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THE AGROECONOMIC VALUE OF REED CANARY GRASS, *Phalaris arundinacea* IN REPUBLIC OF MOLDOVA

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Abstract

Grasses are considered as one of the most important sources of feed for herbivorous animals and feedstock for renewable energy production. The aim of the current study was to evaluate the biomass quality (green mass, hay and haylage) from reed canary grass, Phalaris arundinacea, cv. Premier grown under the conditions of the Republic of Moldova. A rapid predictive method based on near-infrared spectroscopy (NIRS) was developed to measure crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL) and total soluble sugars (TSS). The results of the research revealed that the harvested reed canary grass (first cut) contained 25.1-25.6% dry matter. The biochemical composition and energy value of prepared hay and haylage: 109-127 g/kg CP, 92-95 g/kg ash, 417-443 g/kg ADF, 695-708 g/kg NDF, 28-44 g/kg ADL, 62-64 g/kg TSS, 54.4-56.4% digestible dry matter, 10.87-11.23 MJ/kg digestible energy, 8.92-9.22 MJ/kg metabolizable energy and 4.94-5.24 MJ/kg net energy for lactation. The biochemical methane potential of investigated Phalaris arundinacea biomass were 335-362 l/kg ODM. Reed canary grass, cv. Premier, produces high yields with optimal nutrient content, can be used as feed for ruminant animals, as well as substrate for the production of biomethane by anaerobic digestion.

Key words: *biochemical composition, biomethane potential, fodder value, green mass, hay, haylage, Phalaris arundinacea.*

INTRODUCTION

Grasslands serve critical habitat for many plant and animal species, have tremendous economic value ensuring humans food, forage for herbivores and ruminants animals, and feedstock for biorefinery, provides an important regulating ecosystem service such as pest control, carbon storage, protection of soil from erosion and nutrient leaching, contributing to a recreational values and cultural heritage. Recently, the interest in the efficient use and conservation of grassland has been restarted, efforts to conserve the remaining permanent grasslands. The creation of grasslands on polluted and degraded agricultural land are underway in many states and around the world.

Forage nutritive value affects forage utilization by herbivores. Higher nutritive value grasses have the potential to significantly increase milk or meat production and profitability of an expanding animal husbandry industry. Productive reconversion, considers agronomic criteria, such as the changes of current species by native species or alternative crops that are apt to survive and produce in areas susceptible to conversion.

Poaceae is clearly the most abundant and important family, accounting for about 24% of the Earth's vegetation, contained belong to 777 plant genera and includes 11461 accepted species names. *The Plant List* includes 110 scientific plant names of species rank for the genus *Phalaris* of these 19 are accepted species names. Reed canary grass, *Phalaris arundnacea* L. (syn. *Baldingera arundinacea* (L.) Dumort; *Phalaroides arundinacea* (L.) Rauschert; *Typhoides arundinacea* (L.) Moench) is a long-lived perennial grass, native to Europe, C_3 photosynthetic pathway. The stem is sturdy, hairless and hollow with some reddish coloring in the upper part, 60 to 200 cm tall. The leaf blades are flat with prominent ligules, usually green, flat, glabrous and taper gradually, 30-45 cm long and 0.8-1.2 cm wide. The leaves of the lower stem become light deprived as the plant grows and are replaced with new leaves higher up the stem. The inflorescence is branched panicles 7 to 40 cm long. Immature panicles are compact and resemble spikes, but open and become slightly spreading at anthesis. Spikelets are lanceolate, 5 mm long and pale. The fruit is a caryopsis covered by coriaceous pallets, grain 1.5-4.0 mm long, 0.7-1.5 mm wide, containing a single grain, subovoid brown with faintly striate surface, the weight of 1000 seeds averages 0.9 g. *Phalaris arundinacea* develops an extensive, rhizomatous root system. New rhizomes originate almost entirely below the soil surface from buds at the nodes of other rhizomes. Roots and rhizomes may form an almost impenetrable sod.

