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Alternative use for grassland cuts

Forage grasses as biogas co-substrates

The suitability of different fresh and ensiled grass types as co-substrates in biogas production was investigated at Potsdam-Bornim. Gas production over time can be very well described through an exponential function. The measured gas production was between 678 and 929 l biogas • kg^{-1} organic dry matter over 28 days. The results did not appear to be variety-specific but to be dependent on the quality of the silage.

Around one third of farmland in Germany is grassland. It characterises the landscape and plays an important role in the protection of species and biotopes. But the current reduction in dairy cow numbers and continuous increase in required forage quality standards has brought a decrease in the utilisation of grassland as a feed source for ruminants [1]. This offers opportunities for an interesting alternative use of grass as co-substrate in biogas production. Co-substrates can be added in agricultural biogas plants to offer, depending on the substrate used, a clear increase in biogas production and in the financial viability of the plant [2].

The following report investigates the suitability of seven viable forage grasses – fresh and ensiled – as co-substrates. Year-round biogas production requires that such grass be conserved. Using laboratory scale batch trials gas production over time was determined. This could be described by an exponential function. The curve adaptation delivered the value for maximum possible gas production ymax as well as production y(t) at any particular point of time t.

Substrate

The first cut of co-substrate grasses was harvested mid-May 2001 from the Paulinenaue at the State Institute for Consumer Protection and Agriculture Brandenburg (LVL), Department of Grassland and Forage Management. After one day wilting at around 25 °C, a portion of each grass variety was frozen at -18 °C for later biomethane production and analysis. Another portion was pressed for ensiling without silage additive in glass containers and stored for eleven months. At the same time as the biomethane production, analysis was carried out to determine dry matter (dm) at 105 °C, organic dry matter (odm) and pH according to DIN (*table 1*).

Experiment plant

The repeat laboratory batch trials (V1, V2) were conducted under controlled mesophilic conditions (35 °C) over 28 days. 2 l plastic fermenting jars were filled each with 50 g of the co-substrate to be tested and with 1.5 kg of already fermented slurry as inoculation material to encourage a stable fermentation. One control per trial unit served to record possible gas production by the inoculation material. The produced gas (standard conditions: 20 °C, 1016 mbar) was recorded daily via calibrated gas mouse. The methane content was determined at defined times with an ansyco deposit gas monitor.

Table 1: Dry matter (TS), organic dry matter (oTS), pH and biogas output of selected grass species V1 and V2 ($y_{V1/2}$)

Fresh grasses (FG)	**dm [%]**	**odm [% TS]**	**pH**	**Y_{V1} [l/kg]**	**Y_{V2} [l/kg]**
Perennial ryegrass 'Bardonna' (*Lolium perenne*)	17,6	90,1	6,5	--	859
Cocksfoot 'Baraula' (*Dactylis glomerata*)	18,6	89,1	6,7	678	800
Tall fescue 'Elfina' (*Festuca arundinacea*)	13,9	89,1	6,4	688	836
Red fescue 'Roland21' (*Festuca rubra*)	22,8	92,4	6,5	752	845
Timothy 'Odenwälder' (*Phleum pratense*)	14,8	90,1	6,6	733	828
Meadow fescue x ryegrass 'Paulita' (*Festulolium*)	18,3	91,4	6,4	714	--
Meadow fescue 'Cosmos11' (*Festuca pratensis*)	17,6	91,5	6,4	708	909
Silage (S)					
Perennial ryegrass 'Bardonna' (*Lolium perenne*)	18,7	88,5	4,6	914	929
Cocksfoot 'Baraula' (*Dactylis glomerata*)	27,3	88,8	6,1	718	718
Tall fescue 'Elfina' (*Festuca arundinacea*)	17,3	89,6	4,0	887	818
Red fescue 'Roland21' (*Festuca rubra*)	30,0	92,0	4,9	795	767
Timothy 'Odenwälder' (*Phleum pratense*)	22,8	89,8	5,3	775	599
Meadow fescue x ryegrass 'Paulita' (*Festulolium*)	19,6	87,9	5,5	883	921
Meadow fescue 'Cosmos11' (*Festuca pratensis*)	27,4	89,9	4,7	887	846

