Felipe Kaiser, Michael Diepolder, Joachim Eder, Stephan Hartmann, Helmar Prestele, Raphaela Gerlach, Gerald Ziehfreund and Andreas Gronauer, Freising

Biogas Yields from Various Renewable Raw Materials

Besides manure, renewable raw materials are increasingly being used as co-substrates to increase biogas generation. However, at present only insufficient data are available about the suitability of various raw materials. Investigations are being made on whether their usefulness as fodder plants (feeding-value tables) also corresponds with their ability to generate biogas.

Dipl.-Ing. agr. MSc. Felipe Kaiser is ascientist at the Bayerische Landesanstalt für Landwirtschaft, Institut für Landtechnik, Bauwesen und Umwelttechnik, Am Staudengarten 3, D-85354 Freising; e-mail: *felipe.kaiser@lfl.bayern.de*

Keywords

Biogas, methane yield, grassland, maize, renewable primary products

Liquid or solid manure from animal husbandry is typically used as basic raw material for biogas production. As long as transport is not required, animal manure is available for free. However, the relatively low biogas yields from animal manure suggest co-digestion of other raw materials with higher potential biogas yields [1, 5]. In recent years renewable raw materials have been increasingly used for this purpose. Nowadays more than half of the biogas plants operating in Bavaria produce biogas from co-digestion of these materials [4]. The German Law on Renewable Energy Sources (“Erneuerbare-Energien-Gesetz - EEG”) has supported this development by improving the framework for biogas technology.

However, available data on process kinetics, material properties, biogas output and economical impacts of renewable primary products are insufficient. Publications show inconsistent results with respect to potential biogas yields of renewable primary products, and the methods used have not been validated so far [2, 3, 6, 7, 8, 9].

In the field of animal nutrition detailed feed value tables have been developed for a broad variety of fodder plants. The question arises whether these tables are valid also for the purpose of biogas production, or whether other characteristics have to be used for ranking different sorts and breeds with respect to potential biogas output.

Materials and methods

Batch experiments in small and large laboratory digesters including extensive chemical analyses have been performed in order to assess process kinetics and biogas yields of anaerobic digestion of renewable primary products. The small bench-scale unit consisted of 5 modified hot-air cabinets with temperature control. Each cabinet contained 14 glass bottles (volume: 2 l) as reactors. Each reactor was connected to an individual gas meter (Milligascounter®) with continuous data logging (Access data base). Combined biogas flows from five parallels were stored in a bag and intermittently delivered to a gas analyser.

The large bench-scale unit comprised 24 reactors (volume: 36 l). Each reactor was connected to an individual gas meter (Milligascounter®) and a gas bag. Logging of biogas production data and biogas analyses were performed by a measuring instrument with integrated programmable logic controller. This system was newly developed by the company AWITE® in cooperation with our institute. At least 10 liquid samples of reactor content were taken over the course of each experiment to assess degradation kinetics.

Results

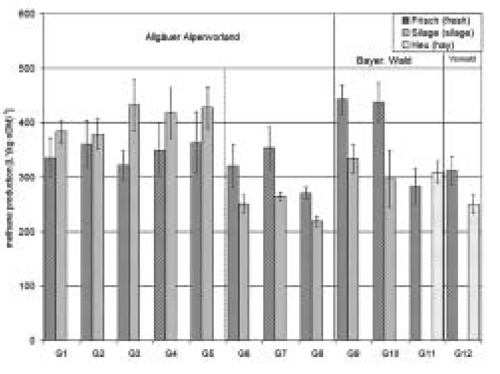
In summary, results with respect to biogas yields obtained to date are as follows:

Biogas yields of samples of fresh grass from different sites in Bavaria showed mean values between 282 and 438 l of methane per kg of organic dry matter (*Table 1*). Mean biogas yields of samples of grass silage and hey ranged from 250 to 436 l and from 250 to 310 l methane per kg organic dry matter (ODM), respectively (*Fig. 1*). Variations became even larger when data from digestion experiments and yield data of different sites were combined to calculate methane yields with respect to area of grassland (*Fig. 2 and 3*). Furthermore it can already be concluded that intensity of management and site cha-

