reduce greenhouse gas emissions

- So 2009 EU Renewables directive: “20% power from renewables by 2020”
- June 2010: Member states National Renewable Energy Action Plan (NREAP)
- 2011 Huge uptake due to Renewable Heat Incentives (RHI’s)
- 2011 Germany uses many crop only plants (most on farm) to maximise biogas output 6-7000
- Germany - Renewable energy sources act, guaranteed pricing for 20 years (2012)
- (Fukoshima 2011)
- UK consider using Biogas for Muck as a primary objective and crop use secondary
  - Less land in UK for food security, nitrogen and land stewardship
- 60% Danish homes heated by biogas
- Nov 2016, Paris protocol: Global temperature rise below 2 degrees C°
Bio Gas process

- Slurry & manure
- Crops & crop residues
- Food & food waste
- Pasturisation
- Gas Scrubber
- Liquid application
- Solid application

Anaerobic - digester

BIO-Methane

POWER

HEATING & Cooling

GAS

Bio fuel inclusion
Size of AD Plants?

Large - Basingstoke AD Plant

www.Tamar-energy.com

Small

http://www.build-a-biogas-plant.com/
Why AD Plants?

“Real”/original objective was mitigation of Slurry and Manure

- 2,500,000 Litres = 3-4 MW of electricity
- 90 - 100,000 tonnes of slurry produced each year in UK + Beef and Poultry muck! (111-160 MW)
- Then UK produces 16-18m tonnes of food waste, mostly landfilled: 4800-5400KW hours energy (350K UK Houses)

- Availability of farmland for AD vs food
  - 1MW requires 1000 to 1200 acres of land
  - Environmental legislation - Carbon, NVZs, water (WFD)

- Proximity to urban population: Flies and odours, GHG emissions...
- Reduction in food waste to landfill, EU Landfill Directive (65% by 2016 to 1995 level)
- Limitation to farm output prices, stagnant yields !! = reducing income
Why add a crop to slurry/manure in the AD Ration?

- When fed with Green Crop Silage Biogas Production is enhanced hugely
  - Ration Typically 30% Slurry, 70% Crop silage

- Primary feedstock (Slurry) only available 6-7 months
  - Winter housing
  - Sufficient year round alternative substrates
  - Regulatory issues with foodwaste

- Economic return on plant investment - Scale economies

- Use of Manure, crops and food waste

<table>
<thead>
<tr>
<th>Energy yield from 1m³ biogas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1m³ biogas</td>
</tr>
<tr>
<td>Electricity only</td>
</tr>
<tr>
<td>Heat only</td>
</tr>
<tr>
<td>CHP of biogas</td>
</tr>
</tbody>
</table>

BioCow claims the largest AD plant.

5MW predicted needs = 80,000 tonnes of crops

- Maize, Rye & Sugar beet
- In excess of 1000M per hour
- 40 Farms
Biogas output from different feedstocks

When fed with Green Crop Silage Biogas Production is enhanced hugely.
AD Ration Typically: 30% Slurry, 70% Crop silage

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Feedstock biogas yield (m$^3$ per tonne)</th>
<th>Equivalent value (£ per tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle slurry</td>
<td>15-25</td>
<td>4.00-6.00</td>
</tr>
<tr>
<td>Pig slurry</td>
<td>15-25</td>
<td>4.00-6.80</td>
</tr>
<tr>
<td>Poultry</td>
<td>30-100</td>
<td>8.10-27.00</td>
</tr>
<tr>
<td>Maize silage</td>
<td>200-220</td>
<td>54.40-60.00</td>
</tr>
<tr>
<td>Grass silage</td>
<td>160-200</td>
<td>43.50-54.40</td>
</tr>
<tr>
<td>Whole crop wheat / Sugar beet</td>
<td>170-190</td>
<td>50.00-60.00</td>
</tr>
<tr>
<td>Crude glycerine</td>
<td>580-1000</td>
<td>155.00-270.00</td>
</tr>
<tr>
<td>Rape meal</td>
<td>600-650</td>
<td>160.00-170.00</td>
</tr>
</tbody>
</table>

Source: DARD: Anaerobic Digestion - Production of Biogas
UK Agricultural issues for arable farmers

