Determination of production of biogas of maize silage from selected hybrids

1. Introduction

The largest biogas production is achieved from the fresh biomass of plants. Fresh green matter harvest options are in the spring and summer about 2-4 months in the case of perennial forage crops and about 1 month – for annual crops such as maize. Therefore, a necessary requirement for the production of plant biomass as raw material for the production of biogas is its preservation. The best known way of preserving biomass plant for the production of biogas is silage, much like in the production of milk. According to the long-term practical experience is the best crop for producing silage – maize.

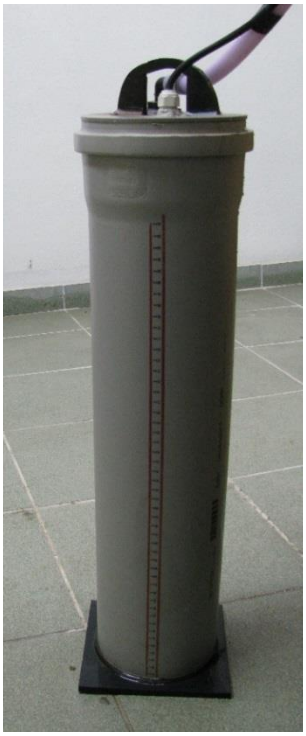
Assortment of varieties of maize is very extensive. Significantly differs yield potential of the various varieties and their quality parameters that affect the resulting value of silage. In recent years seed companies began to carry out the selection and offer specialized maize hybrids suitable for silage for subsequent production of biogas. In the Czech Republic recently, there is a system of evaluation of hybrid maize for biogas production. However, we know the equations from the literature, which provides the theoretical production of biogas by organic nutrients. At present, there are laboratory tests of gasification of vegetable biomass in mini-fermenters, that are used on different sites.

2. Brief description of the objectives and methodology of experiments

The aim of the experiments was to compare the potential of biogas production in 4 hybrids and determination of production of biogas/methane/,specifically retained the proceeds of units of area. In laboratory conditions was made from chopped straw of tracked hybrids of maize in a silage mini-silos (Photo 1, mini-silos with a capacity of 5 l). After 90 days the fermentation at a temperature of 25 ° C, were the mini-silos were opened. Were sampled for chemical analysis and produced silage was stored in plastic anaerobic mini-fermenters (Photo 2, with a capacity of 5 l)

Photo 1 plastic laboratory mini-silos for fermentation of silage, with a double bottom and weight

Photo 2 Mini- fermenter unit producing biogas with an automatic mixing device



A sample of each silage hybrid was divided into three mini-fermenters, and these were stored in a water bath with automatic control of the temperature on mesophilic temperature of 38-40 °C .The water temperature in the bath water was guarded by a thermostat with a sensitivity of plus-minus two mini-fermenters that are equipped with mechanical mixers, which are automatically switched on by using the timer (15 minutes, hourly).

From each fermentation is an emerging biogas fed into a submersible without-pressure meters with a capacity of 7 litres (Photo 3). These meters are calibrated by 1 litre and used as a temporary reservoir of created biogas. The amount of generated biogas is measured every day and then are these reservoirs emptied. At the same time they are using the Biogas analyser (Photo 4) monitored methane CH4, carbon dioxide CO2, oxygen O2. and hydrogen sulfide H2S The production of biogas and the proportion of methane in the biogas is recorded in 24 hours. intervals. These tests have been prepared in accordance with VDI 4630 methodology for comprehensive assessment of quality silage.

Photo 3 Malleable incubation vessel and collection of biogas

Photo 4 Biogas Unit on measuring the quality of biogas

The total test time was uniformly fixed for biogas production at 28 days (about 1 month). At the end of the test period for all samples was production of biogas decreased virtually to negligible levels, even when still did not stop completely. It is apparently associated with the slow fermentation of biodegradable components difficult to biomass of cellulose and hemicellulose. In the course of the experiments, the intense stage of biogas in the deduction since their start-up period (the so-called ' lag-phase) mostly took about 2-4 weeks, the ramp phase lasted about 1-5 days.

3. Results and brief assessment

Table 1 shows the results of the evaluation of the content of organic nutrients, indicators of the fermentation process and the production of biogas and methane. According to the identified indicators, it can be stated that all hybrids were harvested in the same fenofázi růsti with minimal differences in the content of dry matter silage (34.3 35.5% dry up). At the same time and pH all had the same level of silage, which is proof that all of silage were harvested in the same stage of growth and a successful fermentation in laboratory conditions. The biggest differences were detected in the starch content (up to 26.5% in 30.4 SAS.), this indicator can be taken as an indicator of the proportion of heads to the overall plant. The contents of the ADF (up to 22.5% in 27.0 SAS.) and content of NDF (44.5 51.2% in to SAS) as an indicator of the total pulp at harvest time. The content of protein and ash content had minimal differences between the hybrids, which corresponds to normal fluctuations in other hybrids. The table also lists the detected value.

