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The influence of ear and stover fraction on biogas production of maize

The study was designed to investigate the influence of ear and stover of silage maize on biogas production. Two varieties were planted in different environments. The stover and the ear were harvested separately and analysed in a batch experiment. No significant influence of the variety on gas production was found. On average the ear reached a 13 % higher specific biogas gas yield as well as a higher methane content as the stover. The gas production from the ear mainly took place during the first 10-12 days of the fermentation period. In contrast biogas from the stover emitted more steadily almost throughout the whole experiment. This points out to the potential that a manipulation of the gas production can be possibly achieved through the choice of the maize variety.

Keywords
Maize, biogas production, stover, ear

Abstract
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Over the last years the biogas production from renewable resources has become an essential economic aspect of German agriculture. Hereby maize is the dominant substrate [1]. For cultivation there are different varieties, on the one hand so-called biogas types with high mass yield and low ear content, on the other hand the classical, partly ear-focused silage maize varieties used in animal feeding. The wide range of varieties is due to the unresolved discussion on the influence of both maize fractions (stover and ear) on methane gas production and exploitation. Beginning with the planting season 2007 a cooperation project of the Bayerische Landesanstalt für Landwirtschaft (LfL), the Landwirtschaftskammer Niedersachsen and Syngenta Seeds was performing specific investigations with two varieties on two locations.

Material and methods

The field trials were carried out on two locations (Dasselsbruch, Lower Saxonia; Freising, Bavaria) in four-row plots of 18 m² each and threefold repetition. The study was done with the intermediate maturity varieties NK Magitop (ripe coefficient S240, silage and biogas maize) and NK Famous (ripe coefficient S250, silage and corn maize). Average plant density, tillage, fertilization and pest control/herbicide treatment were used according to local standards. The middle rows of the plots were harvested. One row was chopped as whole plant, in the other row the ears were removed before chopping the stover. The harvested plant material was gently dried at a maximum temperature of 60 °C and ground to 10 mm for analysis.

The potential for the production of biogas and methane was measured at the Institute for Agricultural Technology and Animal Keeping (ILT) according to laboratory methods complying to VDI 4630 standards [2]. Each sample (location × year) was analyzed in a separate trial. The analyzed samples were mixes of the three field repetitions. The gas production was analyzed in three replicates, whereas the methane content was determined as weighted average. Because there is strong evidence that different laboratory trials may yield relevant differences in gas production and methane content impeding the comparability of results [2], all values of the different trials have to be judged independently each other. The measured gas production was standardized to temperature (25 °C) and atmospheric pressure (1023 hPa), corrected to water content and normalized according to inherent internal standards (cellulose). The cellulose was defined with a gas production potential of 745 $L_N \cdot kg^{-1}$ oTS. There was no further correction on the methane content of the biogas.

Results and discussion

In all years the maize had a normal development for the whole growth period. When harvested the whole plant showed generally a dry matter content making it suitable for silage (**table 1**). There were almost no differences between the varieties. NK Magitop had a slightly lower ear and slightly higher stover dry matter content than NK Famous.

The variation coefficient in determining the biogas production potential 2007 was in average of all samples 9,8 %, 2008 5,9 % (Freising), 2009 8,0 % (Dasselsbruch) and 7,5 % (Freising). Hence the variation coefficients were all in a normal range of the used measurement method (up to 10 % with threefold measurements) [2]. With alternating methods towards determination of the biogas production potential lower variations were partially reported [3], sometimes even significantly higher variations [4; 5; 6].

The specific biogas yield as well as methane content differed significantly in the trials. These differences may be due to the consistency of the substrate or the inoculums used for fermentation or maybe a combination of both circumstances. In almost every direct comparison both biogas production from ear and the respective methane content were higher than those from the stover. On average the stover produced 87 % of the biogas yield of the ear regardless of the variety. The higher biogas yield of the ear may be due to the fat content which is low at a whole but higher in the ear than in the stover.