- Grass weed resistance?
- 70% of crops planted in the autumn Sept/Oct and harvested in July and August
- Poor soil care, recreational tillage
- Increasing wet, unstructured soils
- Low organic matter in soils, Mg not Ca
- Little integrated crop management
  - cover crops
- Chemistry - No new solutions
- Declining / static farm incomes

Source: Ebay.co.uk, Rothamsted, DEFRA, Yara, Defra, October 26th 2016, Farm Income by type
Now here is an idea: Agroecology in practical farming

“Our mission is to understand the ecological mechanisms that deliver sustainable crop production” - Rothamsted

“Fundamentally, you should think of weeds as an indicator and to me black-grass is an indication of cultivated, wet, anaerobic, sour soils, so we have to change these characteristics.”

“Poor soil health is contributing to the development of serious black-grass problems on many farms.”

• Cultivation and crop residue strategies can help

“If you want long-term control, you need to change the environment you have created, because at the moment, we have an environment which is fantastic for growing black-grass.”

Source: http://www.rothamsted.ac.uk/agroecology. www.fginsight.com
## Rotations and Blackgrass

<table>
<thead>
<tr>
<th>Traditional UK Rotation</th>
<th>AD Crop Rotation - Pure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
<td><strong>Crop</strong></td>
</tr>
<tr>
<td>W.Wheat</td>
<td>Maize (Corn)</td>
</tr>
<tr>
<td>Aug-Sept</td>
<td>April-May</td>
</tr>
<tr>
<td>August</td>
<td>Sept-Oct</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>Rye (Not heavy soils)</td>
</tr>
<tr>
<td>August</td>
<td>October</td>
</tr>
<tr>
<td>July</td>
<td>July</td>
</tr>
<tr>
<td>W.Wheat</td>
<td>Italian Ryegrass or Festulolium</td>
</tr>
<tr>
<td>Aug-Sept</td>
<td>July /August</td>
</tr>
<tr>
<td>August</td>
<td>April-May</td>
</tr>
<tr>
<td>W. Beans</td>
<td>Or. W. Wheat</td>
</tr>
<tr>
<td>Oct - Nov</td>
<td>Aug/Sept</td>
</tr>
<tr>
<td>August - Sept</td>
<td>August</td>
</tr>
<tr>
<td></td>
<td>Or. S. Rye</td>
</tr>
<tr>
<td></td>
<td>March</td>
</tr>
<tr>
<td></td>
<td>July/August</td>
</tr>
</tbody>
</table>

**Summary:** 3 crops /2 years - Keep the ground covered.  
Prevent Blackgrass Maturity.  
Fungicide and herbicide savings!
### Survival Rates of Seeds and Organisms in MAD

<table>
<thead>
<tr>
<th>Organism</th>
<th>Pasteurisation 70°C</th>
<th>MAD 37.5°C</th>
<th>Stored in digestate at 7-11°C</th>
<th>Detection method(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato seed (Lycopersicum esculentum) cv Ailsa Craig</td>
<td>1 hour</td>
<td>Still viable at 6 days</td>
<td>Still viable at 10 days</td>
<td>Tetrazolium staining</td>
</tr>
<tr>
<td>Black grass seed (Alopecurus myosuroides)</td>
<td>1 hour</td>
<td>5 days</td>
<td>Still viable at 10 days</td>
<td>Tetrazolium staining</td>
</tr>
<tr>
<td>Phytophthora infestans</td>
<td>1 hour</td>
<td>1 day</td>
<td>1 day</td>
<td>Culture</td>
</tr>
<tr>
<td>Phytophthora cinnamomi</td>
<td>1 hour</td>
<td>1 day</td>
<td>5 days</td>
<td>Culture</td>
</tr>
<tr>
<td>Phytophthora nicotianae</td>
<td>1 hour</td>
<td>1 day</td>
<td>5 days</td>
<td>Culture</td>
</tr>
<tr>
<td>Fusarium culmorum</td>
<td>1 hour</td>
<td>1 day</td>
<td>5 days</td>
<td>Culture</td>
</tr>
<tr>
<td>Fusarium oxysporum f. sp. radicis lycopersicae</td>
<td>1 hour</td>
<td>1 day</td>
<td>5 days</td>
<td>Culture</td>
</tr>
<tr>
<td>Plasmodiophora brassicae</td>
<td>1 hour</td>
<td>1 day</td>
<td>6 days</td>
<td>PCR, Bioassay, Bioassay+PCR</td>
</tr>
</tbody>
</table>

