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Biogas from Energy Crops – Preliminary Results of Biomass Storage and Pre-treatment under Northern Conditions

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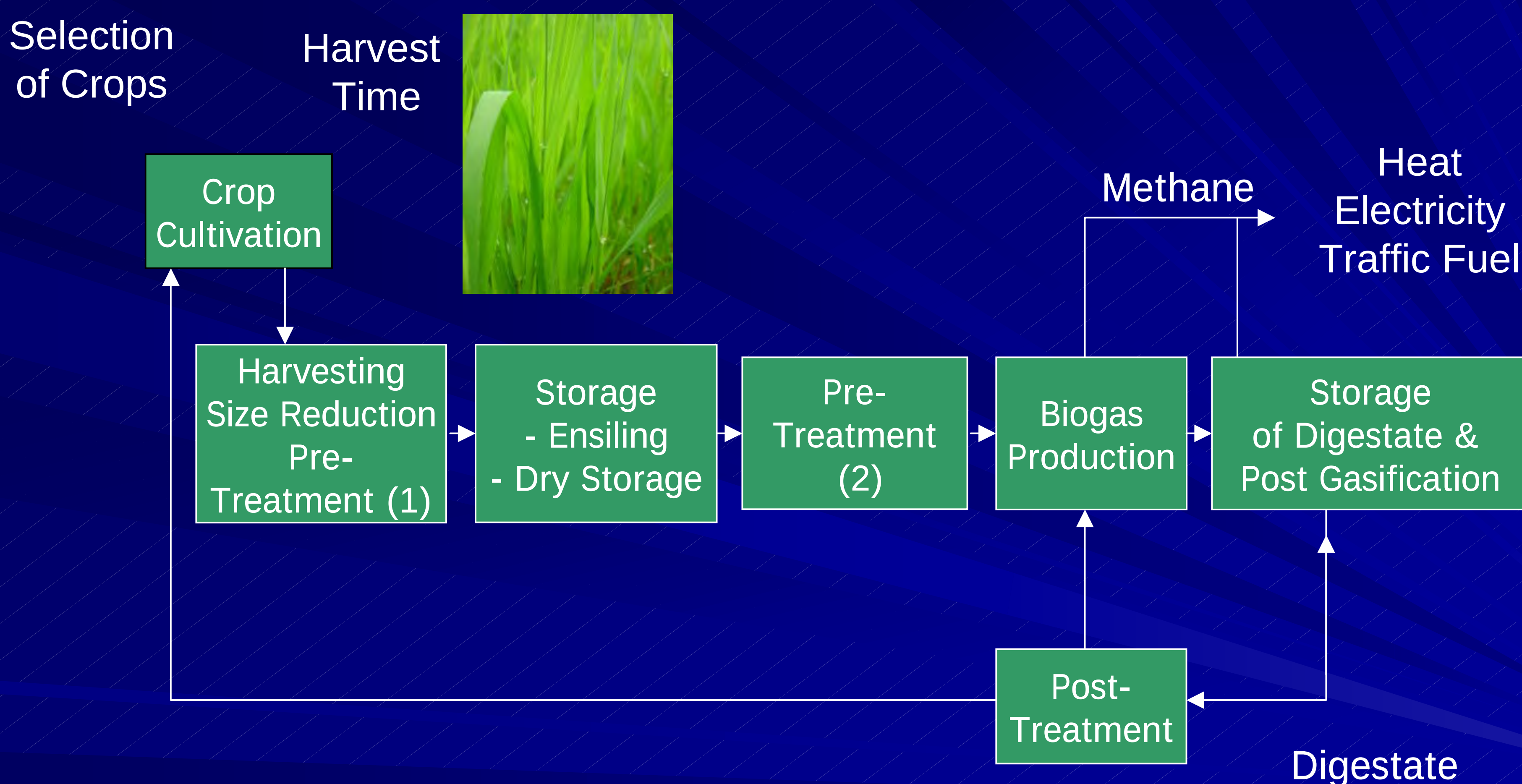
Methane from Energy Crops



Reasons for Pre-storing Biomass for Biogas Production

- Short cultivation periods, storage needed up to 8 months
- Optimal methane yields per hectare with several harvesting times (methane yield / VS, biomass production per hectare)
- Energy produced when most optimum / needed

Methods for Pre-storing Biomass

- Aiming at low CH_4 potential losses (VS losses (non-structural carbohydrates))
- Storage as a pre-treatment: improving methane yields and methane production rates
- Simple and low cost techniques and management
- Potentially different options (scale) for
  - farm-scale vs. centralised digesters
  - co-digesting vs. crop digesting plants
  - dry vs. wet processes

