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.

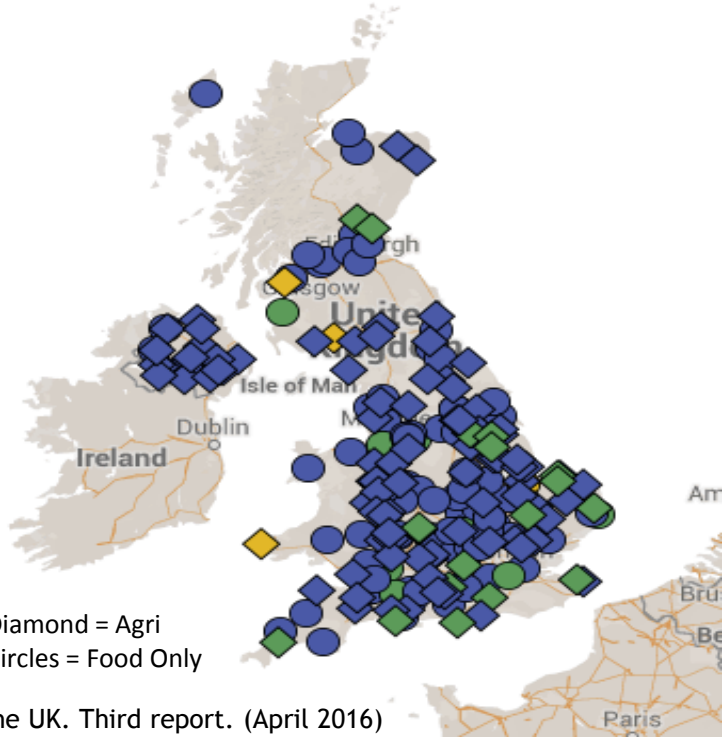
The subsequent effects on soil health, crop rotations and weed management experienced, including the effect of blackgrass seeds in the AD system will be commented on.

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

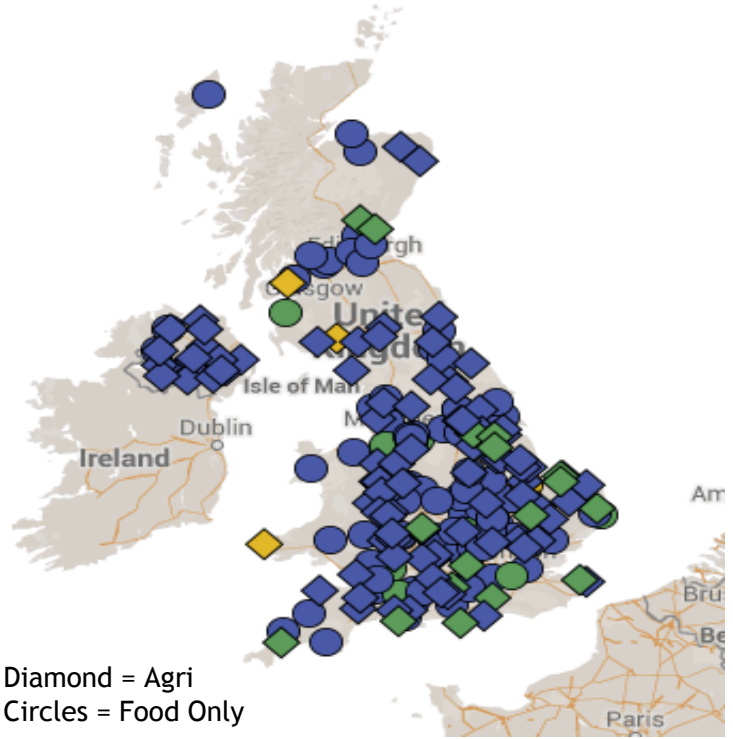


Diamond = Agri
Circles = Food Only

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?



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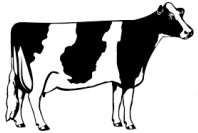
Source: NNFCC National Non Food Crop Centre – Anaerobic digestion deployment in the UK. Third report. April
Source: 2016 https://www.theguardian.com/environment/georgemonbiot/2014/mar/14/uk-ban-maize-biogas

A few timelines

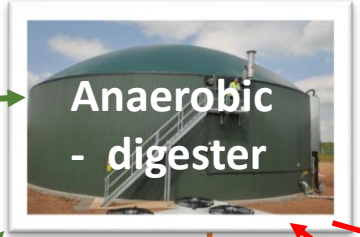
- 2005 Kyoto: The **Kyoto** Protocol is an international treaty which extends the 1992 United Nations Framework Convention on **Climate Change** (UNFCCC) that commits State Parties to reduce greenhouse gas emissions

