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The bioenergy potential from the anaerobic digestion of switchgrass and other energy crops

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PLAN

Introduction

- What we do
- Energy crops

Objectives

Methodology

- Pre-treatments
- Methane potential

Results

- Starch crops
- Cellulosic crops (switchgrass)
- Energy yields

Conclusions

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INTRODUCTION

Who we are ¦ What we do

- Environmental Bioengineering Group → Bioenergy from organic matter → Biotechnology Research Institute → National Research Council
- Anaerobic digestion for the past 20 years: industrial wastewaters (dairy, pulp and paper, chemical), soil and groundwater decontamination (TCE), biosolids, OFMSW, manure, crops.
- Generic research, collaborative research in partnership with clients, service contracts.

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INTRODUCTION

Energy crops

- Energy crops are receiving a lot of attention for biofuels production (ethanol, biodiesel, methane).
- Production of ethanol mostly from corn; pilot-scale from lignocellulosic.
- Biodiesel: canola and soy.
- Corn silage, corn stover, wheat straw, switchgrass, *Miscanthus*…

Anaerobic digestion and energy crops:

- With anaerobic digestion, all of the carbon can be transformed into biofuel, excepted lignin. Only sugars for ethanol, only lipids for biodiesel.
- Farms: increase production of methane in manure digester.
- Biorefinery directed toward purified methane production.
- Bioconversion efficiency and the use of pre-treatments.

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OBJECTIVES

- **Evaluate different pre-treatments in order to increase the biodegradability of the crops as well as the kinetics of methane generation**

- **Assess the specific methane production from the pre-treated crops and extrapolate the yield**

METHODOLOGY

Impact of different pre-treatments:

Trying to extend the crops biodegradability, increase the conversion efficiency to obtain more methane in shorter time.

- **List of pre-treatments (mechanical, chemical, enzymatic)**
  - Chopping; blending; grinding
  - Temperature (90°C, 3h), sonication, microwave
  - Alcalinization (NaOH), 35°C, 55°C
  - Autoclave (120°C, 20 psi)
  - Enzymes: peroxidases (*Coprinus*, Lignin, Mn); pectate-lyase; poly-G

Main concern: trying to be less energy intensive than, for ex., ETOH production

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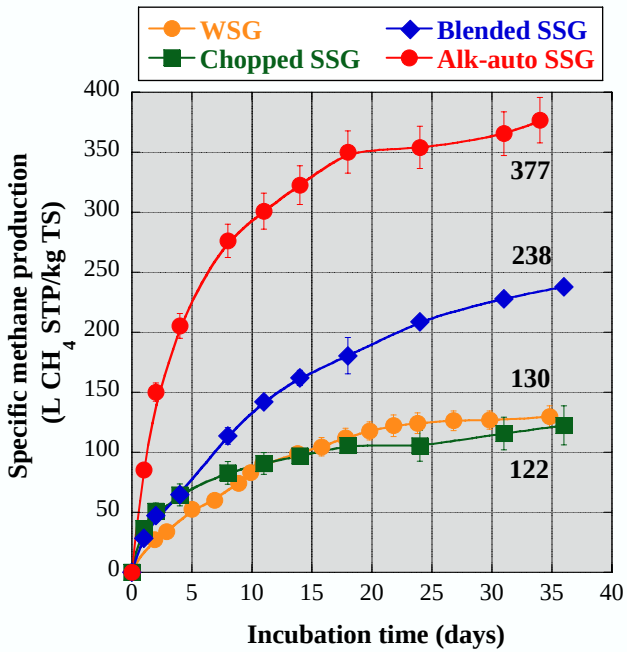
METHODOLOGY

METHODOLOGY

Methane potential evaluation



- 500 mL serum bottles
- Sealed, anaerobic conditions
- Nutrients, buffer
- 35°C; agitation