Post-storing Digested Biomass for Biogas Production

- Reasons for (covered) post-storing digested biomass
  - Only short periods (3-4 months) potential for land application
  - No other use for the digestate than land application
  - Recovery of remaining methane potential, prevent methane losses / emissions
- Post-storing digested biomass
  - Up to 8-9 months, sufficient capacity
  - Simple and low cost structures at ambient temperatures
  - Stimulate methane recovery:
    - Post-treatment before post-storage
    - Low cost passive heating systems to increase temperature
  - Different options for farm-scale vs. centralised digesters and for co-digesting vs. crop digesting plants

Storage of Crop Biomass

- Traditional methods: drying, ensiling
- Drying

  High losses of organic matter, subjectivity to weather conditions, dry material not suitable for biogas production

- Ensiling: soluble carbohydrates contained in plant matter undergo lactic acid fermentation:→ pH drop → Inhibition of growth of detrimental micro-organisms
- The process can be controlled by
  - Preventing the growth of all micro-organisms (e.g. acids)
  - Stimulating the growth of lactic acid bacteria (e.g. bacterial inoculum or enzymes)

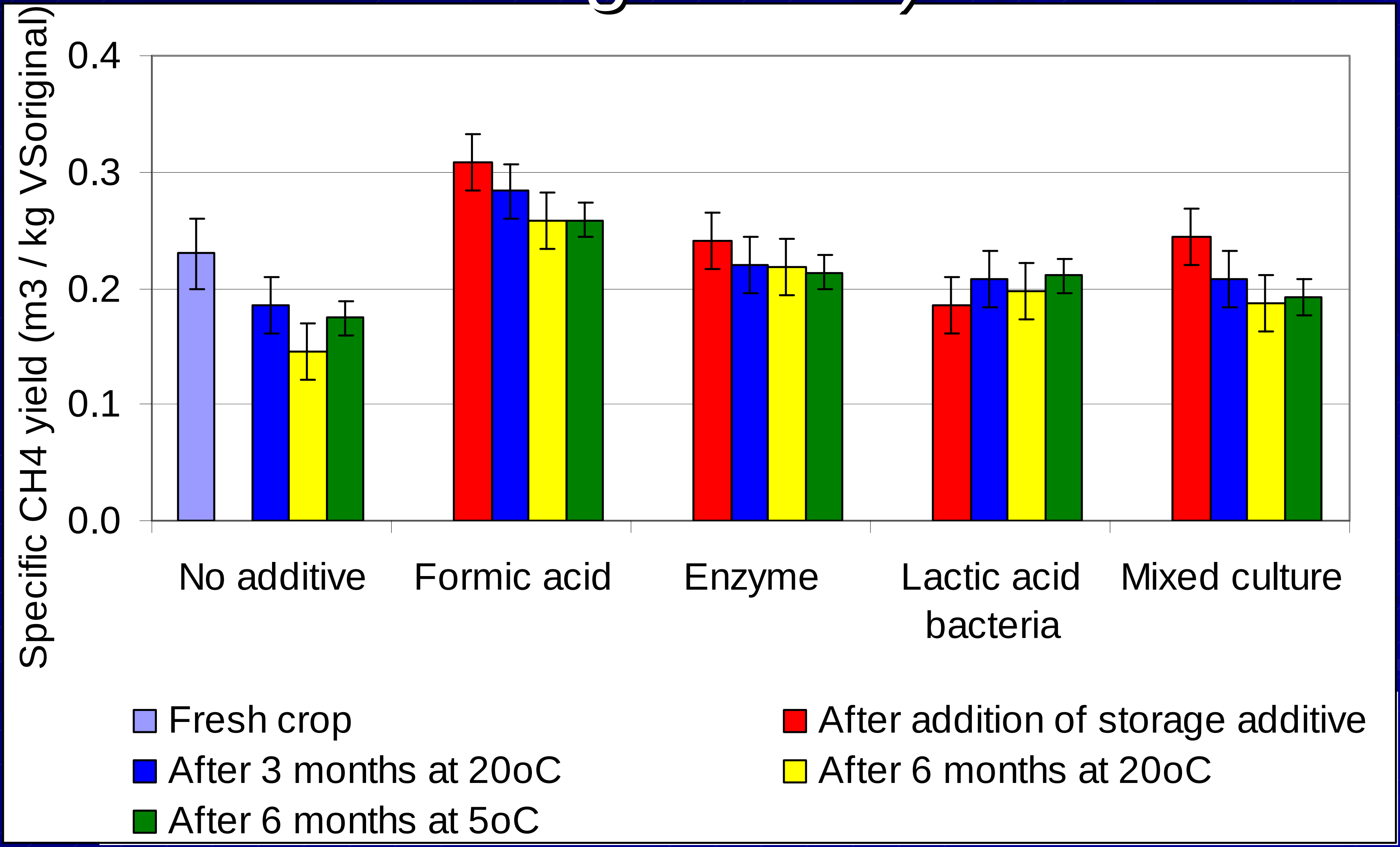
Storage trials

- Storage of timothy-clover grass and rye grass as silage in bales for 3-8 months in field conditions with and without additives
- Systematic follow-up of the chemical characteristics, CH_4 potential and mass
- Finally, after 6-8 month storage co-digested with manure in farm digester

Storing – laboratory studies

- Grass (75 % timothy *Phleum pratense,* 25 % meadow fescue *Festuca Pratensis*), 30 % TS, VS/TS 0,9, lignin 15 % of TS, 0.23 m^3CH_4/kgVS, 64.2 m^3CH_4/tFW
- Stored in 5 L laboratory silos for 3 months at 20ºC, and for 6 months at 20 and 5 ºC without and with additives:
  - Formic acid
  - Enzymes
    - - Xylanases and cellulases
  - Lactic acid bacteria
    - *- Lactobacillus rhamsonus* and *Propionibacterium freudenreichii*
  - Mixed culture from a farm biogas reactor

Specific methane yields (per original VS)



Storing Grass - Results

- Storage without additives led to losses of 17-39 % in methane potential.
- Most additives increased the initial methane yields (partially acting as substrate) and decreased the methane potential losses during storage.
