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THE BIOCHEMICAL METHANE POTENTIAL OF *Miscanthus giganteus* BIOMASS UNDER THE CONDITIONS OF MOLDOVA

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Abstract

Biomass production is one of the key sectors with significant potential for the production of renewable energy and diversification of rural economy in the Republic of Moldova. Obtaining biogas from biomass is one of the possibilities to produce renewable energy and to reduce greenhouse gas emissions. The decisive factors for the cultivation and exploitation of energy crops are the productivity, the chemical structure and the cost of production of phytomass. The genus Miscanthus in general, and Miscanthus giganteus in particular, has been selected and studied as one of the most promising energy crops in Europe, over the past two decades, because of an array of attributes including high photosynthetic efficiency, high stress tolerance, perennial growth, low nutrient requirements and high content of carbon. We investigated some biological peculiarities and the biochemical composition of Miscanthus giganteus biomass under different harvest regimes and on different dates: single mowing regime (June 16, August17, October 2) and double mowing regime (1st mowing on June and 2nd mowing on October). The samples were collected from the 3-year-old Miscanthus giganteus (cv. Titan) plants cultivated in the experimental land of the Botanical Garden (Institute). The results of our study, based on the near infrared spectroscopy (NIRS) technique, indicated that the biomass of Miscanthus giganteus harvested in June contained 1.63% nitrogen, 41.7% cellulose, 31.7% hemicelluloses, 4.9% acid detergent lignin and 7.4% ash; in August - 0.35% nitrogen, 50.1% cellulose, 32.0% hemicelluloses, 7.7% acid detergent lignin and 4.5% ash, but the biomass obtained by late single mowing in October - 0.59% nitrogen, 45.1% cellulose, 29.4% hemicelluloses, 6.6% acid detergent lignin and 6.6% ash, respectively. The chemical composition of the biomass of Miscanthus giganteus obtained during the 2nd mowing, did not differ essentially from the biomass obtained as a result of the 1st mowing in June, however, the amount of acid detergent lignin and hemicelluloses varied, reaching 5.7% and 28.0%, respectively. The biochemical methane potential of the biomass of Miscanthus giganteus, obtained during the 1st mowing in June, reached 314 L/kg, in August - 259 L/kg, of late single mowing regime in October - 277 L/kg and 2nd mowing in October - 293 L/kg, respectively.

***Key words**: biochemical methane production potential, harvest dates, Miscanthus × giganteus biomass, near infrared spectroscopy.*

INTRODUCTION

Taking into account the global rise in the demand for energy and the concerns associated with serious negative consequences, such as the depletion of the resources of fossil fuels and climate change caused by the growing greenhouse gas emissions, the use of alternative sources of energy is considered advantageous and environmentally friendly. The European Union intends to achieve a 20% share of renewable energy in overall energy consumption until 2020, leading to an increased share in the forthcoming years. Biomass production is one of the key sectors with significant potential for renewable energy production and diversification of rural economy in the Republic of Moldova. Phytomass has significant potential for meeting the future energy need, besides, agricultural lands offer an alternative to the traditional agriculture, which is referred to as energy farming (Hăbăşescu, 2011; Ţîţei, 2015). The use of traditional species as energy crops risks conflict with food uses. Domesticating new species specifically for energy production may allow access to species that are better suited to energy production and avoid diversion of food species. The accelerated domestication of new species should be able to take advantage of the growing understanding of the process of domestication and the knowledge of biological peculiarities, productivity and chemical composition of plants.

Perennial grasses play an important role as an extensive CO_2 sink significantly increases the content of soil carbon, dry organic matter possesses many beneficial attributes as energy crops, and there has been increasing interest in their use for this purpose in the US and Europe since the mid-1980s. The C_4-plants, having a more effective photosynthetic pathway, possess such features as resistance to aridity, high photosynthetic yield and a high rate of CO_2 capture when compared with C_3 plants (Lewandowski et. al., 2003). Based on their physiological properties, they have great potential of biomass production, frequently higher than the productivity of trees. Promising perennial grasses, C_4 photosynthetic pathway, belong to the genus *Miscanthus* Andersson, which includes about 16-25 species, found mostly in East Asia. The *Miscanthus sinensis* Andersson*, Miscanthus sacchariflorus* (Maxim.) Franch*., Miscanthus floridulus* Warb. ex K. Schum. and Lauterb*., Miscanthus lutarioriparius* L. Liu ex S.L. Chen and Renvoize and *Miscanthus giganteus* Greef et Deu. are the most commonly known and used (Xi, Jezowski, 2004; Arnoult, Brancourt-Hulmel, 2015; Lewandowski et al., 2016; Weijde et al., 2016; Kiesel, Lewandowski, 2017; Tejera, Heaton, 2017; Borso et al., 2018) .

