BIOCHEMICAL METHANE POTENTIAL OF FAST GROWING ENERGY FOREST

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Abstract. Biochemical methane potential from fast growing energy forest first year trees was investigated. Biogas output from different biomass was investigated in laboratory scale digesters. Biomass mixed with inoculums (fermented cow manure) was investigated for biogas production in fifteen digesters, operated in batch mode at temperature 38±1.0 ºC. Average methane yield per unit of dry organic matter added (dom) from willow Ingers was 172 $l \cdot kg_{dom}^{-1}$ and average methane (CH_4) content was 44.16 %. Average methane yield from asp was 244 $l \cdot kg_{dom}^{-1}$ and average methane content was 46.33 %. Average methane yield from poplar was 178 $l \cdot kg_{dom}^{-1}$ and average methane content was 47.38 %. Average methane yield from osier *Salix viminalis* was 163 $l \cdot kg_{dom}^{-1}$ and average methane content was 42.85 %. All investigated biomass can be cultivated for energy production in Latvia.

Keywords: biomass, anaerobic digestion, biogas, energy forest, methane.

Introduction

Latvia cannot provide the country with own produced energy and fossil energy resources are imported from other countries. There are 368500 ha of unused and bad used agriculture land in Latvia. Effective use of this land could help obtain a significant amount of energy. One of the most advanced methods of energy production from biomass is anaerobic digestion [1]. Biogas is a product of great value and its production technology does not increase carbon dioxide emission and is environmentally friendly. In recent years the biogas production is booming also in Latvia. There is a need to use different raw materials in biogas plants. Biogas potential investigation results from various biomasses are very important for calculating the right loading rate and maintaining a stable anaerobic digestion process [2]. In biogas plants, where the raw materials have high N content (as poultry manure) to stabilize the C/N ratio it would be appropriate to use raw materials with high C content [3]. Such raw material can be rapidly growing forest. This study aims to find out how much methane might be derived from the first year of energy forest biomass.

1. Willow Ingers

Materials and methods

Investigations on laboratory equipment with different raw materials were carried out using one method. The willow Ingers was used for the first investigations. It together with leaves was chopped by an electric chopper that produced 3-10 mm pieces. The average substrate was taken and the Latvia University of Agriculture, Bioenergy Laboratory determined the composition of the substrate using ISO 6496:1999. The substrates from each type of raw materials were analysed for dry matter (total solids), organic matter, ash content and chemical composition. The analysis was measured by using standardized methods [4]. All digesters were connected to the gas storage facilities and taps; the digesters were operating in batch mode. The data of gas volume and composition were registered every day. Also the digestate was weighed and the pH value, total solids (TS), ash content and organic matter composition (Dom) were determined. Fermented cow manure was used as inoculum in all 15 reactors (R1-R15). Only inoculum was filled in reactor R1 inoculum (control), which was that same for each raw material. Biogas or methane volumes obtainable from inoculum in reactor R1 inoculum were used for evaluation of net biogas or methane obtainable from the added biomass. All 15 bioreactors were positioned in a heated camera having automatic temperature control at 38±0.5 ºC. Fermentation was provided in a period up to 30 days or until no biogas was released from the reactors.

Dry matter, ashes content and pH level were measured before and after the anaerobic fermentation process. Biomass weight was measured on the scales Kern16KO2 FKB having accuracy ±0.2 g. Measurement of pH level was provided by help of equipment PP-50. By help of specialized unit Shimadzu the biomass samples were dried for moisture and total solids content at temperature 120 ºC with mass weighting accuracy ± 0.001 g. Ashes for volatile solids content evaluation were measured by help of the oven Nabertherm at temperature 550 ºC. Biogas from every reactor was guided into external storage bags for gas volume measurement and analyses of gas composition. Gas composition, e.g., methane, carbon dioxide, oxygen and hydrogen sulphide content, was measured with the gas analyser GA 2000. Standard error was estimated by help of standardized data processing tools for each group of digesters.

Results and discussion

The results of analyses of raw materials are shown in Table 1, digestate in Table 2. Biogas and methane yields are shown in Table 3 and Fig. 1.

Table 1

Raw material analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom tot., g
Willow Ingers R2 - 4	–	46.31	9.262	3.61	96.39	8.92	520	30.67
Inoculum	7.36	5.85	29.25	25.65	74.35	21.74	500	21.74

The results of digestate analysis are shown in Table 2.