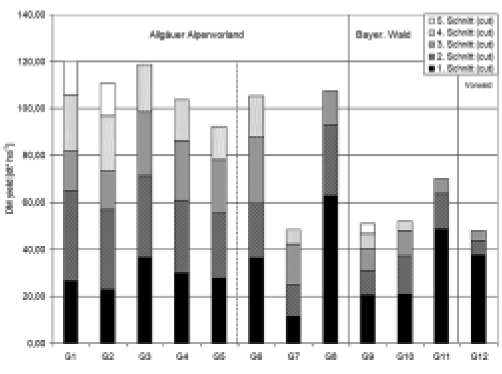
Table 1: Description of grassland variants

Code	Site	Cuttings per year	Fertiliszation	N (kg/ha); (m^3/ha)
G1	Alpine forelands	5	mineral	300
G2		5	mineral	200
G3		4	mineral	300
G4		4	mineral	200
G5		4	mineral	120
G6		4	liquid manure	4 x 20
G7		4	none	ohne
G8		3	liquid manure	3 x 20
G9	Bavarian Forest	5	liquid manure	3 x 20
G10		4	liquid manure	3 x 20
G11		3	liquid manure	2 x 25
G12	Forelands of Bav. Forest	3	none	none

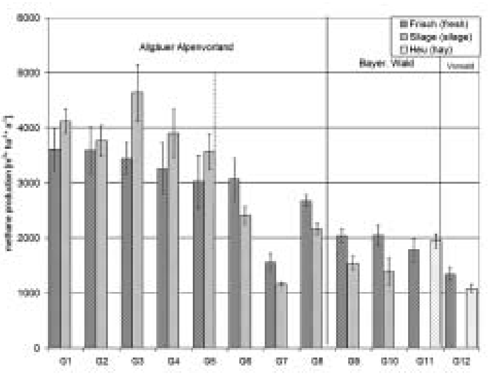
1



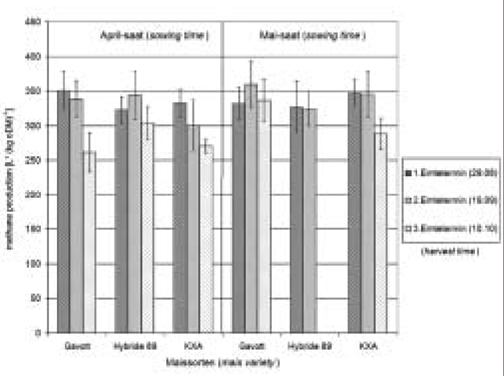
2



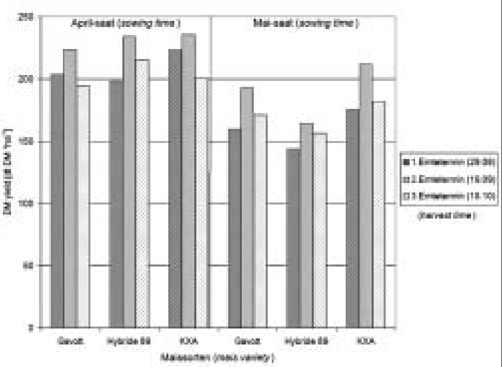
3



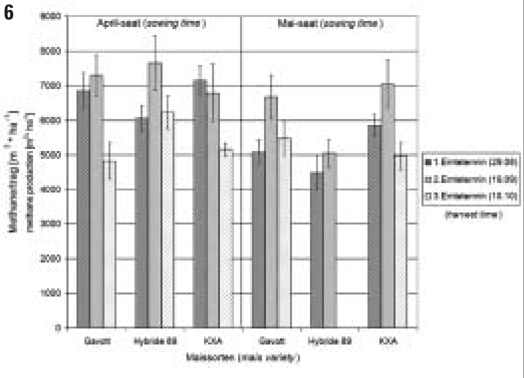
4



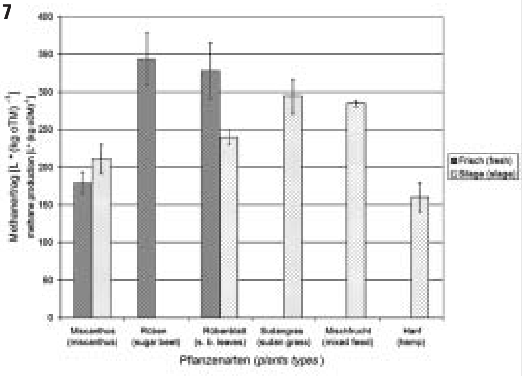
5



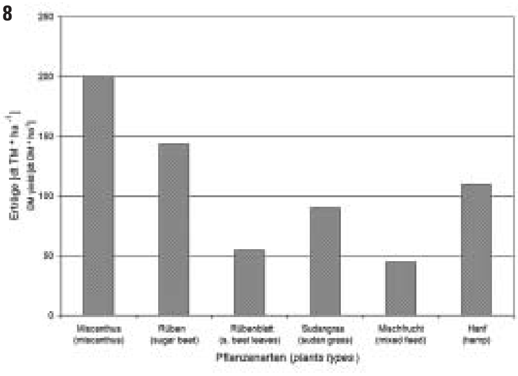
6



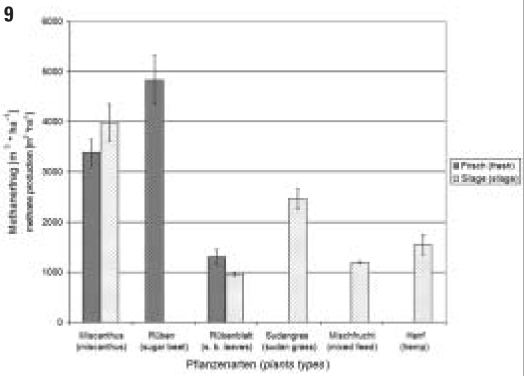
7



8



9



racteristics have a significant influence on potential biogas production from grassland.

The three maize breeds tested were sown on two different dates (in April and May, respectively) and harvested on three different dates. Experimental results showed mean biogas yields from silage between 261 and 360 l of methane per kg ODM (*Fig. 4*). Combining these results with area-specific yields of dry matter makes clear that dry matter yields are more important than methane yields per kg ODM (*Fig. 6*).

Results from digestion experiments with other renewable primary products are summarised in *Figure 7*. Mean values of methane yields from samples of fresh material and silage ranged between 160 and 344 l methane per kg ODM. Again, dry matter yield per hectare was the predominant factor for area-specific methane yield.

Outlook

Data from chemical analyses (feed analyses) of the tested raw materials will be used to correlate composition of renewable primary products and measured methane yield. The goal is to generate a computer-based expert system for optimising feed mixtures for biogas plants. This software is planned to be available for biogas plant operators and consultants by the end of 2005.