The natural hybrid between *Miscanthus sinensis* x *Miscanthus sacchariflorus,* sterile triploid plant, was developed in Japan, introduced as ornamental plant in Denmark in 1935 and distributed to some European countries towards the end of 1970s. But its exact taxonomic position had not been examined in detail for a long time, and the plant was called *Miscanthus sinensis giganteus*, until Greef and Deuter (1993) conducted the syntaxonomy and nominated it as *Miscanthus×giganteus* Greef et Deu., and included it in genus *Miscanthus*, section *Triarrhena*, family *Poaceae* (Xi, Jezowski, 2004).

Transport energy in the form of biofuels requires sustainable high biomass production in a form that facilitates conversion to high quality fuel. The suitability of plants as feedstock for industrial conversion to biofuels and biomaterials varies depending upon the type of plant biomass and the processes used. The second generation of biofuels under development is based on the conversion of the structural carbohydrates; the plant cell wall has received much attention in recent years. The biogas obtained from biomass is one of the possibilities to produce renewable energy and to reduce greenhouse gas emissions. Its quantity and quality depend on the substrate used in the anaerobic digestion process. Identification of cell wall characteristics desirable for biorefining applications is crucial for lignocellulosic biomass improvement (Klimiuk et al. 2010; Dandikas et al., 2014; Arnoult, Brancourt-Hulmel, 2015; Lewandowski et al., 2016; Weijde et al., 2016; Kiesel, Lewandowski, 2017)

Near infrared reflectance spectroscopy (NIR) has been used in agriculture research for years, as a robust method, low cost and doing non-destructive measurements with limited sample preparation, providing quantitative and qualitative information (Vidican et al., 2000; Harmanescu, 2012; Jin et al., 2017).

The aim of this research was to evaluate some biological peculiarities and the biochemical composition of *Miscanthus giganteus* biomass obtained under different harvest regimes and on different dates, as feedstock for biogas production, under the conditions of the Republic of Moldova.

MATERIALS AND METHODS

The cultivar *Titan* of *Miscanthus giganteus,* which was cultivated in the experimental plot of the Botanical Garden (Institute), latitude 46°58′25.7″ and longitude N28°52′57.8″E, served as subject of this study. The green mass of 3-year-old plants was harvested manually under different harvest regimes and on different dates: single mowing regime (June 16, August 17, October 2) and double mowing regime - 1st mowing (June 17) and 2nd mowing (October 2). The dry matter content was detected by drying samples up to constant weight at 105°C. The content of neutral detergent fibre, acid detergent fibre and acid detergent lignin was evaluated using the near infrared spectroscopy (NIRS) technique PERTEN DA 7200 of the Research-Development Institute for Grassland Brasov, Romania. The biochemical biogas potential (Yb) and methane potential (Ym) were calculated according to the equations of Dandikas et al., 2014, based on the chemical compounds - acid detergent lignin (ADL) and hemicellulose (HC) values:

biogas potential Yb=727+0.25 HC-3.93 ADL; methane potential Ym=371+0.13HC-2.00ADL.

RESULTS AND DISCUSSIONS

It is known that the growth and development rates of plants influence of the biomass accumulation, the leaf share and the dry matter content in harvested biomass.

The biological peculiarities of *Miscanthus giganteus* are described in Table 1. The third growing season for *Miscanthus giganteus* began on April 10. The cultivar *Titan* was characterized by faster growth. The plants developed shoots that reached a height of 157 cm in mid-June, 260 cm in mid-August and in the period when the panicle development started, the first days of October - 385 cm. Analysing the results of the study on the influence of the harvest time on the leaf: stem ratio, we found that stem mass increased from 10.16 to 52.69 g, but the leaf mass from 10.94 to 25.64 g, which caused a decrease in the leaf content in the harvested biomass from 53.50 to 32.73%.

We may mention that after the harvest, the plants of the cultivar *Titan* of *Miscanthus giganteus* were characterized by a moderate rate of revival and, in early October, the stems reached 193 cm. The content of dry matter was higher (38.90%), in comparison with the first mowing (20.46%).