Apart from the potential biogas yield the operation of a biogas plant also takes a focus on the process of gas extraction from the substrate to better „feed“ the plant and to identify or avoid problems.

When comparing the diagrams of the presented trials (**figure 1 a-d**) one can see both similarities and differences although the used material was relatively similar. In most cases the fermentation of the stover had a short but strong peak of biogas production in the beginning, followed by a continuous biogas production at steady rate. The peak at the start probably shows the degradation of easily digestible water soluble carbohydrates from leaves and stalks. Later on the degradation of cell wall parts like cellulose and hemicellulose is probably dominant. After approximately 14 days the biogas production from the stover is very low, although higher than that of the ear. This could be observed almost until the end of the dwelling time in the fermenter (not shown in the diagrams).

The biogas production from the ear was usually slower. Approximately after one day a high biogas production was yielded, lasting several days afterwards. About ten days later the biogas

Table 1

Dry matter content, potential specific biogas yield and methane content of the harvested parts of the varieties NK Magitop and NK Famous in the four tested environments

Sorte *Variety*	**Ganzpflanze** *Whole plant*	**Kolben** Ear			**Restpflanze** Stover		
	TS-Gehalt *Dry matter content [%[*	**TS-Gehalt** *Dry matter content [%[*	**Spezifischer Biogasertrag** *Specific biogas yield [L_N • kg-1 oTS]*	**Methangehalt** *Methane content [%[*	**TS-Gehalt** *Dry matter content [%[*	**Spezifischer Biogasertrag** *Specific biogas yield [L_N • kg-1 oTS]*	**Methangehalt** *Methane content [%]*
Dasselsbruch 2007							
NK Magitop	31.1	52.8	570	53.2	25.1	506	50.7
NK Famous	31.2	55.7	610	53.5	21.5	500	50.9
Freising 2008							
NK Magitop	33.4	53.1	703	56.8	23.2	598	53.8
NK Famous	31.5	57.0	702	56.6	20.6	554	51.3
Dasselsbruch 2009							
NK Magitop	34.5	53.0	839	53.3	24.5	670	52.9
NK Famous	33.3	57.7	673	53.2	23.8	673	51.3
Freising 2009							
NK Magitop	33.4	54.9	623	52.3	24.1	610	51.0
NK Famous	33.3	56.9	666	52.3	22.4	572	51.0
Sorten-Mittelwerte (über Standorte • Jahre) / Variety means (for variety • year)							
NK Magitop	33.1	53.5	684	53.9	24.2	596	52.1
NK Famous	32.3	56.8	663	53.9	22.1	575	51.1

production declined rapidly and even fell below the level of the stover. This may be explained by the comparatively higher level of easily fermentable carbohydrates in the ear, especially in form of starch. This also implies that the significantly untypical results in Freising 2008 have to be explained by a different composition of the substrate, although the dry matter content suggests a proper condition. A study on the relevant parameters for this case was not available at the time of publishing this article.

For the constantly recurring little difference in the specific biogas yield of ear and stover the higher fat content of ear and the lignin content in the stover may be an explanation that has to be tested in further trials.

Conclusions

Based on the chosen experimental setup it was possible to measure repeatedly differences in biogas yield between ear and stover that so far had not been detected, because they were minor enough to be lost in the spread of measurements.

The different - in process time and quantity - biogas yield of ear and stover seems to potentially allow it, by choosing a variety with higher ear or stover content or by using CCM, to better control the biogas production in the fermenter. A verification of these observations by analyzing the residual contents is still to be done.

The differences in the trials, especially the resulting biogas yield, show that a comparison between the results of different trials and laboratory approaches and even more between different laboratories can hardly be done.

