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Biogas Production from Grassland Biomass in the Alpine Region

Biogas production from meadow grass will gain in importance as a key technology for the sustainable land use of diversified manmade landscapes. The research project ascertained bench-marks on possible methane yields from high and low input grasslands and with varying numbers of cuts. It recommends measures on how biogas production efficiency from grassland can be optimised.

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Keywords

Biogas, grassland, grass, sustainability, renewable energy

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Grassland is an important forage source for beef and dairy cattle. In addition, grassland is of growing importance for raw material and renewable energy production. All activities must aim at sustaining and productive use of a multifaceted cultivated landscape [1]. Biogas production, a key technology for the sustainable use of agrarian biomass, is one option of grassland utilisation. A lasting success is only achieved, if grassland is managed after sustainable principles [2].

Against this background, the following questions are investigated:

- Which methane yield can be achieved in valley and mountainous regions of typical Alpine grassland locations?
- How are the biomass yield, the grass composition, the specific methane yield and the methane yield per hectare effected by the intensity of grassland management?

The core aim is to improve biogas production from grassland under consideration of ecology, economy, technology and society aspects. Alpine grassland as a renewable energy source shall be promoted.

Materials and Methods

16 grassland treatments were grown in two Alpine regions: „Buchau/Admont", an extensive mountainous region and „Irdning/Gumpenstein", an intensive valley area. Experimental set up and sampling allowed a differentiation of management intensity and vegetation stage at harvesting. *Table 1* gives the characteristics of the locations „Admont" and „Irdning". These two locations are typical of the Alpine grassland region. They differ in altitude, precipitation and temperature.

Table 2 contains data on the experimental set up: number of cuts, growth, harvest date, vegetation stage at harvesting, grass height, fresh and dry matter yields. More detailed information on the percentage of grass, leguminosae and herbage can be taken from [2]. The extensive grassland in the mountainous region was cut two or three times. The intensive grassland in the valley area was cut three or four times. After harvest, grass was conserved as silage.

The specific methane yields from the contrasting grass silages were measured in three replicates under controlled lab conditions in 1 l- eudiometer batch digesters after DIN 38414 [3]. The inoculum was received from commercial biogas plants that mainly digest energy crops. The pH value in the digestate was controlled twice a week. The digestion period lasted for 40 days.

The methane concentration in the biogas was measured twice a week with a NDIR analyser. Concentration readings were validated with a GC at regular intervals. H_2S and NH_3 concentration was analysed twice a week by Dräger tubes. The digestate was analysed for dry matter, ash, total N, TAN, C, crude fibre, crude protein, crude fat, N free extracts, acetic acid, propionic acid, butyric acid, and valeric acid.

Results and Discussion

Biomass yield

Figure 1 gives the biomass yield per year of all grassland treatments. The extensive location „Admont" yielded 4.2 t dry matter per year when cut once and 6.4 t dry matter per year when cut twice. The treatment with three cuts resulted in a decline in total biomass yield (5.9 t DM yr^{-1}). The treatments grown in the intensive valley area were cut

Table 1: Description of experimental sites for meadow grass „Admont" and „Irdning"

Location	altitude	precipitation temperature	soil type	preceding crop	gras since	pest managem.	fertilisation
Admont „Buchau" (low input area)	890	1250 mm / 6.1°C	brown clay	permanent grasland	~1900	none	cattle compost 12-19 t
Irdning (intensive area)	710	1019 mm / 6.9°C	brown clay	permanent grasland	2000	none	cattle compost 20 t

