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Which Energy Maize Varieties when to Harvest for Biogas Production?

Digestion of nine different maize varieties, which were harvested at four different times in 2004, showed only minor differences in specific biogas and methane yields per kg VS (volatile solids) in laboratory tests. In contrast, the dry matter yields per hectare showed strong distinctions. Based on the current level of knowledge, well adapted varieties with high dry matter yields are recommendable.

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Keywords

Biogas, methane, energy crop, maize cultivar, harvest time

The German renewable energy sources act (EEG) amended on 21st of July 2004 led to a boom in the construction of new biogas plants in rural areas. Planner, constructors and manufactures of components work on a base of valuable experiences at the technical perfecting of biogas plants. Companies and various organisations offer a lot of information about "how to start" and "how to operate" a biogas plant.

Currently researchers analyse the capability of different systems especially for the digestion of renewable raw materials.

Within the scope of the research project „Optimization of biomass supply for innovative energy recovery schemes", all steps of the life cycle of biomass like cultivation, storage, pre-treatment and digestion will be investigated.

Energy maize varieties were cultivated and tested on their specific biogas and methane yield at the University of Hohenheim. Maize cultivars are defined as energy maize and suitable for energy production, by virtue of their high dry matter yields and their composition of ingredients. At the end of the project on the basis of a concluding balancing, it is aimed to identify the most favourably varieties cultivars, under the aspects of ecology and economy.

Material and Methods

In 2004 field trials with nine maize varities and four harvest times were realised at „Goldener Acker" at the University of Hohenheim. The field is located approximately 400 m above sea level with an average annual air temperature of 8.8 °C and a precipitation of 698 mm per year.

Table 1 shows the wide range in FAO rating of maize cultivars that has been investigated.

While harvesting four times the dry matter yields per hectare had been recorded. The criterion for starting the first harvest was the wax-ripe stage of the maize variety Gavott (earliest of the chosen varieties). The following harvest times occurred approximately every two weeks, this means that the cultivars are in different states of ripeness when harvested. The chopped maize samples were preserved by drying them.

All samples of the nine maize varieties as whole plants, harvested at four different

Tab. 1: Investigated maize cultivars and FAO rating (medium-early, medium-late and late maturing)

Maize variety	FAO rating
Gavott	S250
PR 39F58	S260
Eminent	S270
Pollen	S300
PR37D25	S ~ 330
Méridienne	S ~ 400-450
Mahora	S440
Mikado	FAO500
Doge	FAO700

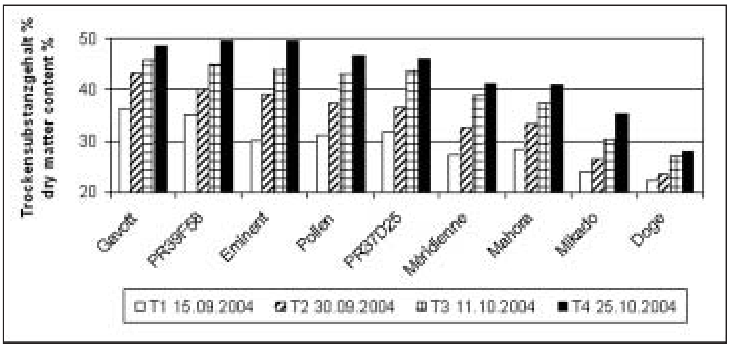

Fig. 1: Dry matter content of investigated nine maize cultivars, four harvest times (T1 to T4), FAO rating increasing from left to right

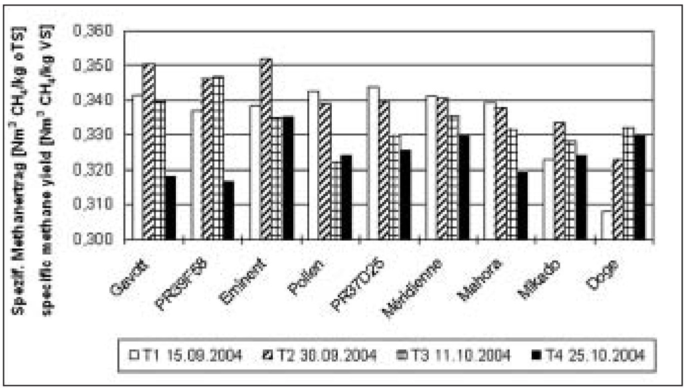

Fig. 2: Specific methane yield (Nm³ methane/kg volatile solids (VS)) of nine maize cultivars at four harvest times (T1 to T4)