- Without additives storage time (3-6 months) and temperature (5 -20°C) had major impacts on methane potential, but not with additives.

Pre- /Post -treatment of Energy Crops

- Objectives:
  - Increase methane yields or / and methane production rates:
    - in biogas digesters: 35°C, HRT 20-40 days
    - during post-storage/methanation (several months at 5-20°C)

- Impacts:
  - Increasing available surface area for microbial action
  - Breaking polymeric chains to more easily accessible soluble compounds

    Promoting subsequent biodegradation

Pre-treatment Laboratory Trials

- Substrate: timothy-clover grass (also tops of sugar beets, straw)
- Physical
  - autoclaving, water incubation
- Biological
  - enzymes, composting, white-rot fungi
- Chemical
  - Alkalis (NaOH, $Ca(OH)_2$+Na_2CO_3), peracetic acid

Pre-Treatment Results

- Alkali treatments (NaOH, $Ca(OH)_2$ $+Na_2CO_3$)
  – 15 % increase in CH_4 yields
- Physical, biological, peracetic acid treatment
  – High losses of organic matter
  – No increase in methane yield

Publications

- Lehtomäki, A., Ronkainen, O. & Rintala, J. 2005: Developing storage methods for optimised methane production from energy crops in northern conditions. Proc. 4th International Symposium on Anaerobic Digestion of Solid Waste, 31.8.-2.9.2005, Copenhagen, Denmark, p. 101-108.
- Lehtomäki, A., Ronkainen, O., Viinikainen, T., Alen, R. & Rintala, J. 2005: Factors affecting methane production from energy crops and crop residues. Proc. 8th Latin American Workshop and Symposium on Anaerobic Digestion, 2.-5.10.2005, Punta del Este, Uruguay.
- Lehtomäki, A., Viinikainen, T. A., Ronkainen, O. M., Alen, R. & Rintala, J. A. 2004: Effect of pre-treatments on methane production potential of energy crops and crop residues. Proc.10th World Congress on Anaerobic Digestion, 29.8.-2.9.2004, Montreal, Canada, p. 1016-1021.
- Lehtomäki, A., Viinikainen, T., Alen, R. & Rintala, J. 2003: Methane production from energy crops and crop residues: Effect of harvest time and chemical composition. Proc.Int. Nordic Bioenergy Conference, 2-5 September 2003, Jyväskylä, Finland, p.198-200.
- Lehtomäki, A., Viinikainen, T. & Rintala, J. (submitted): Screening boreal energy crops and crop residues for methane biofuel production.
- Viinikainen, T., Lehtomäki, A., Ronkainen, O. & Rintala, J. (in prep.): Effect of chemical pre-treatments on anaerobic digestion of energy crops and crop residues.