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BIOGAS AND METHANE YIELD FROM RYE GRASS

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Abstract

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Biogas production in the Czech Republic has expanded substantially, including marginal regions for maize cultivation. Therefore, there are increasingly sought materials that could partially replace maize silage, as a basic feedstock, while secure both biogas production and its quality.
Two samples of rye grass (*Lolium multiflorum* var. *westerwoldicum*) silage with different solids content 21% and 15% were measured for biogas and methane yield. Rye grass silage with solid content of 15% reached an average specific biogas yield 0.431 $m^3 \cdot kg^{-1}$ of organic dry matter and an average specific methane yield 0.249 $m^3 \cdot kg^{-1}$ of organic dry matter. Rye grass silage with solid content 21% reached an average specific biogas yield 0.654 $m^3 \cdot kg^{-1}$ of organic dry matter and an average specific methane yield 0.399 $m^3 \cdot kg^{-1}$ of organic dry matter.

Keywords: biogas, biogas yield, methane yield, rye grass

INTRODUCTION

In Western European countries, the growing number of agricultural biogas plants causes an increasing demand for energy crops as a feedstock in digestion processes. Under the agroclimatic conditions of Central Europe, maize (*Zea mays* L.) is currently the most competitive crop for biogas production due to its high yield of methane, easy integration into existing farming systems, and good suitability for storage of biomass (Schittenhelm, 2008). High biogas and methane yield and the easy harvest, silage and storage of maize make this crop very suitable as co-substrate for biogas plants (Weiland, 2006). On the other hand the over fertilization of the soil, and the consequent harmful environmental effects on water and biodiversity, together with the current increase in the price of maize makes it necessary to look for alternative biomass feedstock for biogas production. The search of new cheap co-substrates, with high biogas and methan yield, are nowadays major issues in order to obtain a more economically feasible process in biogas plants in Europe.

This paper presents results of lab-scale experiments conducted in a batch fermenters to determine biogas yield (BY) and methan yield (MY) and methane content in biogas of first cut of rye grass (*Lolium multiflorum* var. *westerwoldicum*).

MATERIAL AND METHODS

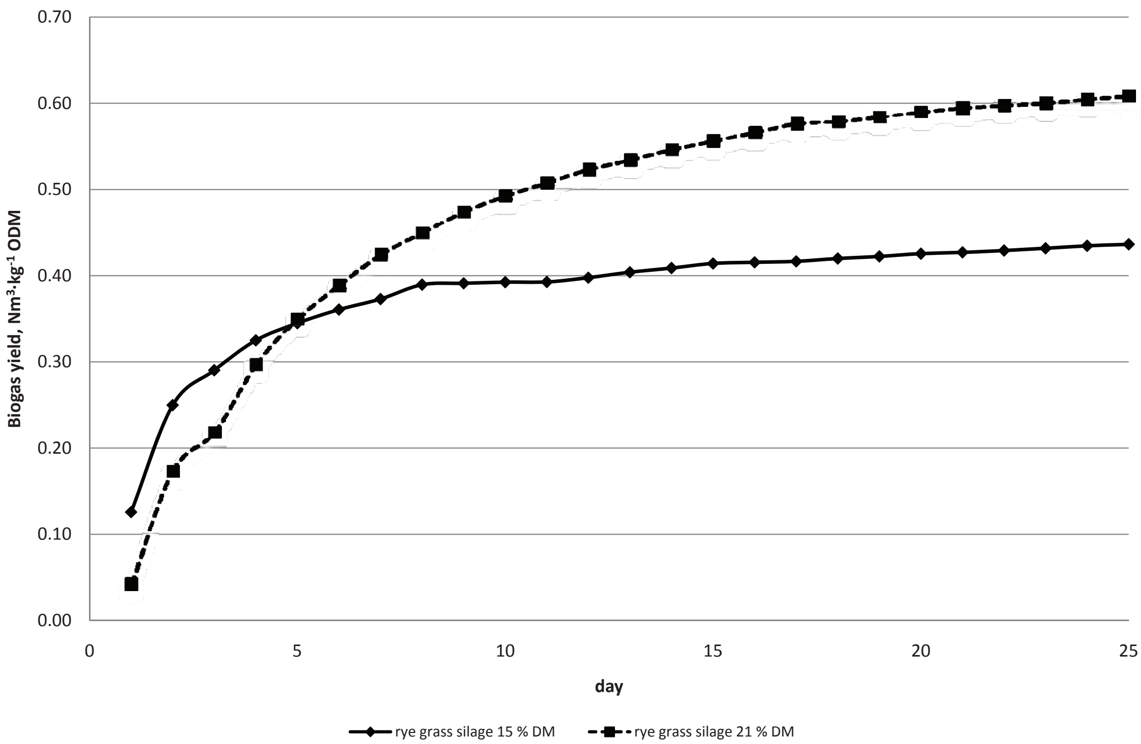
Sowing date of rye grass (*Lolium multiflorum* var. *westerwoldicum*) was 13th of August 2012 in Vatín production area, Czech Republic, altitude 560 m above sea level. First cut of grass forage was on 23rd of October 2012. In order to investigate the impact of ensiling and storage on the biogas yield, freshly harvested and wilted forage was pressed in laboratory scale silos. The laboratory silos were stored at the temperature of 23 °C for 90 days; silage preparation was performed in three repetitions. After 90 days samples of silages were investigated for pH, dry matter (DM), organic dry matter (ODM), ash, total nitrogen, fiber and metabolizable energy (ME). The composition of silage is shown in Tab. I.