Literature

[1] *Amon, T.*: Optimierung der Biogaserzeugung aus den Energiepflanzen Mais und Kleegras. Endbericht Juli 2003. Institut für Land-, Umwelt- und Energietechnik, Universität für Bodenkultur, Wien, 2003

[2] *Amon, T., V. Kryvoruchko, B. Amon, G. Reinhold, H. Oechsner, M. Schwab, P. Weiland und B. Linke*: Biogaserträge von Energiepflanzen und Wirtschaftsdüngern - Laborversuche. Die Landwirtschaft als Energieerzeuger. KTBL-Tagung, Osnabrück, 2004, S. 46-61

[3] *Baserga, U.*: Vergärung organischer Reststoffe in landwirtschaftlichen Biogasanlagen. FAT-Berichte 546/2000, Eidgenössische Forschungsanstalt für Agrarwirtschaft und Landtechnik (FAT), Tänikon, 2000

[4] *Effenberger, M., F. Kaiser, M. Schlattmann und A. Gronauer* : Biogasanlagen-Monitoring und Emissionsverhalten von Biogas-Blockheizkraftwerken. Endbericht Februar 2003. Bayerische Landesanstalt für Landtechnik, Arbeitsgruppe Umwelttechnik der Landnutzung, Freising, 2003

[5] *Gronauer, A., M. Effenberger, F. Kaiser, R. Kissel und M. Speckmaier*: Verfahrenstechnik und Bewertung der Biogaserzeugung im landwirtschaftlichen Betrieb. In: Biogas International 2002, Tagungsband, Berlin, 2002

[6] *Linke, B., K. Baganz und R. Schlauderer*: Nutzung von Feldfrüchten zur Biogasgewinnung. Agrartechnische Forschung 5 (1999), H.2, S. 82-90

[7] *Mähnert, P., M. Heiermann, M. Plöchl, H. Schelle und B. Linke*: Verwertungsalternativen für Grünlandbestände - Futtergräser als Kosubstrat für die Biomethanisierung. Landtechnik 57 (2002), H. 5, S.260-261

[8] *Oechsner, H., A. Lemmer und C. Neuberg*: Feldfrüchte als Gärsubstrat in Biogasanlagen. Landtechnik 58 (2003), H.3, S.146-147

[9] *Zauner, E., und U. Küntzel*: Methane production from ensiled plant material. Biomass 10 (1986), pp. 207-223