Table 1 Contents of organic nutrients, fermentation and digestibility indicators of fiber (NDF) in silage maize hybrids in 2014

	Cemata	Cebir	Cemora	Cebesto
Dry matter %	35,5	35,2	35	34,3
Soluble dry matter %	17,6	19,7	21	17,9
pH	4	4,1	4	4,1
AWE g/KOH*	1029,7	946,3	1156	1053,7
Lactic acid %	3,7	3,1	2,3	1,5
Acetic acid %	0,9	0,6	0,7	1,1
Propionic acid %	0	0	0	0,1
Sum VFA* %	0,9	0,6	0,8	1,2
Lactic acid/VFA	4,2	5,2	3,1	1,3
NH3 %	0	0	0	0
N-NH3 %	4	4,5	5,8	3,1
N- NH2 %	15,1	14,5	15,7	13,4
Proteolisis %	19,1	19	21,5	16,5
NS* in 100% dry matter	7,5	7,7	8,2	8,6
Starch in 100% dry matter	29,5	29,1	30,4	26,5
ADF* in 100% dry matter	22,5	23,9	22,7	27
NDF* ve 100% suš.	45,4	47,6	44,5	51,2
Ash in 100% dry matter	4	4,1	4	4,7
DOM* 24 hours	68,7	71,3	68,5	67,6
DNDF* 24 hours	44,6	46,7	42,7	41,7
CH4, NL* / kg suš.	286	288	284	272
Biogas NL*/kg suš.	556	537	531	532

Explanatory notes:

- AWE – Acidity of water extract / Potassium hydroxide
- VFA – Volatile fatty acids in the rumen
- NS – Nitrogen substances
- ADF – Acid-neutral fiber
- NDF – Neutral-detergent fiber
- DOM – Digestibility of organic matter
- DNDF- Digestibility of neutral-detergent fiber
- NL – Normalised liter

Here are the cumulative values of the potential production of biogas or methane in the equivalent of the biomass of silage, in dry matter. Potential biogas production, respectively, methane (CH4) as a main energy biogas folder is a very important parameter for the evaluation of input raw materials. The practical yield of biogas, however, depends not only on the potential of biogas production from used substrates, but also on the efficiency of the use of this particular technology of biogas plant. That is why for the assessment of the quality of the substrate in terms of biogas production is preferable to use the value of the potential production of biogas (methane), which is independent of the fermentation technology.

Table 2 Production of biogas and methane on normalised litre in kg of dry matter feed (silage) for each hybrids grown in 2014

Biogas	**Resulsts without correction**				**Results calculated on a normalised volume of gas**			
Hybrid	**BG, l/kg FM**	**BG, l/kg DM**	**CH4, l/kg FM**	**CH4, l/kg DM**	**BG, NL/kg FM**	**BG, NL/kg DM**	**CH4, NL/kg FM**	**CH4, NL/kg DM**
CEMATA	**244**	**687**	**126**	**354**	**197**	**556**	**102**	**286**
CEBIR	**234**	**665**	**126**	**357**	**189**	**537**	**101**	**288**
CEMORA	**230**	**658**	**123**	**352**	**186**	**531**	**99**	**284**
CEBESTO	**227**	**661**	**116**	**338**	**182**	**532**	**93**	**272**

**FM – Fresh matter*

**DM – Dry matter*

Table 3 Correlation table based on fibre digestibility (DNFD), digestibility of organic matter (DOM) and the production of biogas

	DNFD	Production of Methane	Production of Biogas
DOM	0,95	0,76	0,1
DNFD		0,82	0,41
Production of Methane			0,44