Biogas production and quality from rye grass silage was measured in batch anaerobic fermentors at the temperature of 38 °C according to German Standard VDI 4630. For each variant (fresh and wilted forage, Tab. I) of rye silage eight batch fermenters of volume 3 dm^3 have been used. Batch fermenters were filled with 2 dm^3 of inoculum. For inoculation, fermenter content from commercial biogas plant was used. The inoculum for the batch anaerobic fermentation tests was specified by analysing the parameters DM, ODM, pH, organic acids and the electrical conduction. Two from eight batch fermenters with inoculum volume of 2 dm^3 were used without any addition of rye grass silage. Six remaining batch fermenters with 2 dm^3 of inoculum were filled with 100 g of rye grass silage. The biogas produced was collected in wet gas meters over a defined period of 25 days and was measured daily. Besides other gas components methane (CH_4) and carbon dioxide (CO_2) content were measured during the batch fermentation tests using gas detector Drager X-am® 7000 (Dräger SafetyAG& Co.KGaA, Germany). Biogas production was converted to standard conditions (T_0 = 273 K, p_0 = 101 325 Pa). The volume of biogas and methane produced by a sample was converted to BY and MY, by expressing them as m^3 per kg of organic dry matter (ODM) of the substrate.

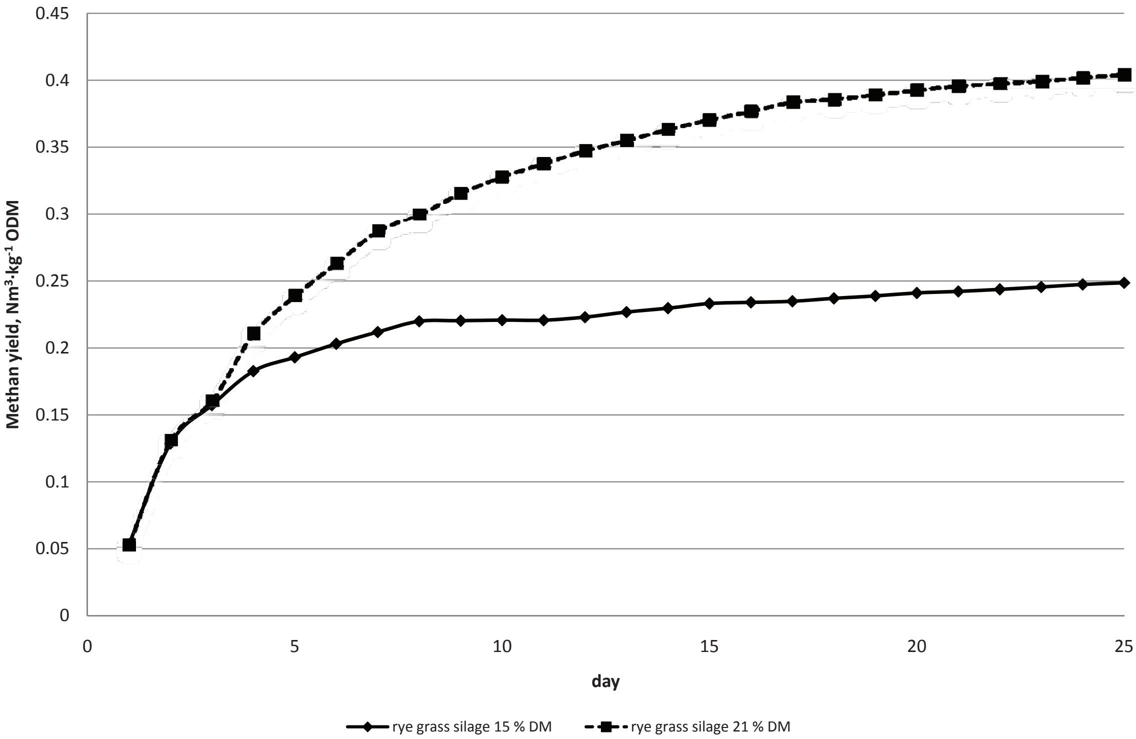
I: *Composition of rye grass silage after 90 days*

Variant	pH [-]	Dry matter [%]	Organic dry matter [%]	In dry matter			
				Ash [%]	Total nitrogen [%]	Fiber content [%]	ME [$MJ \cdot kg^{-1}$]
wilted forage	3.9	25.1	87.1	13.1	16.5	17.1	17.9
fresh forage	4.1	15.2	86.9	13.4	17.1	15.5	17.9

ME – metabolisable energy



1: *Biogas cumulative production from rye grass silages with different dry matter content*



2: *Methan cumulative production from rye grass silages with different dry matter content*

RESULTS AND DISCUSSION

Results of batch anaerobic fermentation tests are presented as cumulated biogas yields per kg of ODM and methan yields per kg of ODM after 25 days retention time as a mean value of three replicates. All samples of ensiled rye grass tested show monophasic curves of cumulated biogas production (Fig. 1, Fig. 2).

