A Study on Mono- and Co-digestion of Riverbank Grass Under Anaerobic Conditions for Production of Biogas

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Abstract This paper investigates the application of riverbank grass as a potential alternative energy crop for maize silage in the production of biogas. Grass samples have been mowed on the embankments of the Sava River in the city of Zagreb, Croatia. Carbon and nitrogen content and C/N ratio have been determined in the grass samples. Further, laboratory investigations on the anaerobic mono- and co-digestion of the collected riverbank grasses with different ratios with maize silage and animal manure have been conducted. The laboratory reactors have operated under the mesophilic conditions (39 °C) with the dry matter contents of 6 %. During the anaerobic digestion process, the biogas production and composition and pH value of the reaction mixture have been monitored. Results show that the riverbank grass could serve as a (co)-substrate in the anaerobic mono- and co-digestion.

Keywords: • Anaerobic digestion • Mono- and co-digestion • Riverbank grass • Biogas production • laboratory experiment •

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1 Introduction

Anaerobic digestion is a technology of conversion of organic compounds into a sustainable source of energy, biogas and digestate (Siddique & Wahid, 2018). Any biodegradable material can be used as a substrate in anaerobic digestion. However, the focus should be put on substrates that ensure sustainable management and development, with prior characteristics like abundant quantities and non-competitiveness with the food production. As authors in the article (Meyer et al., 2016) have stated, the biogas production in Europe should be based on the use of animal manure, straw and grass as main substrates. Riverbank grass comes in abundant quantities and does not compete with production of food, and therefore it is suitable feedstock for biogas production.

The quality of grass for biogas production depends on the composition, time of harvest and particles size (Elsäßer et al., 2012). Current investigations have shown that different types of grass give different cumulative biogas and methane yields. For instance, canary grass has shown biogas yield of 406 Ndm^3/kg of volatile solids, while wild grass only 120 Ndm^3/kg of volatile solids (Oleszek et al., 2014). Such variety of results indicate that not all the grass types are equally suitable for biogas production.

The aim of this study is to investigate the possible application of fresh riverbank grass as a mono-substrate in the anaerobic digestion, and as a co-substrate together with animal slurry in the ratio 1:1 based on dry mass. Additionally, grass was mixed with maize silage at different ratios on dry basis (0.75:0.25, 0.5:0.5, 0.25:0.75) to investigate if grass could be an alternative substrate for food-competitive maize silage in the actual biogas plants. Anaerobic digestion was performed under mesophilic conditions (39 °C) and wet fermentation (6 % of dry matter content).

2 Materials and methods

Grass samples were collected on the southern embankment of the Sava River in the city of Zagreb at the end of April in 2018 (Figure 1). By the visual inspection of the riverbank grass, it has been envisaged that it belongs to a ryegrass type (*Lolium*). After the grass samples were collected, they were put in bags and stored in the fridge at low temperatures. For the purposes of the investigation, the riverbank grass stems have been cut into smaller pieces as it is shown in Figure 1.

The inoculum and maize silage were obtained from a biogas plant treating poultry manure and maize silage and operating under mesophilic conditions. Fresh cattle slurry has been collected from a small farm in a municipality of Šentilj. Before the analyses, inoculum and slurry were filtered through a coarse filter to remove large particles and to improve homogeneity. Before feeding the substrates to reactors, the substrates have been dried in triplicates to determine dry matter content of substrates.

Anaerobic digestion has been performed in 250 mL batch digesters for 42 days in a heating bath at 39 °C. All the samples have been prepared based on the average dry matter (DM) content of samples in triplicates as it is shown in Table 1. The basic medium containing salts (Angelidaki et al., 2009) has further been added to substrate mixtures to reduce the DM concentration in reactors to 6 %.

Figure 1: Collection and preparation of grass stems for analysis

Table 1: Batch assay setup of samples on dry basis (g)

	Inoculum	Grass	Maize silage	Cattle slurry
Grass	4.5	4.5	/	/
Grass-Slurry (Co1)	4.5	2.25	/	2.25
Grass-Silage-Slurry 0.75:0.25 (Co2)	4.5	1.6875	0.5625	2.25
Grass-Silage-Slurry 0.5:0.5 (Co3)	4.5	1.125	1.125	2.25
Grass-Silage-Slurry 0.25:0.75 (Co4)	4.5	0.5625	1.6875	2.25
Silage-Slurry (Co5)	4.5	/	2.25	2.25
Inoculum	4.5	/	/	/

During anaerobic digestion biogas production was measured daily, methane composition in biogas was measured five times during the process (once a week) and twice a week pH was analyzed.

3 Results and discussions

For grass samples the carbon and nitrogen contents have been determined and thus C/N ratio is calculated. C/N ratio of grass (Table 2) shows that it is suitable for biogas production in anaerobic digestion process.