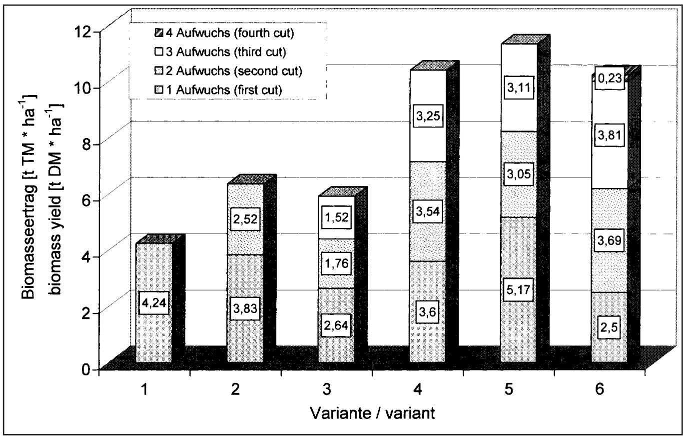

Fig. 1: Biomass yield from Alpine grassland at different intensity of use

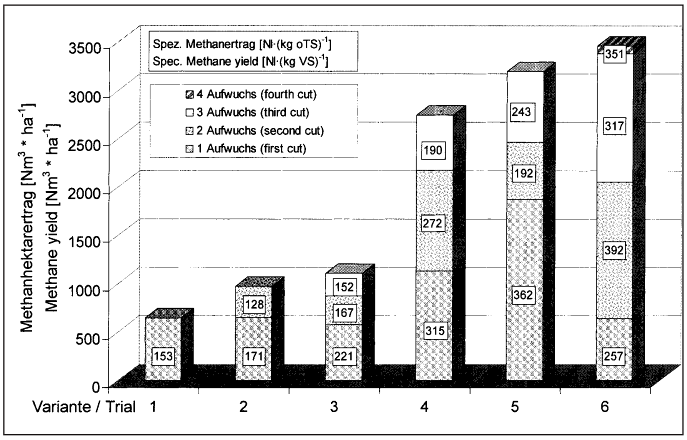

Fig. 2: Methane yield per hectare from Alpine grassland at different intensity of use

three to four times and yielded more biomass. The „three cut treatment" was further differentiated into „early first cut" (1st June) and „late first cut" (15th June). The treatment „early first cut" yielded much less biomass than the treatment „late first cut". The loss in biomass yield was not compensated through slightly higher biomass yields in the second and in the third cut. This means, that the timing of the first cut is of key importance for the total biomass yield from a full vegetation period. Under comparable growing locational conditions, for the treatment variant 6 with four cuts a reduction in yield to 10.2 DM yr^{-1}, was measured.

Requirements on the biomass quality are different when grass is anaerobically digested compared to being fed to cattle. The digester offers more time to degrade the organic substance than does the rumen. In addition it is likely to assume that the micro-organism population in the digester is different from that in the rumen. Biogas plants can make better use of cellulose-lignin complexes than the rumen of dairy cows. With biogas production, the key factor to be optimised is the methane yield per hectare. This may result in different harvesting strategies when growing grass for anaerobic digestion compared to growing grass as a forage source for ruminants. Specific harvest and processing technologies are required when grass is used as a renewable energy source.

Specific biogas yield and methane yield per hectare

The methane yield per hectare was calculated from the biomass yield and the specific methane yield (*Fig. 2*). Detailed data on the biogas quality can be taken from [2]. An increase in the number of cuts did not necessarily result in an increase in biomass yield (*Fig. 1*), but always resulted in an increase in the methane yield per hectare (*Fig. 2*). However, in the extensive treatments, the increase in the methane yield per hectare from two to three cuts was rather low, as was the increase in the methane yield per hectare in the intensive treatments, when cut four instead of three times. It is thus doubtable if the additional effort for three, respectively four cuts is paid off by the small increase in the net total methane yield per hectare.

When the first cut in the intensive valley area was done at a later vegetation stage, then the net total methane yield per hectare increased from 2,714 to 3,213 Nm^3 $CH_4 \cdot ha^{-1}$.

Table 2: Intensity of use, time of cutting and yield of meadow grass at the Admont and Irdning

No.	variant	harvests per year	cut no.	date of harvest	vegetation stage	height [cm]	biomass [t/ha]	dm [t/ha]
Admont								
1	1	1	1	30.08.04	4	69	19,2	4,24
2	2	2	1	05.07.04	3	78	22,8	3,83
3	2	2	2	11.10.04	2	47	15,7	2,52
4	3	3	1	09.06.04	2	48	16,1	2,64
5	3	3	2	29.07.04	2-3	28	11,7	1,76
6	3	3	3	11.10.04	2	22	10,5	1,52
Irdning								
7	4	3	1	01.06.04	2	44	23,7	3,60
8	4	3	2	22.07.04	2-3	64	20,8	3,54
9	4	3	3	27.09.04	1-2	61	22,7	3,25
10	5	3	1	15.06.04	2-3	52	25,0	5,17
11	5	3	2	03.08.04	3	59	18,5	3,05
12	5	3	3	10.10.04	1-2	62	21,5	3,11
13	6	4	1	18.05.04	1-2	46	15,7	2,50
14	6	4	2	06.07.04	2	62	23,7	3,69
15	6	4	3	09.09.04	2	68	22,2	3,81
16	6	4	4	30.09.04	1	19	1,87	0,23

Vegetation stage: 1 = stem elongation, 2 = ear emergence, 3 = flowering, 4 = overmature

Conclusions and Outlook

Biogas production from grassland will gain in importance as key technology for sustainable land use of diversified man-made landscape. The altitude and the location of the grassland determine its production potential and the achievable methane yield per hectare. The experiments in an intensive valley area showed that four cuts compared to three cuts resulted in only a small increase in the net total methane yield per hectare from that was produced during a full vegetation period. The timing of the first cut has a key influence on the total methane yield per hectare. The results so far show that - in contrast to the production of forage for ruminants - the number of cuts can be reduced when grass is anaerobically digested in biogas plants. Thus the effort for harvesting can be reduced and hence the economic efficiency be increased. In future, our research will concentrate on developing harvesting, conservation and processing technologies that are specifically adapted to produce methane from grassland. The environmentally-friendly recycling of the digestate will be another focus of research.

Literature

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