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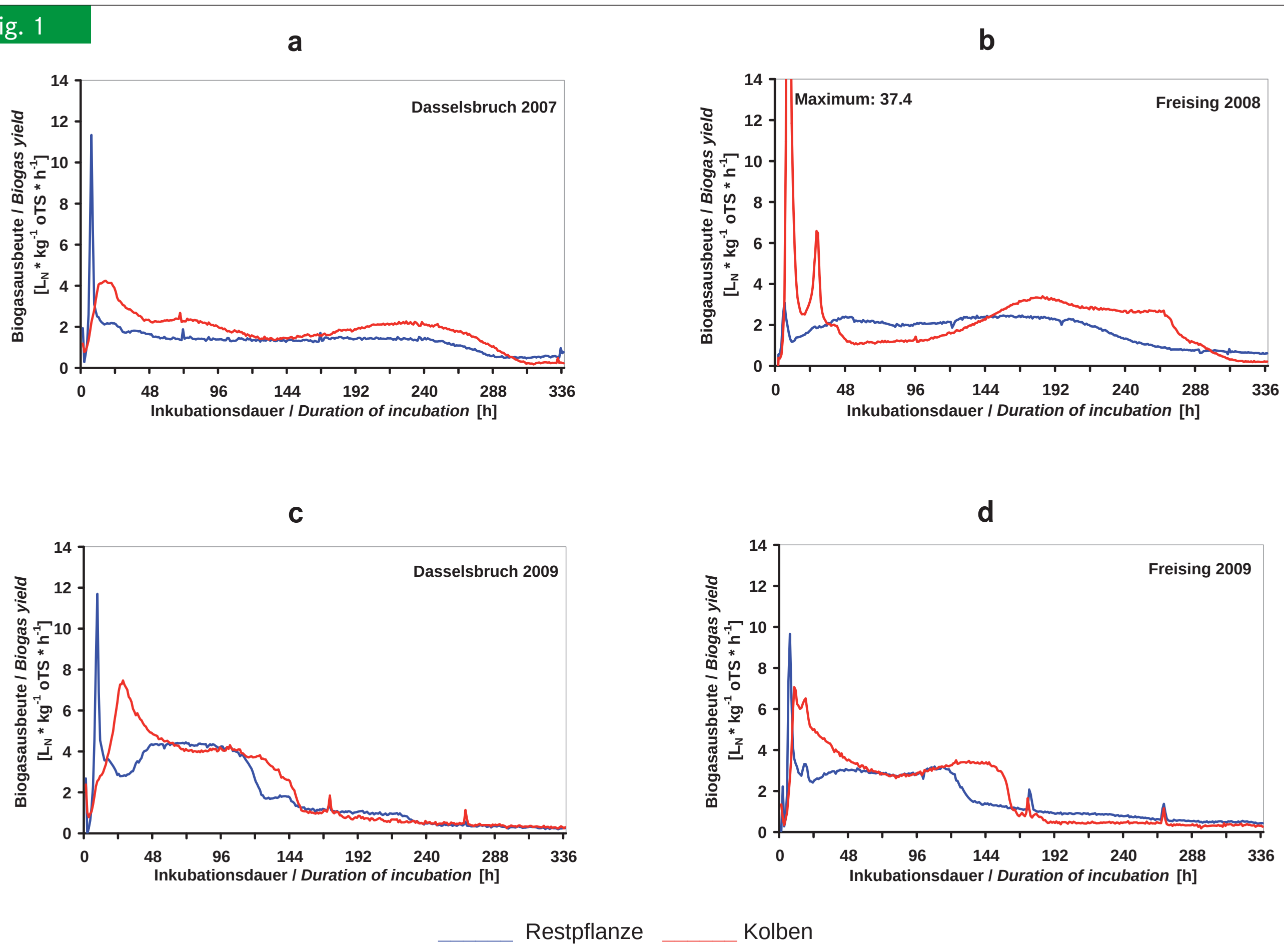
Fig. 1



Gas production of ear and stover as a mean value of the varieties NK Magitop and NK Famous in the four tested environments a to d. Hourly data of the first 14 days of the batch experiment are presented

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