The biochemical composition and the biochemical methane potential of *Miscanthus giganteus* biomass under different harvest regimes and on different dates is presented in Table 2. The obtained results showed that the concentrations of nitrogen, ash, the neutral detergent fiber fraction, the acid detergent fiber fraction and the concentrations of lignin and cellulose differed significantly depending on the harvesting period.

Table 1. Some biological peculiarities of cv. *Titan* of *Miscanthus giganteus*

Harvesting period	Plant height, cm	Stem		Leaf		Leaves content in biomass, %
		green mass, g	dry matter, g	green mass, g	dry matter, g	
16 June	157	60.18	10.16	42.83	10.94	53.50
17 August	260	65.95	25.53	43.42	16.36	39.05
2 October (1st mowing)	385	102.0	52.69	61.64	25.64	32.73
2 October (2nd mowing)	193	30.11	11.76	26.54	10.30	46.69

Table 2. Biochemical composition and biochemical methane potential of cv. *Titan* of *Miscanthus giganteus*

Indices	Harvesting period			
	16 June 1st mowing	17 August 1st mowing	2 October 1st mowing	2 October 2nd mowing
Dry matter, g/kg	204.6	389.6	464.5	389.0
Nitrogen, %	1.63	0.35	0.59	1.09
Ash,%	7.4	4.5	6.6	7.6
Acid detergent fibre, %	46.6	57.8	51.7	46.7
Neutral detergent fibre, %	72.3	89.8	81.1	74.7
Acid detergent lignin,%	4.9	7.7	6.6	5.7
Cellulose, %	41.7	50.1	45.1	41.0
Hemicellulose, %	31.7	32.0	29.4	28.0
Biochemical biogas potential, L/kg VS	614	505	541	573
Biochemical methane potential, L/kg VS	314	259	277	293

In the biomass harvested in mid-August, there was a significant decrease in the nitrogen content (0.35%) and an increase in cellulose (50.1%) and acid detergent lignin content (7.7%), because of the more unfavourable weather conditions caused by the amount and distribution of rainfall and the number of days with air temperature above 30°C. The hemicellulose content was approximately the same level as in the biomass harvested in mid-June, but higher than in the biomass obtained as a result of the late single mowing, in October. The chemical composition of the biomass of *Miscanthus giganteus* obtained during the 2nd mowing in October did not differ essentially from the biomass harvested in mid-June, however, the amount of acid detergent lignin and hemicelluloses varied, reaching 5.7% and 28.0%, respectively.

The differences in the chemical composition of the biomass affected the biochemical biogas and methane potential of the biomass of

Miscanthus giganteus. The biochemical gas forming potential varied from 505 to 614 L/kg VS. The calculated biochemical methane potential under single mowing regime ranged from 259 to 314 L/kg VS, and 2nd mowing in October - 293 L/kg, respectively.

The obtained values are in good accordance with Kiesel and Lewandowski (2017) who reported, the substrate-specific methane yield of *Miscanthus x giganteus* biomass decreased with later harvest dates and reached 247 L/kg VS in October, and the significantly highest SMY was measured in the both cuts of the double-cut regime. In contrast Klimiuk et al. 2010 observed lower yields, 100 L/kg VS in *Miscanthus giganteus* silages prepared in autumn.

CONCLUSIONS

The obtained results showed that leaf: stem ratio, dry matter content, concentrations of nitrogen, ash, neutral detergent fiber fraction, acid detergent fiber, lignin and cellulose differed significantly depending on the harvesting period, which have influenced the methane yield.

The biomass of *Miscanthus giganteus* harvested in June contained 53.50% leaves, 20.46% dry matter, 1.63% nitrogen, 41.7% cellulose, 31.7% hemicelluloses, 4.9% acid detergent lignin and 7.4% ash; in August- 38.96%, 39.05%, 0.35%, 50.1%, 32.0%, 7.7% and 4.5%, but the biomass obtained by late single mowing in October -46.45%, 0.59% nitrogen, 45.1% cellulose, 29.4% hemicelluloses, 6.6% acid detergent lignin and 6.6% ash, respectively. The biochemical gas forming potential varied from 505 to 614 L/kg VS. The calculated biochemical methane potential under single mowing regime ranged from 259 to 314 L/kg VS, and 2nd mowing in October - 293 L/kg, respectively.

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