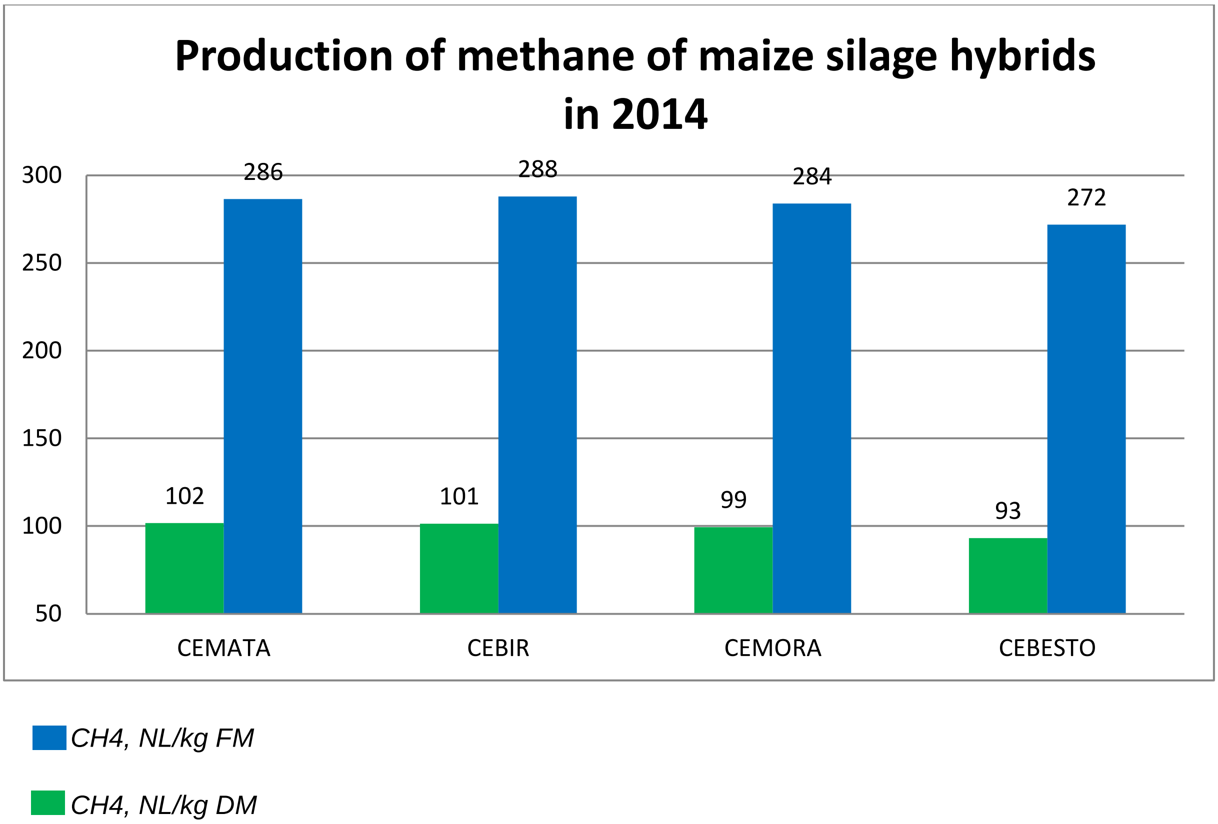
For each observing of silage hybrids was also studied a qualitative indicator of the NDF (neutral-detergent fiber) digestibility affecting an intake of dry matter by dairy cows. Whereas the breakdown or degradability of the fiber is the most important factor for the formation of methane, so we have tried to also evaluate the princip of the degradability (24 h incubation in the rumen) in the rumen fluid. The resulting values have shown positive effect of DNDF for the production of methane.

Table 4 Effect of yield of dry matter of maize for the production of methane, from hectar

Hybrid	**Yield of dry matter (t/ha) / production of methane - CH4 (m³)**						**Actual yield t/ha**	**Methane m³/ha**	**CH4 l/kg DM**
	15t	**16 t**	**17 t**	**18 t**	**19 t**	**20 t**			
CEBESTO	4080	4352	4624	4896	5168	5440	17,56	4776	272
CEBIR	4320	4608	4896	5184	5472	5760	19,21	5532	288
CEMATA	4290	4576	4862	5148	5434	5720	18,44	5274	286
CEMORA	4260	4544	4828	5112	5396	5680	18,76	5328	284
Avarage	**4238**	**4520**	**4803**	**5085**	**5368**	**5650**	**18,49**	**5228**	**283**

Table 5 Effect of yield of dry matter of maize for the production of biogas, from hectar

Hybrid	Yield of dry matter (t/ha) / production of biogas (m³)						Actual yield t/ha	Production BG m³/ha	BG l/kg DM
	15t	**16 t**	**17 t**	**18 t**	**19 t**	**20 t**			
CEBESTO	7980	8512	9044	9576	10108	10640	17,56	9342	532
CEBIR	8055	8592	9129	9666	10203	10740	19,21	10316	537
CEMATA	8340	8896	9452	10008	10564	11120	18,44	10253	556
CEMORA	7965	8496	9027	9558	10089	10620	18,76	9961	531
Average	**8085**	**8624**	**9163**	**9702**	**10241**	**10780**	**18,49**	**9968**	**539**



How is an apperant from the Graph 1, each of the substrates report in terms of biogas yield quite a balanced production, ranging from 272 to 288 l of methane equivalent to 1 kg of dry silage matter. The highest production of methane in produced biogas, calculated on the dry silage matter shows a silage sample of the hybrid CEBIR (288 l of CH_4 from 1 kg of dry silage matter), followed by a hybrid CEMATA with the amount of 286 l of methane for 1 kg of dry matter. The lowest production of methane showed the sample of the silage hybrid CEBESTO (272 l of CH_4 from 1 kg of dry matter). According to literary data, the average value of the potential production of methane in maize silage was moving in the range of 160 – 350 l/kg of dry matter with a diameter of around 240-250 l/kg of dry matter. As you can see from the Table and the Graph 1, all the samples of silage show an above-average potential for the production of methane. The theoretical maximum (100% decomposition, which never behind) is approximately 380-400 l of CH_4 for 1 kg of dry matter silage. The overall average of all ever- tested silage is around 283 l of CH_4/kg of dry matter, which means when the above literary values of approximately 70-75% productivity.