- Gas production
- Methane concentration
- pH and VFA monitoring
- TVS, VSS

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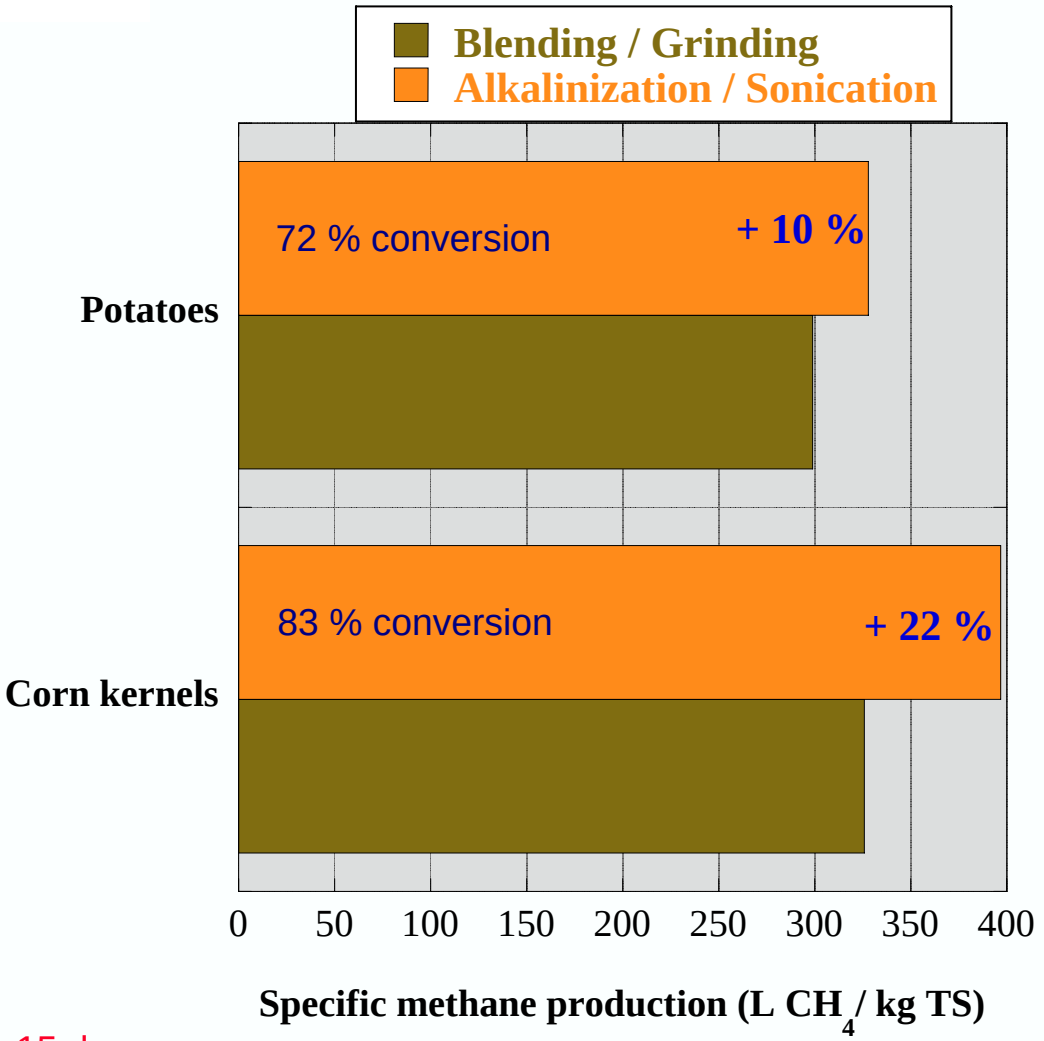
RESULTS: starch crops