Table 2

Average results of digestate analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
R2 - 4	7.25	4.02	20.62	18.16	79.84	16.47±0.25	513±0.7
Inoculum	7.99	3.77	18.54	26.87	73.13	13.56	492

Table 3

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$	Methane, %	CH4 without inoculum, l	Methane, $l \cdot g_{dom}^{-1}$ add
Inoculum	0.1	–	20.9	0.02	–
Average R2 - 4	3.47	0.388	44.16	1.53	0.172

Average methane yield was 0.172±0.011 $l \cdot g_{dom}^{-1}$

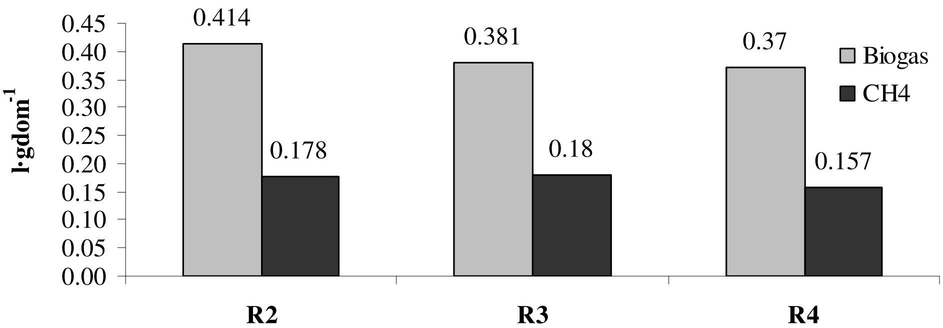

Fig. 1. **Biogas and methane $l \cdot g_{dom}^{-1}$ from willow Ingers**

In this study, the results of individual bioreactors were little change values, so it was able to fill the reactor with very similar materials and inoculum. Although the weight of the raw materials is the same, the bacterial composition and the composition of equity cannot always be achieved.

2. Asp

Materials and methods

First year chopped asp was used for the investigations. The methods and work pace are the same as described in investigation 1. 0.7 l digesters (R5-8) were filled with 20 g asp and 0.5 l inoculum.

Results and discussion

The results of analyses of raw materials are shown in Table 4, digestate in Table 5. Biogas and methane yields are shown in Table 6 and Fig. 2.

Table 4

Analyses of raw materials

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom tot., g
Asp R5-8	7.38	49.79	9.958	4.97	95.03	9.463	520.99	31.21
Inoculum	7.36	5.85	29.25	25.65	74.35	21.74	500	21.74

Table 5

Digestate analyses results

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
Asp R5-8	7.24	4.38	22.4	17.37	82.63	18.51	511.3±1.0
Inoculum	7.99	3.77	18.54	26.87	73.13	13.56	492

Table 6

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$	Methane, %	CH4 without inoculum, l	Methane, $l \cdot g_{dom}^{-1}$ add
Inoculum	0.1	–	20.0	0.02	–
Average	4.975	0.526	46.33	2.306	0.244

Average methane yield was 0.244±0.078 $l \cdot g_{dom}^{-1}$.

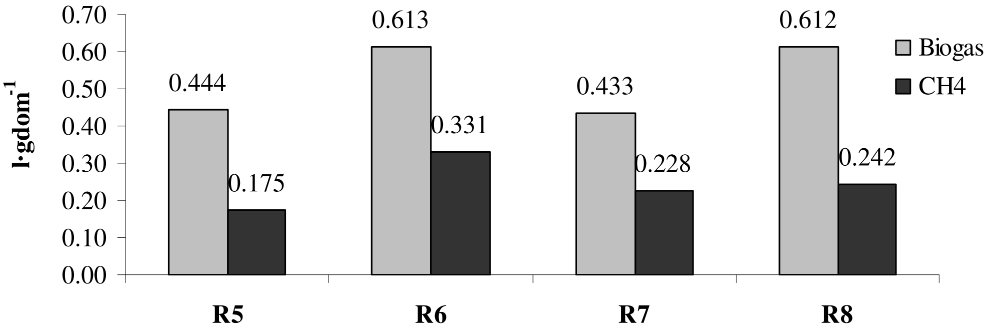

Fig. 2. **Biogas and methane $l \cdot g_{dom}^{-1}$ from asp**

3. Poplar

Materials and methods

Chopped first year poplar was used and methane potential was investigated. The methods and work pace are the same as described in investigation 1. 0.7 l digesters (R10-12) were filled with 20 g poplar and 0.5 l inoculum.

Results and discussion

The results of analyses of raw materials are shown in Table 7, digestate in Table 8. Biogas and methane yields are shown in Table 9 and Fig. 3.

Table 7

Analyses of raw materials

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom tot., g
Poplar R10-12	7.37	48.44	9.688	6.43	93.57	9.065	519.4	30.81
Inoculum	7.36	5.85	29.25	25.65	74.35	21.74	500	21.74

Table 8

Digestate analyses results

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
Poplar R7-10	7.27	3.91	19.97	20.75	79.25	15.91	510.1± 3.5
Inoculum	7.99	3.77	18.54	26.87	73.13	13.56	492

Table 9

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$	Methane, %	CH4 without inoculum, l	Methane, $l \cdot g_{dom}^{-1}$ add
Inoculum	0.1		–	0.02	–
Average	3.4	0.375	47.38	1.614	0.178

Average methane yield was 0.178±0.042 $l \cdot g_{dom}^{-1}$.