A cool season grass, reed canary is one of the first grasses to sprout in spring, is adapted to poorly drained soils, it also is used for erosion control along streambanks, gullies, ponds, and lakes. It is very competitive once established and will frequently develop a solid monoculture. Reed canary grass has excellent frost tolerance and it also has good drought tolerance. It survives prolonged flooding by possessing anoxia tolerant rhizomes; once established, it can withstand continuous inundation for 60 to 70 days. Because of its importance as a pasture grass, most efforts to develop improved populations or cultivars have focused on solving problems related to agronomic performance or livestock utilization. New cultivars of reed canary grass have reduced gramine concentrations and no tryptamine or β-carboline alkaloids (Anderson et al., 2008). The productivity of *Phalaris arundinacea* reached 90 t/ha green mass, the digestible indices of nutrients: 72% crude protein, 55% crude fats, 65% crude cellulose and 72% nitrogen free extract (Medvedev & Smetannikova, 1981). This species has been an important component of permanent and temporary grassland, it has been the subject of much agricultural research (Alway, 1931; Chalupa et al., 1961; Tosi & Wittenberg, 1993; Ordakowski-Burk et al., 2006; Maruşca et al., 2011; Tokita et al., 2015), in the past decades has also been the subject of much research into biomass/energy crops which are suitable for biorefinery feedstocks (Anderson et al., 2008; Sepälä et al., 2009; Butkuté et al., 2014; Oleszek et al., 2019).

The objective of this research was to evaluate quality of the *Phalaris arundinacea,* and the possibility to use green mass, hay and haylage as feed for ruminant animals and feedstock for the production of biomethane.

MATERIALS AND METHODS

The cultivar *'Premier'* of reed canary grass *Phalaris arundinacea*, created in the Research-Development Institute for Grassland Brasov, Romania and grown in monoculture on the experimental land of National Botanical Garden (Institute) Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research.

The green mass was harvested manually. The samples were collected in pre-anthesis period (1-st cut) in second and third growing season. The leaves/stems ratio was determined by separating the leaves from the stem, weighing them separately and establishing the ratios for these quantities (leaves/stems). The prepared hay was dried directly in the field. The haylage was prepared from wilted green mass, shredded and compressed in well-sealed glass containers, after 45 days, the containers were opened and haylage were evaluated in accordance with standard laboratory procedures. Dry matter content was detected by drying samples up to constant weight at 105°C. Some assessments of the main biochemical parameters: protein, ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total soluble sugars (TSS) have been evaluated using the near infrared spectroscopy (NIRS) technique PERTEN DA 7200 of the Research-Development Institute for Grassland Brasov, Romania. The concentration of hemicelluloses (HC) and celluloses (Cel), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl)) were calculated according to standard procedures.

The carbon content of the substrates was obtained using an empirical equation reported by (Badger et al., 1979). The biochemical biogas potential (Yb) and methane potential (Ym) were calculated according to the equations of Dandikas et al. 2015, based on the protein (PB), acid detergent lignin (ADL) and hemicellulose (HC) values:

biogas Yb = 670 + 0.44PB + 0.16HC - 3.02ADL
biometan Ym = 370 + 0.21PB + 0.05HC - 1.61ADL

RESULTS AND DISCUSSIONS

We could mention that, the second growing season reed canary grass *Phalaris arundinacea* resumed growth and development in spring, in the middle March, when temperatures above 5-6 C were established, but in third growing season in the end March. The weather conditions in April-May 2019, with an optimal amount of rainfall, and lower air temperatures as compared with the previous year, helped the plants produce more shots and were favourable for their growth, development, and biomass production. The results regarding some agrobiological peculiarities of the *Phalaris arundinacea* 'Premier' and the structure of the harvested biomass are presented in Table 1. We would like to mention that the reed canary grass 'Premier', at the time of harvest, in the 2018 y. reached the height of 62.3 cm, but in 2019 y. the plants being the highest - 116.1 cm. In the harvested biomass the leaves content was 29.9-31.2%, the amount of dry matter - 25.1-25.6%. The green mass productivity from first cut in second growing season reached 35.9 t/ha, but in the third growing season 48.9 t/ha.

According to Maruşca et al. (2011) the potential yields of the *Phalaris arundinacea* 'Premier' in Romania were 65-80 t/ha green mass or 16-20 t/ha dry matter. Tokita et al. (2015) reported that the proportions of stem and leaf tissue in the harvested reed canary grass, were 62.0% and 29.0% at first cut, and 44.0% and 56.0%, respectively at second cut.

