Crops for biogas production; yields, suitability and energy balances

Dr. Andrew Salter
University of Southampton, UK

15th European Biomass Conference
Berlin 8th May 2007
Workshop 2 – Biogas: Energy throughout the whole world
overview

which crop should I grow?

• methane potentials
• crop yields
• crop criteria
• digestate
• energy balances
• legislation
which crop should I grow?

- want maximum methane yield per hectare of crop

\[
\text{yield of methane / ha} = \text{methane potential} \times \text{crop yield} \times \text{methane yield/kg ODM} \times \text{yield of ODM/ha}
\]
crop yields

• vary according to:
  – geographical location
    • climate
    • soil type
  – growth stage at time of harvest
yields (MT/ha)

wheat

maize

(data source FAO/AGLL)
growth stage at harvest

need to consider:
• total biomass yield
• moisture content
• storage
• lignin
• digestibility
• following crop

crop criteria

- annual vs perennial
- mono crops
- mixed crops and crop rotations
- digestibility
annual vs perennial

- annual crops
  - planted and harvested every year
  - e.g. wheat, maize, sugar beet, beans, sunflowers

- perennial crops
  - planted one year, harvested over a number of years
  - e.g. perennial ryegrass, miscanthus
mono crops

- one crop species grown year after year
- mostly annual - sown and harvested in the same 12 month period
- can be grown in as little as 3 months
- e.g. wheat, maize, rice
effects of mono cropping

- high nutrient requirement
- build up soil borne pests and diseases
- bare soil
  - nutrient run off
  - erosion
- nutrient depletion
- damage to soil structure
- diversity of plant and animal life
multiple cropping systems

- crop rotations
- inter crops
- undersown crops
- legume mixes e.g. vetch/oats, beans/wheat

- increase crop production through the use of multiple crops per year
crop rotations

mono-crop
wheat  wheat  wheat  wheat  wheat  wheat

2 year rotation
maize  soybean  maize  soybean  maize

4 year rotation
wheat  barley  oilseed  clover  wheat

year 1  year 2  year 3  year 4  year 5

a crop rotation for energy

winter wheat  forage rye  maize  wheat

Oct  Aug  Sept  March  April  Oct
## Crops for Biofuel Production

### For Biodiesel
- oilseed rape
- sunflower
- linseed
- soya
- peanut

### For Bioethanol
- wheat
- sugar beet
- maize
- sugar cane

### For Biogas
- barley
- cabbage
- carrot
- cauliflower
- clover
- elephant grass
- flax
- fodder beet
- giant knotweed
- hemp
- horse bean
- Jerusalem artichoke
- kale
- lucerne
- lupin
- maize
- marrow kale

- meadow foxtail
- miscanthus
- mustard
- nettle
- oats
- pea
- potato
- rape
- reed canary grass
- rhubarb
- ryegrass
- sorghum
- sugar beet
- triticale
- turnip
- verge cuttings
- fetch
- wheat

---

IEA Bioenergy

15th European Biomass Conference
Berlin 8th May 2007
energy balances

crop production
digestion
digestate disposal
crop production

- fuel
- fertiliser & pesticides
- equipment
- irrigation
- labour

– direct and indirect energy requirements
energy requirements in crop production

---

IEA Bioenergy

15th European Biomass Conference
Berlin 8th May 2007
digestion process

digester

electricity

heat

biogas

digestate
energy requirements

forage maize

crop production 27%
fertilizer 29%
parasitic heat 22%
parasitic electricity 4%
embodied in digester 14%
digestate disposal 3%
crop transport 1%
digestate

- contains most of the nutrients from the original feedstock
- improved nutrient availability
- can be separated into liquid and solid components
- high fertiliser value
digestate as fertiliser

**mineral fertiliser**
- digestate disposal: 3%
- embodied in digester: 14%
- parasitic electricity: 4%
- parasitic heat: 22%
- crop transport: 1%
- fertilizer: 28%
- crop production: 33%
- 14% parasitic heat
- 27% parasitic electricity
- 17% embodied in digester
- 14% digestate disposal
- 3% crop transport
- 1% fertilizer
- 28% crop production
- 28% parasitic heat
- 22% parasitic electricity
- 19% embodied in digester
- 4% digestate disposal
- 4% crop transport
- 4% fertilizer
- 37% crop production

**50% N from digestate fertiliser**
- digestate disposal: 3%
- embodied in digester: 17%
- parasitic electricity: 5%
- parasitic heat: 27%
- crop transport: 1%
- fertilizer: 33%
- crop production: 33%
- 29% parasitic heat
- 6% parasitic electricity
- 19% embodied in digester
- 3% digestate disposal
- 1% crop transport
- 14% fertilizer
- 37% crop production

**100% N from digestate fertiliser**
- digestate disposal: 4%
- embodied in digester: 19%
- parasitic electricity: 6%
- parasitic heat: 29%
- crop transport: 1%
- fertilizer: 4%
- crop production: 37%
- 1% parasitic heat
- 6% parasitic electricity
- 19% embodied in digester
- 4% digestate disposal
- 1% crop transport
- 4% fertilizer
- 37% crop production

**Energy requirement per hectare**
- mineral fertiliser: [Data]
- 50% digestate: [Data]
- 100% digestate: [Data]
CO$_2$ and carbon sequestration

- minimising fossil fuel use minimises CO$_2$ released
- perennial crops increase soil sequestration of carbon
- in a crop based AD system CO$_2$ released is CO$_2$ absorbed by the plants
legislation

- slurry and digestate storage and application
- subsidies, single area payment
- set-aside
- animal by-products
- waste and waste disposal
conclusion
– which crop should I grow?

• simplest answer is – the one that gives the best yield
• there is no single ‘best crop’
• what grows best in your fields?
• what will give the most sustainable crop production
• need to consider economics vs global impacts
Thank you

www.cropgen.soton.ac.uk

coop-funded by the European Commission within the Sixth Framework Programme