SILAGE MAIZE SIZE FRACTIONS EFFECTS ON BIOGAS QUANTITY SUBSTRATE

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Abstract. The effect of the maize silage fraction size on the biogas production efficiency plays an important role in the field of agricultural biogas plants as energy renewable resources with economic advantages. Within biogas production, it is necessary to distinguish among many starting factors which influence the biogas production. One of these influences is the size fraction of maize silage and the quantity needs. It is crucial to know how to improve the production of biogas and increase its potential. In the present research project, we focus on biogas stations owned and managed by agricultural farms that use varying sorts of biological wastes and different maize varieties as inputs in order to increase their efficiency of biogas production and thereby also their performance. It is necessary to limit the side effects of maize silage and adapt the amount of waste with higher efficiency for suppliers. It is important to arrange the composition of biological waste as efficient as possible by a mixture of humus and maize silage of appropriate fraction size with high rate of utilization. Identification of all the factors that affect production can help us reduce substrate requirements, achieve higher utilization and to help the farms be more independent. Identifying all the factors important for increasing the efficiency of biogas production will lead to a reduction in the use of biological wastes and to an increase in utilization, as well as to a higher economic independency of farms.

Key words: biogas, utilization, geometrical means length, quantity of maize, fraction size.

Introduction

The fraction size of maize is one of the essential properties of comminuted material. It is playing an important role in the utilization efficiency, and therefore, it is necessary to define the most efficient fraction size. In order to use biological waste in the biogas production most efficiently, it is necessary to know the rate of utilization of the fraction that would positively influence the biogas production. The research is focused on the material consumption and appropriate mix of chopped maize. The size can be influenced already during the harvest time for increasing the utilization and canned maize. At the moment with the use of maize with other raw materials, it is useful to know how to prepare the substrate mixture. For calculating the dimension sizes, the ASAE Standards 1993 model was used.

The maize for methane production has a very good development potential in the Czech Republic because the number of biogas power stations is gradually increasing. The agricultural farm ZD Čechtice is cooperating with the Czech University of Life Sciences on the research that is in its first year out of the three-year cooperation.

ZD Čechtice has one generator of TCG 2016V12 type with the maximal power of 600 kW which was installed in July, 2011. The monthly use of biological waste ranges between 1300 to 1500 kg. It is a mixture of manure, maize, grass and potato pulp. The daily consumption amounts to around 44 kg of the waste.

Materials and methods

The method of the size fraction determination has to be calculated using the ASAE standards. In a field, samples of the same maize variety differing only in harvesting machinery are chosen and taken afterwards from the harvesters in three different bags. After weighing, the geometric mean length needs to be calculated.

The maize variety Krabas (FAO 290) was chosen and the harvesting machines were Krone B 700 and JD 7050 with different harvesting systems. The maize was harvested in the course of vegetable period. The maize had 22.3 % of air humidity.

The whole shaking procedure was repeated for three 5 kg samples from each of the harvesters using a screen shaker. The shaker was set to work for 120 seconds at the frequency of 2.4 Hz. After separation, the portions from individual screens were weighed. For the definition of the silage maize quantity, it is necessary to calculate the size of the particles as the geometric mean length X_{gm} (1) and standard deviation S_{gm} (2).

Finally, the average mass from three different measurements left over on the screens is calculated and expressed also as percentage.

The analysis of mass distribution of all chopped forage materials is based on the assumption that these distributions are logarithmic normally distributed.

$$X_{gm} = \log^{-1} \frac{\sum(M_i \log \bar{x}_i)}{\sum M_i} \quad (1)$$

For calculation of the standard deviation, the following equation is used:

$$S_{gm} = \log^{-1}\left(\frac{\sum M_i (\log \bar{x}_i - \log x_{gm})^2}{\sum M_i}\right)^{1/2} \quad (2)$$

where X_{gm} – geometric mean length;
M_i – mass on ith screen;
$\bar{x}_i$ – geometric mean length of particles on ith screen;
S_{gm} – standard deviation.

Results and discussion

The quality of energy crops used for biogas production is determined mainly in the field. The content and availability of substances which are able to produce methane are influenced by the variety, cultivation, and stage of maturity at the harvest time. Several relationships between the substrate biodegradability and substrate composition were found. An estimation of the potential of energy crops and animal manure to produce methane is essential. Maximum methane yield requires adequate and efficient nutrient supply for micro-organisms in the digester.

Table 1 shows the weights of the separated silage maize samples provided by the two harvesters.