15 days

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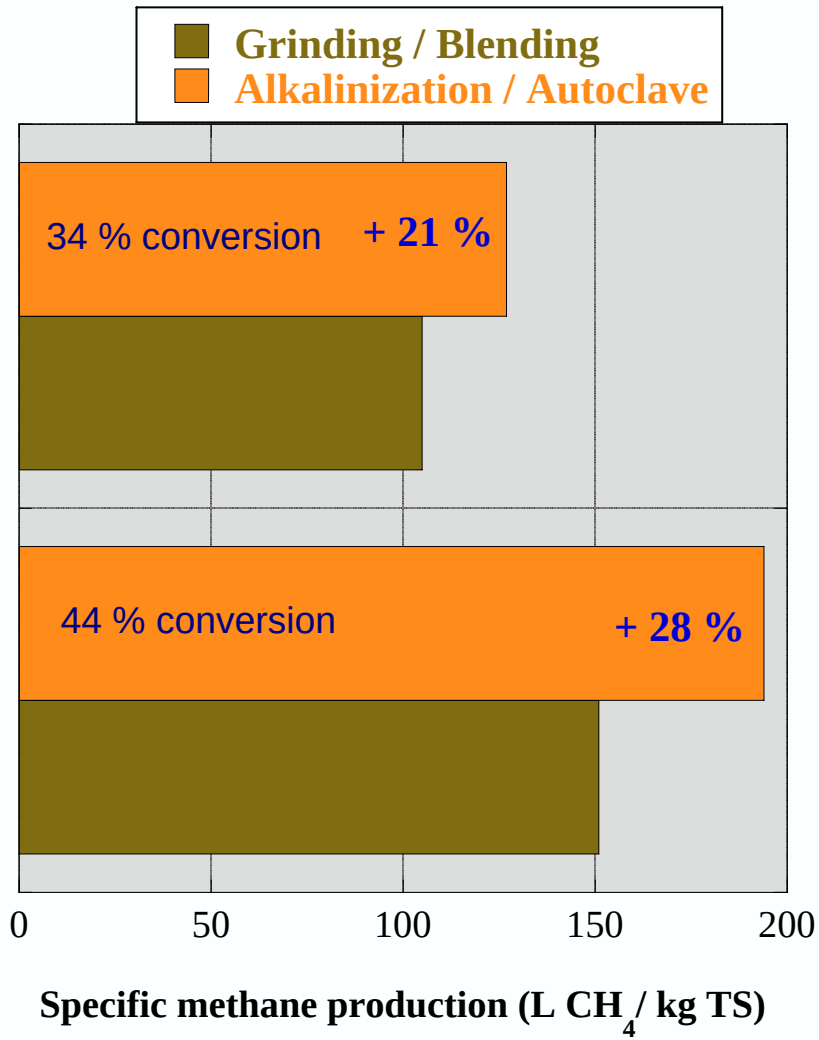
RESULTS: cellulosic crops



After 11 weeks

CS: 229 L CH_4STP / kg TS

CS-auto: 256 L CH_4STP / kg TS

35 days

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Summer switchgrass vs Dried switchgrass

Parameters	Dried SG	Summer SG
TS	961 g/kg	427 g/kg
VS	934 g/kg	396 g/kg
C:N	491:1	92:1
C:P	2344:1	624:1
Lignin	22.3 % TS	28.1 % TS
Hemi-cellulose	ND	37.4 % TS
Cellulose	ND	24.6 % TS