Table 1. Some agrobiological peculiarities and the structure of the green mass of the *Phalaris arundinacea* 'Premier'

Harvest period	Plant height, cm	Leaf, g		Stem, g		Productivity, t/ha	
		green mass	dry matter	green mass	dry matter	green mass	dry matter
Second growing season, 2018 y.	62.3	3.19	0.82	7.24	1.81	35.9	9.1
Third growing season, 2019 y.	116.1	3.92	1.03	9.79	2.42	48.9	12.5

Table 2. Biochemical composition and nutritive value of fodder from Phalaris *arundinacea* 'Premier'

Indices	second growing season, 2018 y.		third growing season, 2019 y.		
	green mass	hay	green mass	hay	haylage
Crude protein, g/kg	144	124	109	109	127
Minerals, g/kg	89	86	74	92	95
Acid detergent fibre, g/kg DM	375	387	411	443	417
Neutral detergent fibre, g/kg DM	615	623	685	708	695
Acid detergent lignin, g/kg DM	36	39	36	44	28
Total soluble sugars, g/kg DM	-	-	115	64	62
Digestible dry matter, %	59.7	58.8	56.9	54.4	56.4
Dry matter intake, % BW	1.95	1.93	1.75	1.69	1.73
Relative feed value	90	88	77	72	75
Digestible energy, MJ/ kg	11.82	11.65	11.32	10.87	11.23
Metabolizable energy, MJ/ kg	9.70	9.56	9.29	8.92	9.22
Net energy for lactation, MJ/ kg	5.72	5.58	5.31	4.94	5.24

Analyzing the results of the green mass quality of the *Phalaris arundinacea* 'Premier', Table 2, we found that dry matter of the harvested green mass contained 109-144 g/kg CP, 74-89 g/kg ash, 375-411 g/kg ADF, 615-685 g/kg NDF, 36 g/kg ADL, 115 g/kg TSS, 56.9-59.7% DDM. The natural fodder have RFV= 77-90, 11.32-11.82 MJ/kg DE, 9.29-9.70 MJ/kg ME and 5.31-5.72 MJ/kg NEl. The concentrations of crude protein was high in the natural fodder second growing season. The level of structural carbohydrates increased substantially in the fodder third growing season, which had a negative effect on digestibility, relative feed value and energy content. Some authors mentioned various findings about the green mass quality of the reed canary grass, *Phalaris arundinacea*. Jansone et al. (2012) mentioned that yields of studied reed canary grass varieties was 8.06-9.67 t/ha DM, crude protein contents 115.6-120.7 g/kg DM, digestible protein 37.8-45.4%. Tokita et al. (2015), reported that the nutrients contents of stems and leaves in harvested mass at the first cut were: 9.3% and 21.6% CP, 1.2 and 3.7% fat, 70.9 and 52.1% NDF, 42.0 and 24.4% ADF, 4.0 and 1.8% ADL, with digestibility 57.0 and 70.9 %, energy content 4119.9 and 4591.8 cal/g, respectively. Villalobos (2012), remarked that nutritional value of reed canary grass were 16.65-19.47% CP, 53.18-57.77% NDF, 34.60-36.86% ADF, 3.78-4.42% lignin, 18.79-20.91% hemicellulose, 31.04-32.34% cellulose, 63.38-70.55% IVDMD with estimated energy content 2.72-2.81 Mcal/kg DE, 2.10-2.18 Mcal/kg ME, 1.29-1.34 Mcal/kg NEl.

The period of winter feeding in our region lasts for about 200 days. Thus the production of preserved forages (hay, silage, haylage) is necessary, which enable the uniform and fully-valuable animal feeding during the whole year. Hay is a very popular and valuable feed for farm animals, a rich source of protein, vitamins and minerals, both in winter and throughout the year, especially for the young animals, pregnant females and breeding males. Feeding high quality hay can also reduce the level of grain supplementation needed during winter. The presence of bulky forages, including hay, in a feeding dose is essential, which determines the proper function of digestive track the fat content in milk. The prepared hay from *Phalaris arundinacea* 'Premier' contained 109-124 g/kg CP, 86-92 g/kg ash, 623-708 g/kg NDF, 387-443 g/kg ADF, 39-44 g/kg ADL, 54.4-58.8% DDM, 8.92-9.56 MJ/kg ME and 4.94-5.58 MJ/kg NEl. Thus, the preparation of the hay resulted in a decrease in the content of crude protein and an essential increase in the content of structural carbohydrates as compared with the freshly harvested mass, and fact had a negative impact on the net energy for lactation and relative feed values.