Determined biogas yield for silage made from rye grass with DM content ranged from 0.608–0.699 Nm^3 biogas per kg of ODM for rye grass silage with DM content of 21% and 0.460–0.401 Nm^3 biogas per kg of ODM for rye grass silage with DM content of 15% respectively. Our results are in correlation with other autors (Amon *et al.*, 2007; Prochnow *et al.*, 2009; Weiland, 2003; Nielsen *et al.*, 2012) who observed similar values for rye grass silage.

Determined methan yields for silage made from rye grass ranged from 0.406–0.402 Nm^3 methan per kg of ODM for rye grass silage with DM content of 21% and 0.263–0.233 Nm^3 methan per kg of ODM for rye grass silage with DM content of 15% respectively. Our results are in correlation with other autors (Amon *et al.*, 2007; Prochnow *et al.*, 2009; Weiland, 2003) who observed similar values for rye grass silage.

Our work indicates that the rye grass silage in two different DM content is supplementary biomass for biogas plants based on traditional inputs (maize silage) and thus enhance the overall biogas production. In order to obtain maximum biogas yield, some parameters have to be considered when selecting a catch crop for biogas production, namely the crop species, the soil characteristics, the weather conditions, harvest time, the dry matter content, and the nitrogen application. All these parameters have direct impact on maximum biogas yield per kg of ODM.

Preliminary calculations on the economy in using catch crops for biogas production revealed that the economy is very dependent on the biomass yield per hectare and of the costs for harvesting, transportation to the biogas plant and biomass storage. In order to be able to analyse such effects, longer term experiments are required. Our findngs are fully in accordance with other authors (Molinuevo-Salces *et al.*, 2013; Wienforth *et al.*, 2010).

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