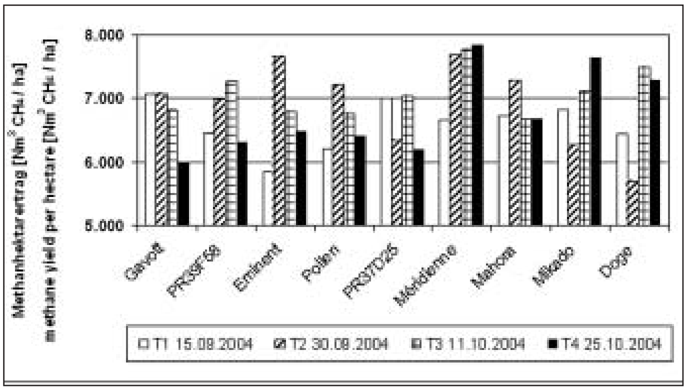

Fig. 3: Methane yield per hectare (Nm³ methane/ha) of nine investigated maize cultivars at four harvest times (T1 to T4)

dates, were analysed by means of the Hohenheim Biogas Yield Test (HBT) in terms of specific biogas and methane yield. The HBT is a small scale Batch-Test, designed by a team of scientists at the University of Hohenheim. [1, 2]

The HBT includes an incubator tempered at 37 °C over 35 day and mini-digesters. They are filled with cattle manure and with the maize samples. Every sample is tested in three repetitions at the same time. This method requires, due to the small amounts of testing material, a good homogenisation of the biomass. This is reached by drying at 60 °C and milling with 1mm mesh passage.

Results & Discussion

The dry matter contents of the maize varieties at the four harvest times are shown in *Figure 1*. On the one hand the values increase within the varieties to the later harvesting times. On the other hand the values of the medium-early maturing lie above the values of the late maturing cultivars.

It was planned to compare a wide range of maize cultivars in terms of potentially specific methane yields, therefore there are combinations of harvest times and cultivars, which are not recommendable in practice. A dry matter content under 25 % leads to silage effluent. The compacting of the biomass for silage with dry matter contents above 45% is difficult. Also the ongoing fermentation after opening the silo may cause losses.

A difference of 27 % was determined between maize variety Eminent (1st harvest time) with the lowest dry matter yield of 18.2 t/ha and Mikado (4th harvest time) with the highest dry matter yield of 24.9 t/ha in 2004. The lowest differences in the dry matter yield within the cultivars over the four harvest times were detected at Gavott with minimal 20 t/ha and maximal 21.7 t/ha. The largest variances over the four harvest times were observed at Doge with minimal 18.8 t/ha and maximal 23.9 t/ha. This means that there were variances of minimal 8 % (Gavott) and maximal 21% (Doge). The dry matter yields of Gavott with the lowest FAO rating decreased from the 1st to the 4th harvest time. The varieties PR39F58, Eminent, Pollen, PR37D25, Mahora und Doge achieved the highest dry matter yields at the 2nd or 3rd harvest time, whereas the yields of Méridienne and Mikado increased till the last harvest time.

The specific methane yields of the various substrates lie between 0.308 and 0.352 Nm³ methane/kg VS and differ maximal 12 %. Within one variety the specific methane yields only differ from 3 to 9 %.

The cultivars with lower FAO rating tend to result in higher specific methane yields than cultivars with higher FAO rating, shown in *Figure 2*. The specific methane yields of most of the cultivars decreased with later harvest time, whereas the values of the extreme late maturing cultivars increased. One explanation for this could be the different growth stages and connected to this, the rates of components. High specific methane yields are not the same as high energy yields per hectare, because a low specific methane yield can be more than compensated by a good dry matter yield, as shown in *Figure 3*.

The methane yields per hectare for the chosen maize varieties at Hohenheim site lay between 5700 and 7800 Nm³ methane/ha in 2004, whereas all cultivars achieved or passed the "limit" of 7000 Nm³ methane/ha at one or two harvest times.

The Hohenheim Biogas Yield Test is a technique at laboratory scale, which indicates the maximum of the specific methane yield of certain biomasses under optimal conditions. Due to the fact that full-scale biogas plants vary in flow through technique etc. a certain variation may be expected.

Conclusion

In 2004 methane yields per hectare of at least 7000 Nm³ methane/ha were realised for all nine maize varieties at the site of Hohenheim. The differences between the cultivars were obviously higher in dry matter yield than in specific methane yield and potential biogas yield respectively.

At today's state of knowledge well adapted cultivars with high dry matter yields are recommended for farms. The optimal point for the harvest is achieved, when the dry matter yield is as high as possible and at the same time a good ensiling is possible.

Literature

[1] *Helffrich, D., und H. Oechsner:* Hohenheimer Biogasertragstest: Vergleich verschiedener Laborverfahren zur Vergärung von Biomasse. Landtechnik 58 (2003), H. 3, S. 148 - 149; Agrartechnische Forschung 9 (2003), H. 1/3, S. 27-30

[2] VDI-Richtlinie: Vergärung organischer Stoffe. VDI 4630, Entwurf, August 2004, Beuth Verlag GmbH