Source: Christine Henry et al 2005, Impacts of Pasturization and AD on some common pests and disease in the UK. WRAP.
Benefits brought to rotation by compost

‘Use solid digestate before the rye, also on hungry fields or unstructured soils’

‘Start of consistent upward yields’

% change in soil organic matter
Benefits brought to rotation by Compost / Digestate

“Saving per unit of N in your system from using digestate”

Ans = “0.26p/KgN” (52p/unit)

Average winter cereal yields over 3 years using different composts/digestate
Soils are most susceptible to erosion when left exposed

- Maize is slow to develop groundcover after sowing
- When maize crops mature in late summer and early autumn, they take in fewer nutrients - that is when you risk losing precious nitrogen to the ground water below.
- **BUT**, not if you have a well-established catch crop of grass beneath your maize
- Grass reduces nitrogen loss and provides a level of erosion control after your maize harvest
Yield of Maize with undersown grass

<table>
<thead>
<tr>
<th>Catch crop</th>
<th>Seeding time</th>
<th>Seeding method</th>
<th>Maize yield per ha</th>
<th>Kg N per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ton dry matter</td>
<td>DM, relative</td>
</tr>
<tr>
<td>No catch crop</td>
<td></td>
<td></td>
<td>15,10</td>
<td>100</td>
</tr>
<tr>
<td>Perennial ryegrass, late Jumbo</td>
<td>Early</td>
<td>Row</td>
<td>14,88</td>
<td>99</td>
</tr>
<tr>
<td>Cocksfoot, late Donata</td>
<td>Early</td>
<td>Row</td>
<td>14,79</td>
<td>98</td>
</tr>
<tr>
<td>Tall fescue, late Jordane</td>
<td>Early</td>
<td>Row</td>
<td>15,17</td>
<td>100</td>
</tr>
<tr>
<td>Perennial ryegrass, late Jumbo</td>
<td>Late</td>
<td>Row</td>
<td>14,97</td>
<td>99</td>
</tr>
<tr>
<td>Cocksfoot, late Donata</td>
<td>Late</td>
<td>Row</td>
<td>14,90</td>
<td>99</td>
</tr>
<tr>
<td>Tall fescue, late Jordane</td>
<td>Late</td>
<td>Row</td>
<td>15,40</td>
<td>102</td>
</tr>
<tr>
<td>Cocksfoot, late Donata</td>
<td>Early</td>
<td>Broad-cast</td>
<td>14,84</td>
<td>98</td>
</tr>
</tbody>
</table>

*LSD*  
0,38 2,5 ns  

*above ground*  

Source: www.dlf.com
Benefits of AD summary. Before and after crop based.

- Improved Slurry Handling & Management
- Target crop nutrients & NUE (Nitrogen use efficiency)
- Increased spreading windows
- Less crop taint & re-grazing times
- Odour reduction, ammonia, GHG
- Less reliance on fossil based fertilisers
- Environmentally based farm diversification
- Less land fill, GHG
- Less risk of water pollution
- Less Carbon Footprint

Source: A Review of Anaerobic Digestion Plants on UK Farms - Barriers, Benefits and Case Studies Supporting Sustainable Agriculture Angela Bywater. RASE.
Summary; with Crop based addition to AD

• Improved sustainability with better gas yield
• Increased rotational options for crops, plus 3 crops/year equals less land use per M³
  Reduced weed control cost - especially resistant weeds. “40-50% saving”!!
• Increasing OM and yield
• Possibly reduced fungicide cost - whole crop
• Sustainable income
• Better wildlife habitat? (CG)
• Improved soil structure
• Improved digestate usage (CG)
• OM + Structure gives greater workability
  • More worms
  • Greater Water Holding Capacity

“We used to grow mainly wheat, oilseed rape, beans and barley on our 1600 acres but the new crop has opened up a new market for growing a wider variety of crops”

“This opportunity allows us to grow crops at a known market value, We are not as susceptible to world trends and market fluctuations, as we know what we will get per tonne from the plant”

www.agritradenews.co.uk
AD

“a path forward in sustainable farming”

Thank you
References

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