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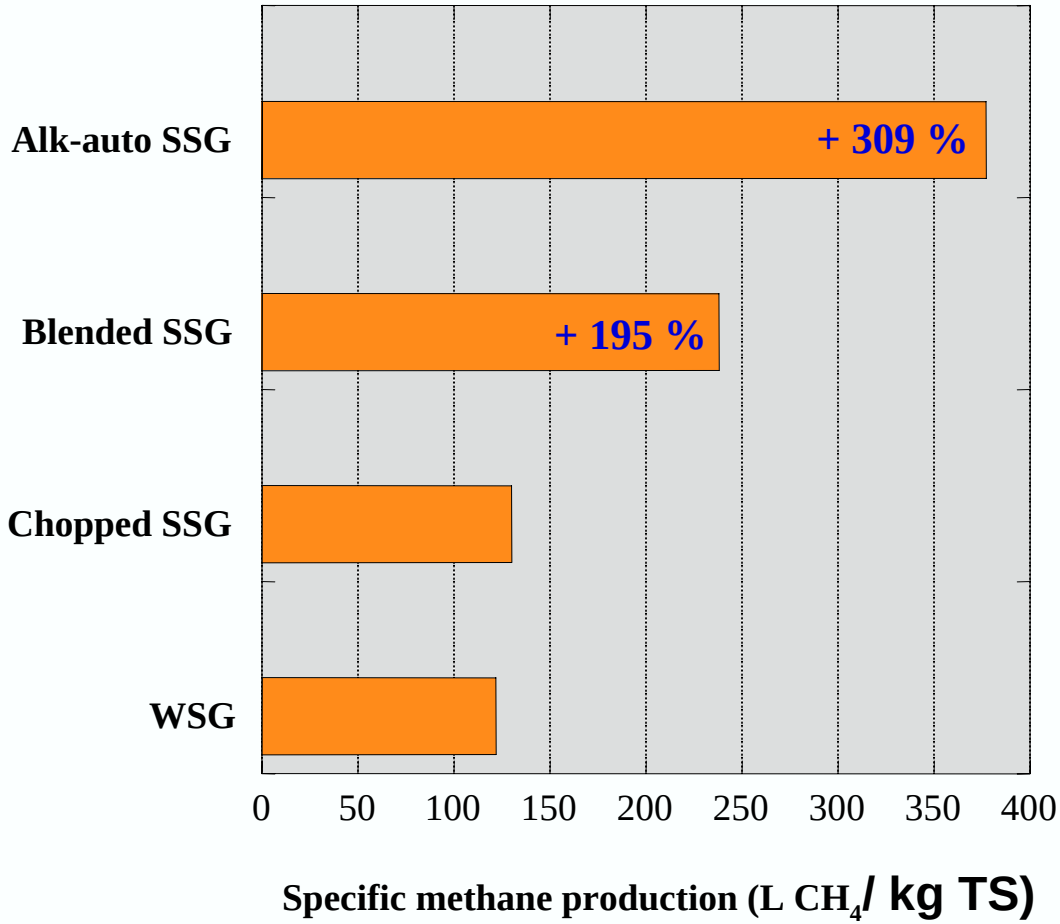
Summer switchgrass

- Better fresh than dried
- Intensive mechanical pre-treatment: 2X CH_4
- Mechanical + chemical: 3X CH_4
- Around 76% conversion: maximal theoretical yield !



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Enzymatic Peroxidases Pectate-lyase Poly-galacturonase

Enzymes	Increase in methane		Comments
	Enzyme only	Enzyme and NaOH	
Coprinus	0 %	ND	No positive effect (expected)
Lignin peroxidase	48 %	35 %	Positive effect of enzyme, no further improvement with NaOH
Manganese peroxidase	65 %	62 %	
Pectate-lyase	40 %	ND	High loading. Organic compound added.
Poly-galacturonase	78 %	ND	

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RESULTS: Yields

Yield extrapolation for the crops: approximation !

Crop	Conversion	Methane	Crop Yield	Methane Yield
	(%)	(L CH4 STP/kg TS)	(t/ha, H°)	(m^3 STP/ha)
Potatoes	72	328	50 t/ha, 80%	3280
Corn silage	44	194	40 t/ha, 60%	3104
Corn kernels	83	397	10 t/ha, 25%	2978
Summer SG	76	377	12 t/ha, 57%	1945
Winter SG	34	127	5.5 t/ha, 7%	629

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RESULTS: Yields

Energy yield: output only !

Crop	Methane Yield	Energy Yield	Energy Yield	Energy Revenue
	(m^3 STP/ha)	(GJ/ha)	(kWh/ha)	($/ha)
Potatoes	3280	113.5	8823	971
Corn silage	3104	107.4	8350	918
Corn kernels	2978	103.0	8011	881
Summer SG	1945	67.3	5232	576
Winter SG	629	21.8	1692	186

Conversion: 34.6 MJ/m^3 STP CH_4; 2.69 kWh/m^3 (28%); 11 c/kWh.

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CONCLUSIONS

- Higher potential conversion of crops into methane than other biofuels.
- Appropriate pre-treatment can triple the production of methane from cellulosic crops.
- There is a need to improve the pre-treatments: maximum impact for lowest energy & cost input, with shorter digestion time.
- Enzymatic pre-treatment, promising but more work required. Focus on competent inoculum.
- Switchgrass currently our target crop (harvest time, silaging…). Interest in other crops.

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Thank you

Questions, comments…

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