Table 2: Share of carbon and nitrogen in riverbank grass expressed on dry basis

Parameters	Composition
Carbon (C)	44.7 %
Nitrogen (N)	2.18 %
C/N	20.5

Results on biogas yield and biochemical methane potential (BMP) of conducted co-digestion experiments are shown in Figures 2 and 3 where x-axis in Figure 3 represents the share riverbank grass : maize silage.

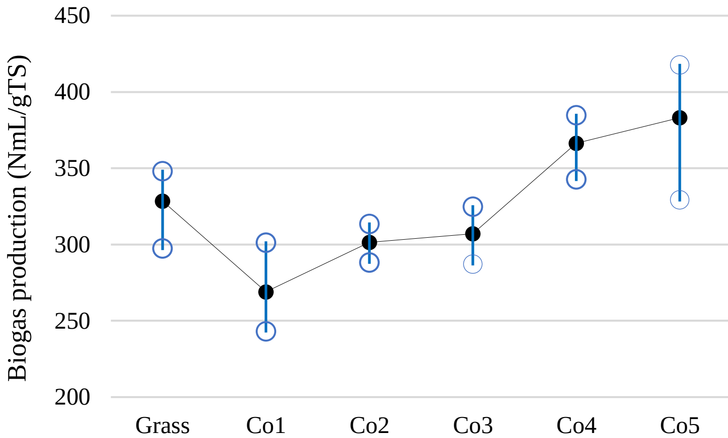

Figure 3: Cumulative biogas yield and the range of biogas production between the parallels

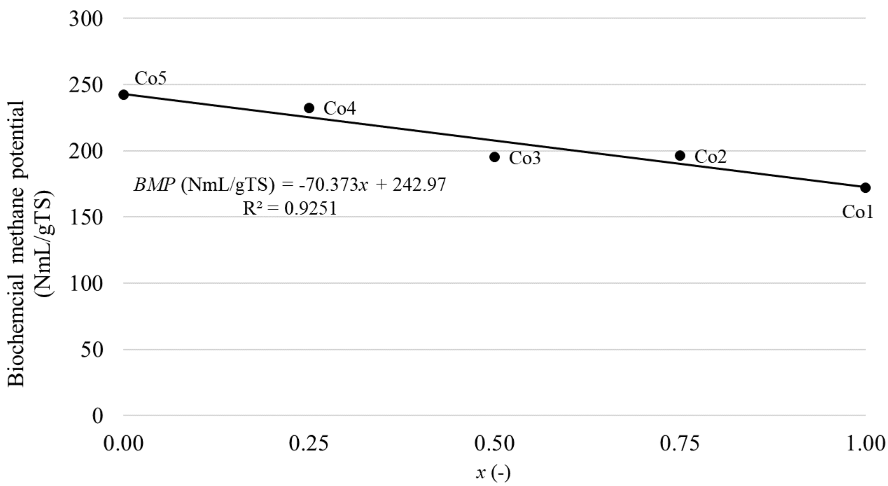

Figure 4: Impact of riverbank grass share in silage mixture on the biochemical methane potential

The highest biogas production has been obtained for co-digestion of maize silage and cattle slurry, 383.1 NmL/gTS on average, and the lowest for co-digestion of grass and cattle slurry, 269 NmL/gTS on average, see Figure 2. Monodigestion of riverbank grass has shown in total 328.5 NmL/gTS of biochemical biogas potential with methane share in biogas of ca. 59 %.

By comparing the results on biogas yield and *BMP* of co-digestions of maize silage and animal slurry (Co5), riverbank grass with maize silage and animal slurry

(Co5, Co4, Co3, Co2) and riverbank grass with animal slurry (Co1), it could be seen that adding the slurry to grass decreases the yield and *BMP*. Results show that as the share of riverbank grass in silage mixture increases, the biogas production and *BMP* decrease almost linearly. Therefore, it can be stated that more riverbank grass is required (on TS basis) compared to maize silage to maintain the same methane production in reactor under mesophilic conditions.
pH values in reactors were in the range between 7.14 and 8.2. Initially, the pH was between 7.8 and 8. In the first four days of operation the pH value has significantly decreased due to hydrolysis and generation of volatile fatty acids. After, the pH has increased and after 15th day of operation it remained almost constant (in the range of 8.08 and 8.18) until the process has stopped.

4 Conclusions

Mono- and co- digestion of riverbank grass under mesophilic conditions in a batch mode has successfully been carried out. The results obtained in this investigation point lead to the conclusion that riverbank grass has potential to serve as a co-substrate in the anaerobic digestion. Even though riverbank grass has shown lower production of biogas compared to maize silage in co-digestion with animal slurry, it is available in abundant quantities and does not compete with food and feed chains and thus could be used in biogas plants. However, in order to apply the riverbank grass at the larger scale in biogas plants, the fed-batch or semi-continuous process should be derived.

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