Several literature sources describe the nutritional performance of hay made from *Phalaris arundinacea*. Chalupa et al. (1961) found that hay contained 127.2-216.4 g/kg CP, 32.5-46.8 g/kg EE, 22.7-268.0 g/kg CF, 356.4-406.0 g/kg NFE, 62.2-70.2 g/kg ash, 536.3-604.2 g/kg total digestible nutrients and 2.407-2.694 Mcal/kg DE, the high-N fertilized applications rate increased the content of crude and digestible protein, fats, total digestible nutrients and energy, while crude fiber and nitrogen-free extract decreased. Archibald et al. (1962), reported that the composition of hay fed was: 21.3% CP, 2.3% EE, 29.1% CF, 37.2% NFE, 10.1% ash, 4.0% sugar, 20.3% cellulose, 5.6% lignin and 19.1% pentosans. Tosi & Wittenberg (1993), remarked that hay produced from reed canary grass contained 10.8-12.2% CP, 61.5-62.8% NDF, 36.7-38.0% ADF with 56.7-64.6% apparent dry matter digestibility, but timothy hay contained 14.4% CP, 59.2% NDF, 33.8% ADF with 60.9% apparent dry matter digestibility. According to Ordakowski-Burk et al. (2006) the nutrient composition of reed canary grass hay was 17.1% CP, 65.4% NDF, 33.5% ADF, 1.8% ether extract, 1.2% starch, 9.6% sugar and 2.3 Mcal/kg DE for horses, but timothy hay-14.4% CP, 62.6% NDF, 35.0% ADF, 2.5% ether extract, 1.6% starch, 11.5% sugar and 2.2 Mcal/kg DE for horses, respectively.

The preserved grass (silage and haylage) is the basis of most winter feeding systems and satisfactory animal performance is largely dependent on the adequate intake of good quality roughage fed. During the organoleptic assessment, it was found that the colour of the prepared haylage from *Phalaris arundinacea* 'Premier' was homogeneous olive, with pleasant smell, similar to pickled vegetables. The fermentation quality of haylage made from *Phalaris arundinacea* 'Premier' is illustrated in Table 3. The haylage material consolidated well and the fermentation was complete with pH values 4.65. It has been determined that the amounts of organic acids reached 34.8 g/kg DM, most organic acids in fixed form. The content of lactic acid reached 83.9 %, butyric acid was detected in fixed form- 1.4 %.

Table 3. The fermentation quality of the haylage from *Phalaris arundinacea* 'Premier'

Indices	*Phalaris arundinacea*
pH index	4.65
content of organic acids, g/kg	34.8
free acetic acid, g/kg	2.1
free butyric acid, g/kg	0.0
free lactic acid, g/kg	9.7
fixed acetic acid, g/kg	3.0
fixed butyric acid, g/kg	0.5
fixed lactic acid, g/kg	19.5
total acetic acid, g/kg	5.1
total butyric acid, g/kg	0.5
total lactic acid, g/kg	29.2
acetic acid, % of organic acids	14.7
butyric acid, % of organic acids	1.4
lactic acid, % of organic acids	83.9

The results of the investigations (Table 2) indicate that haylage from *Phalaris arundinacea* 'Premier', contained 127 g/kg CP, 95 g/kg ash, 695 g/kg NDF, 417 g/kg ADF, 28 g/kg ADL, with 56.4% DDM, 9.22 MJ/kg ME and 5.24 MJ/kg NEl. Thus, the preparation of the haylage resulted in a increase in the content of crude protein and an reduce level of structural carbohydrates as compared with the hay, and fact had a positive impact on the increase net energy for lactation. A similar relationship was noted in other study. Oleszek & Matyka (2017), remarked the chemical composition of ensiled reed canary grass were: 11.7% CP, 2.6% EE, 10.2% ash, 7.7% NFC, 32.2% cellulose, 26.6% hemicellulose, 8.6 % ADL. Utama et al. (2018) mentioned that prepared reed canary grass haylage contained: 547 g/kg DM, 11.1% CP, 2.6% fats, 7.3% ash, 38.5% CF, 66% NDF, 9.4 MJ/kg metabolizable energy.