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Keywords

Biogas, co-substrate, grass, silage

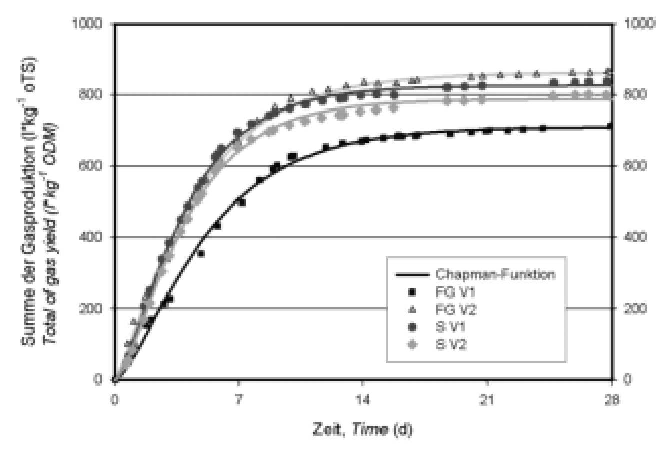

Fig. 1: Means of summation curve and Chapman functions

Results

With the samples from the different varieties of fresh grass, biogas production was between 678 and 752 l per kg odm (V1) and 800 to 909 l biogas•kg^{-1} odm (V2). The silage used in the tests indicated a greater range of production with 718 to 914 l (V1) and 718 to 929 l (V2) per kg odm, but were still more similar in their values than the production from fresh grass. In V2 an extreme value was determined with the 599 l of biogas per kg odm for timothy. Both as fresh grass and as silage co-substrate (V1, V2), the perennial ryegrass achieved the second highest and highest respective gas production and cocksfoot the lowest. No varietal influence was able to be determined, either as fresh or ensiled material, with the other varieties.

Compared to conventional feed silages, the grass silages produced for the trials were of reduced quality in that no silage additive was used. This was to avoid any possible additional effect on biomethane production. The fermenting quality achieved in the batch trials was sufficient although here one could see a possible reason for the greater variability of the associated biogas production.

A clear effect of the variety of grass on the amount of biogas produced from the silages was not evident. However the gas production did seem to be dependent on the quality of the silage.

There were small differences found between the analysed methane contents. Without exception a methane content of ~ 68% was measured for the fresh (from day 11) and the ensiled (from day 14) grass varieties. At the beginning of the experiment (day 3) a 10% difference in methane content could be determined between the gas from fresh grass (23%) and from silage (33%). This difference could be explained through the ensiling process which degraded biomass components which were then available for immediately fermented by the methane-producing bacteria.

Under the assumption that the grass variety had no influence on biogas production, the sum curves regarding the different varieties could be presented per trial unit (*fig. 1*). A very good curve adaptation was able to be achieved with the help of an exponential function on the following types (Chapman function with three parameters):

$$y(t) = y_{max}(1-e^{-a\bullet t})^b \tag{1}$$

$y(t)$: biogas production at time point t (l biogas•kg^{-1} odm)

y_{max}: maximum possible gas production (l biogas•kg^{-1} odm)

t: time (d) a, b: coefficients

Thus the curve sums determined enabled the production of the parameters as shown in *table 2* for calculation of the produced biogas up to a time point t. In the four trials the average biogas production from grass and grass silage after 28 days was in the range from 710 to 862 l•kg^{-1} odm and thus slightly higher than the figures given in the literature. There, one finds information regarding biogas yields from forage pasture grass from 700 l•kg^{-1} odm [3] and from 450 to 700 l•kg^{-1} odm from wilted grass silage with 35% dm [4].

Table 2: Parameters and coefficients of determination from fitting curve according to Chapman

Trial	y_{max}	a	b	R^2
FG V1	710	0,24	1,63	0,997
FG V2	862	0,25	1,29	0,998
S V1	826	0,31	1,61	0,998
S V2	787	0,31	1,63	0,998

Summary

The above trial results show no clear difference in grass production and quality between the different grass varieties neither with fresh grass nor with ensiled grass. The conservation had also no great influence on the amount of biogas produced.

Summarised, it can be said that the investigated varieties are without exception suitable as a co-substrate for biomethane production from fresh or ensiled material. Decisive for the selection of grasses is their organic dry matter content which depends on factors including type of grass, weather and cutting time. The financial return from the production of electricity must be considered in the light of the grass production and harvesting costs as well as possible alternative uses for the forage.

Literature

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