Table 1

Weight of chopped samples (1. harvested by Krone B 700, 2. harvested by JD 7050)

Screen nr.	Nominal size opening, mm	ZD Čechtice					
		1. Krabas (FAO 290)			2. Krabas (FAO 290)		
		1., kg	2., kg	3., kg	1., kg	2., kg	3., kg
1	19.00	0.12	0.16	0.12	0.12	0.16	0.20
2	12.70	1.72	1.86	1.86	1.60	1.84	1.80
3	6.30	2.39	2.32	2.38	2.50	2.38	2.36
4	3.96	0.30	0.30	0.34	0.34	0.32	0.36
5	1.17	0.28	0.28	0.26	0.28	0.28	0.26
6	Pan	0.01	0.01	0.00	0.01	0.00	0.00
Total, kg		4.82	4.93	4.96	4.85	4.98	4.98

The average mass from three different measurements left over on the screens and expressed also as percentage is displayed in Table 2.

The results of the geometric mean length are shown in Table 3. In this case, the results depend strongly on the harvesting machine and the pre-harvest preparation. The whole procedure affects the quantity of maize silage for producing biogas in the end. Nevertheless, the geometric mean length can influenced only the quantity of the produced biogas, not its quality.

Through the harvesting machines and harvesting technology, the appropriate maize fraction for use in the biogas production can be prepared that would reduce the quantity required, as Figure 1 describes.

Table 2

Percent mass distribution (1. harvested by Krone B 700, 2. harvested by JD 7050)

Screen nr.	Nominal size opening, mm	1. Krabas (FAO 290)		2. Krabas (FAO 290)	
		Average mass on screens, kg	Percent of total mass on screens, %	Average mass on screens, kg	Percent of total mass on screens, %
1	19.00	0.13	2.72	0.16	3.24
2	12.70	1.81	36.98	1.75	35.38
3	6.30	2.36	48.20	2.41	48.89
4	3.96	0.31	6.39	0.34	6.89
5	1.17	0.27	5.57	0.27	5.54
6	Pan	0.01	0.14	0.00	0.07

Table 3 shows the differences between two harvest machines Krone B 700 and Krabas variety (1.) and JD 7050 and Krabas variety (2.). These results provide the possibility to estimate the necessity for a reservoir and a possible decrease in the quantity of the maize required; furthermore, it prepares the fraction of maize for a lower distribution in the reservoir.

Table 3

Results of geometric mean length (1. harvested by Krone B 700, 2. harvested by JD 7050)

Sample	Geometric mean length, mm	Standard deviation, mm
1. Krabas	14.30	1.86
2. Krabas	13.27	1.78

Figure 1 illustrates the amount of maize in supplier from the last three month in 2011. The reservoir was filled with the constant mix of manure (10 tons), grass mixture (8 tons) and potato pulp (6 tons).

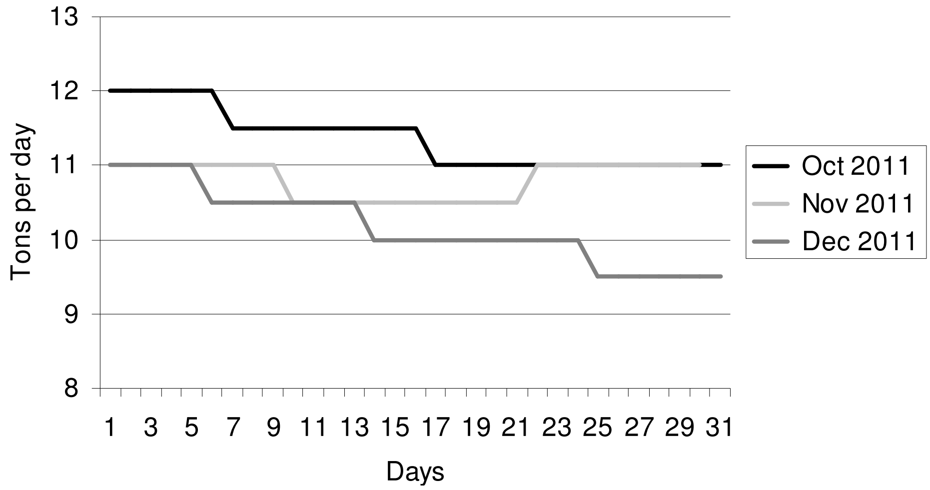

Fig. 1. **Filling of the reservoir**

Already one month ago, the fertiliser was filled by the research mix and prepared for the test. Regular verification of the results started in October, 2011, when the reservoir was filled only by Krabas No. 1. In November, 2011, it was mixed by 50/50 with Krabas No. 2. In December, 2011, we started to fill the reservoir only with Krabas No. 2. From the whole situation, relations concerning optimization of the maize quantity can be deduced. Nevertheless, when reducing the quantity of maize in the silage tanks, we can already prepare the harvesting machines for optimization during the harvesting period with the final effects leading to lower needs of maize and longer supply for the reservoir.

Conclusions

The maize is considered to have the highest yield potential of the field crops grown in the Czech Republic. Unsolved questions are quality needs, the yield potential considering the given limits in water availability and thermal time and the integration of energy maize in sustainable cropping systems to minimize negative effects on the environment and to maximise the net energy yield. The economic efficiency depends on the investment costs, on the costs for operating the biogas plant and on the optimum methane production.

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