Table 4. Biochemical composition and biomethane production potential of *Phalaris arundinacea* 'Premier' substrates

Indices	second growing season, 2018 y.		third growing season, 2019 y.		
	green mass	hay	green mass	Hay	haylage
Crude protein, g/kg DM	144	124	109	109	127
Minerals, g/kg DM	89	86	74	92	95
Nitrogen, g/kg DM	23	19.8	17.4	17.4	20.3
Carbon, g/kg DM	50.6	50.8	51.4	50.4	50.3
Ratio carbon/nitrogen	22	26	30	29	25
Cellulose, g/kg DM	339	348	375	399	389
Hemicellulose, g/kg DM	240	236	274	265	278
Acid detergent lignin, g/kg DM	36	39	36	44	28
Bio biogas potential, L/kg VS	663	645	653	627	686
Biomethane potential, L/kg VS	354	345	349	335	362

Biogas is one of the three most important biofuels in terms of raw material availability and costs of production. The technology of biomass conversion through anaerobic digestion and biomethane production represents the source of renewable energy with great potential, environmentally friendly and rapidly expanding in the latest years. The concentrations of organic constituents in the biomass and their availability, the carbon nitrogen ratio (C/N) plays a crucial role in the process of biomethane production (Vintilă & Neo, 2011; Vintilă et al. 2012; Dandikas et al. 2015).

The results regarding of the substrates quality and its biochemical methane potential are shown in Table 4. We found that investigated substrates from *Phalaris arundinacea* 'Premier', according to the C/N ratio, which constituted 22-30, met the established standards. The essential differences were observed between the content of cellulose, hemicellulose and lignin. The haylage substrate contained an acceptable amount of hemicellulose and a lower content of lignin as compared with the other substrates. The biochemical methane potential of investigated reed canary grass hay substrates was 335-345 l/kg ODM, green mass substrates 349-354 l/kg ODM, but haylage substrate reached 362 l/kg ODM. Krzystek et al. (2020), indicated the biogas potential of reed canary grass silage 490 l/kg and an annual methane productivity 2558 m^3/ha. Alvinge (2010) mentioned that the methane yield for *Phalaris arundinacea* was 323 l/kg, but *Typha latifolia*- 300 l/kg. Sepälä et al. (2009) obtained 296 l/kg from *Phalaris arundinacea.* Butkuté et al., 2014 reported that reed canary grass biomass contained: 37.2-42.2% cellulose, 19.0-22.9.0% hemicellulose, 3.17-7.66% ADL, with C/H=21.9-33.1 and its biomethane potential 316-426 l/kg VS.

CONCLUSIONS

The green mass productivity of *Phalaris arundinacea* 'Premier', at the first harvest, reached 35.9-48.9 t/ha, the dry matter contained 109-144 g/kg CP, 74-89 g/kg ash, 375-411 g/kg ADF, 615-685 g/kg NDF, 36 g/kg ADL, 115 g/kg TSS, 56.9-59.7% DDM, 11.32-11.82 MJ/kg DE, 9.29-9.70 MJ/kg ME and 5.31-5.72 MJ/kg NEl.

The biochemical composition and energy value of prepared hay and haylage can reach 109-127 g/kg CP, 92-95 g/kg ash, 417-443 g/kg ADF, 695-708 g/kg NDF, 28-44 g/kg ADL, 62-64 g/kg TSS, 54.4-56.4% digestible dry matter, 10.87-11.23 MJ/kg digestible energy, 8.92-9.22 MJ/kg metabolizable energy and 4.94-5.24 MJ/kg net energy for lactation.

The biochemical methane potential of the studied substrates was 335-362 l/kg ODM.

Under the conditions of the Republic of Moldova, the cultivar *'Premier'* of reed canary grass produces high yields with optimal nutrient content and can be used as feed for ruminant animals, as well as substrate for the production of renewable energy.

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