- 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

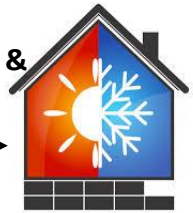
Pasturisation

Food & food waste

Gas Scrubber

POWER

HEATING & Cooling



Bio fuel inclusion

GAS

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

Energy yield from 1m³ biogas

	Energy Value
1m³ biogas	23 MJ
Electricity only	1.7 kWh
Heat only	2.5 kWh
CHP of biogas	1.7 – 2.0 kWh

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

KWS Silage Harvest

NNFCC: National Non Food Crop Centre / Agritrade News

Biogas output from different feedstocks

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

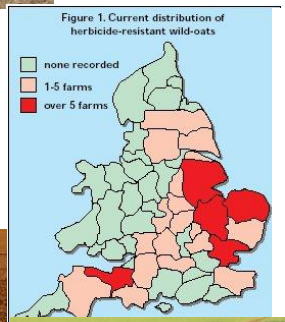
Biogas Output from Various Feedstocks

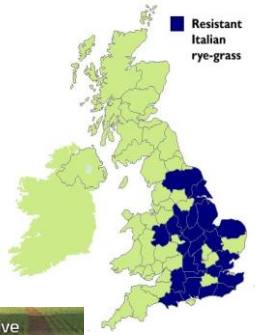
Feedstock	Feedstock biogas yield (m^3 per tonne)	Equivalent value (£ per tonne)
Cattle slurry	15-25	4.00-6.00
Pig slurry	15-25	4.00-6.80
Poultry	30-100	8.10-27.00
Maize silage	200-220	54.40-60.00
Grass silage	160-200	43.50-54.40
Whole crop wheat / Sugar beet	170-190	50.00-60.00
Crude glycerine	580-1000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

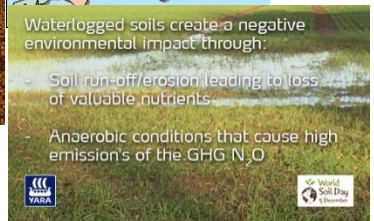
Source: DARD: Anaerobic Digestion – Production of Biogas

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

Steve Townsend

“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

Traditional UK Rotation

Crop	Sow	Harvest
W.Wheat	Aug-Sept	August
Oilseed Rape	August	July
W.Wheat	Aug-Sept	August
W. Beans	Oct - Nov	August - Sept

AD Crop Rotation - Pure

Crop	Sow	Harvest
Maize (Corn)	April-May	Sept-Oct
Rye (Not heavy soils)	October	July
Italian Ryegrass or Festulolium	July /August	April-May
Or. W. Wheat	Aug/Sept	August
Or. S. Rye	March	July/August

Summary: 3 crops /2 years - Keep the ground covered.
Prevent Blackgrass Maturity.
Fungicide and herbicide savings!

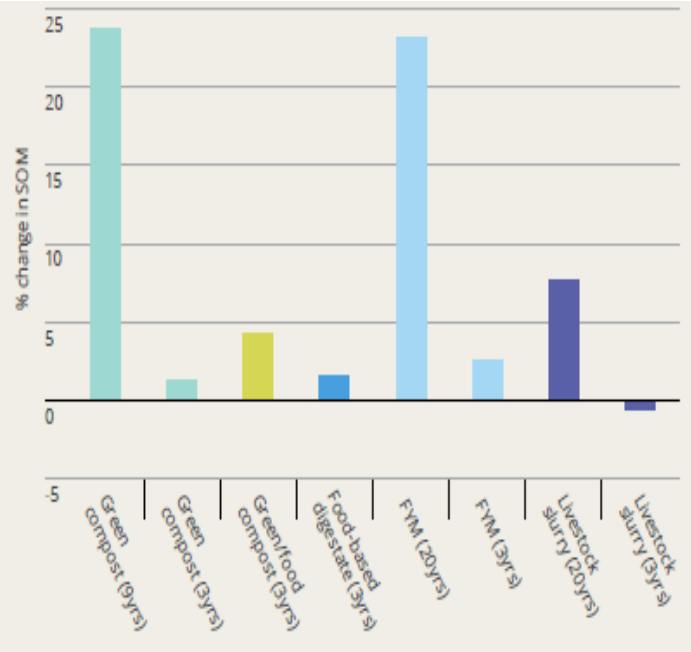
Survival Rates of Seeds and Organisms in MAD

Time after which levels of inoculated organisms dropped below detection limits (LOD). Batch AD results

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

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



% change in soil organic matter

b) Nutrient boost from organic materials

Composts and digestates provided an additional source of phosphate, potash and sulphur, providing a 'nutrient boost' early in the season which resulted in higher crop yields in comparison with crops grown only with bagged fertilisers. This is particularly important on shallow soils over chalk and limestone where it can be difficult to reach and maintain target phosphorus levels, soils with a low nutrient status or soils susceptible to sulphur deficiency.