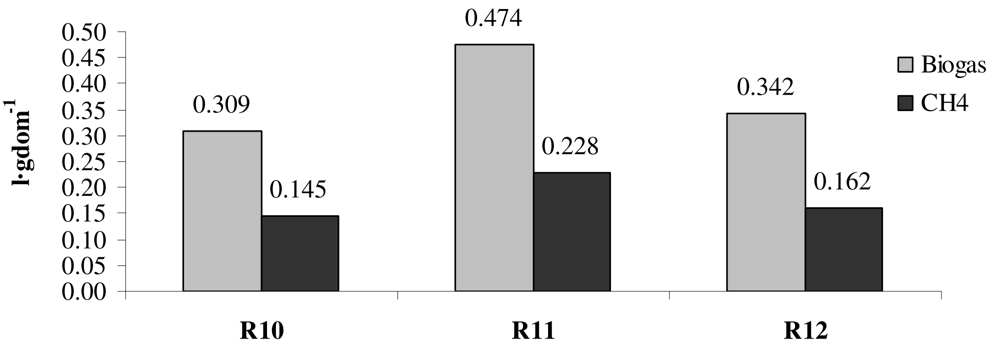

Fig. 3. **Biogas and methane $l \cdot g_{dom}^{-1}$ from poplar**

4. Osier (*Salix viminalis* L.)

Materials and methods

Chopped first year osier (*Salix viminalis* L.) was used and methane potential was investigated. The methods and work pace are the same as described in investigation 1. 0.7 l digesters (R13-15) were filled with 20 g osier Biminalis and 0.5 l inoculum.

Results and discussion

The results of analyses of raw materials are shown in Table 10, digestate in Table11. Biogas and methane yields are shown in Table 12 and Fig. 4.

Table 10

Analyses of raw materials

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom tot., g
Osier *viminalis* R13-15	7.38	47.51	9.502	4.9	95.1	9.036	520	30.78
Inoculum	7.36	5.85	29.25	25.65	74.35	21.74	500	21.74

Table 11

Digestate analyses results

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
Osier *viminalis* R13-15	7.21	4.23	21.63	17.08	82.92	17.94	511.4 ± 1.2
Inoculum	7.99	3.77	18.54	26.87	73.13	13.56	492

Table 12

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$	Methane, %	CH4 without inoculum, l	Methane, $l \cdot g_{dom}^{-1}$ add
Inoculum	0.1	–	–	0.02	–
Average R13-15	3.43	0.380	42.85	1.469	0.163

Average methane yield was 0.163±0.014 $l \cdot g_{dom}^{-1}$.

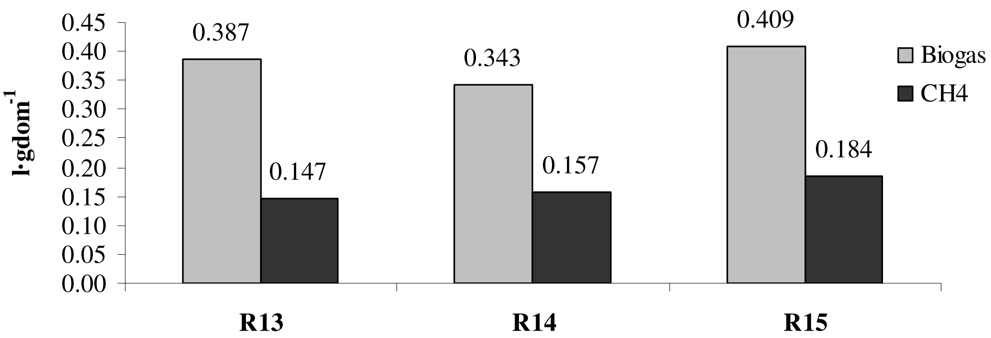

Fig. 4. **Biogas and methane $l \cdot g_{dom}^{-1}$ from osier (*Salix viminalis* L.)**

Conclusions

1. The methane yield 0.172 $l \cdot g_{dom}^{-1}$ from willow Ingers shows that it is possible to be used for the production of biogas in Latvia.
2. Asps anaerobic digestion got 0.244 $l \cdot g_{dom}^{-1}$ methane, which is a good average result. Chopped first year asp is a good raw material for biogas production.
3. Average methane yield from chopped first year poplar was 0.178 $l \cdot g_{dom}^{-1}$. It is possible to use it for biogas production.
4. Average methane yield from chopped first year osier *Salix viminalis* L. was 0.163 $l \cdot g_{dom}^{-1}$.
5. In comparison with literature data [5] (Faustzahlen Biogas KTBL, FNR 2007) the results are average.
6. The study shows that the investigated energy forest can be able to be used for production of biogas.

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