This benefit was valued at £55-£160/ha, taking into account the value of bagged fertiliser saved and the cost of spreading (but not sourcing) the organic materials. It also demonstrated the value of an integrated nutrient management plan, using compost or digestate and manufactured fertiliser together. Benefits were also measured for crops grown using other organic materials.

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

'Start of consistent upward yields'

Benefits brought to rotation by Compost / Digestate

"Saving per unit of N in your system from using digestate"

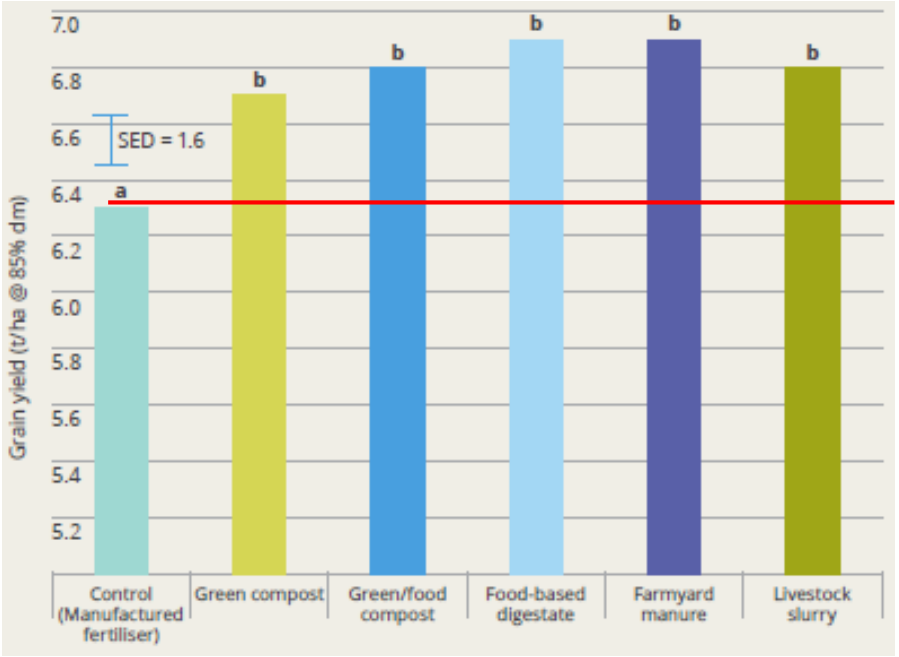
Ans = "0.26p/KgN" (52p/unit)

a) Digestate as a nitrogen fertiliser

Food-based digestate is an effective renewable fertiliser supplying readily available nitrogen. Nitrogen is the single most important nutrient influencing crop yields. It is important to provide farmers with the information necessary to quantify how much crop available nitrogen will be provided by digestate.

Indicative nutrient contents for food-based digestate

Dry matter content	4%
Nitrogen (N)	5 kg/t
Readily available N	4 kg/t
Phosphate (as P_2O_5)	0.5 kg/t
Potash (as K_2O)	2.0 kg/t
Magnesium (as MgO)	0.1 kg/t
Sulphur (as SO_3)	0.4 kg/t



Average winter cereal yields over 3 years using different composts/digestate

AD Problems – soil erosion-Why sow grass beneath maize?

- 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

THREE YEAR´S RESULTS 2012-2014 (8 TRIALS)							
			Maize yield per ha			Kg N per ha	
Catch crop	Seeding time	Seeding method	Ton dry matter	DM, relative	NEL 20 Crop units	Harvested in maize whole crop	Harvested in catch crop*, November
No catch crop			15,10	100	119,8	179	-
Perennial ryegrass, late Jumbo	Early	Row	14,88	99	117,2	171	9,2
Cocksfoot, late Donata	Early	Row	14,79	98	116,6	175	6,2
Tall fescue, late Jordane	Early	Row	15,17	100	121,1	177	6,1
Perennial ryegrass, late Jumbo	Late	Row	14,97	99	118,3	172	5,2
Cocksfoot, late Donata	Late	Row	14,90	99	118,0	176	3,4
Tall fescue, late Jordane	Late	Row	15,40	102	121,7	177	2,8
Cocksfoot, late Donata	Early	Broad-cast	14,84	98	117,3	171	4,5
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 M^3**

  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

cgamble@dlf.co.uk

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