

## THE PRODUCTIVITY AND THE QUALITY OF GREEN MASS AND HAY FROM ROMANIAN CULTIVARS OF *FESTUCA ARUNDINACEA*, GROWN IN THE REPUBLIC OF MOLDOVA

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**Abstract:** Grasses are considered as one of the most important sources in low-cost feed for animals, but also a substrate for the production of renewable energy. We studied the quality of the freshly harvested biomass and hay of Romanian cultivars of tall fescue *Festuca arundinacea*: 'Adela', 'Brio', 'Măgurele 5', created at the Research and Development Institute for Grasslands, Brașov, Romania and cultivated in the experimental plot of the National Botanical Garden (Institute) “Alexandru Ciubotaru”, Chisinau, Republic of Moldova. The samples for assessment were taken in the 2<sup>nd</sup> year of growth, when the plants were cut for the 1<sup>st</sup> time. The amount of dry matter (DM), crude protein (CP), crude ash (CA), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose (Cel), hemicellulose (HC), digestible dry matter (DDM), organic matter digestibility (OMD), relative feed value (RFV), the metabolizable energy (ME), the net energy for lactation (NEL), biomethane production potential (BMP) were analyzed. It has been determined that the green mass productivity of the tall fescue cultivars achieved 30.83-36.96 t/ha, the dry matter contained 114-136 g/kg CP, 74-89 g/kg CA, 582-593 g/kg NDF, 392-396 g/kg ADF, 34-41 g/kg ADL, 322- 329 g/kg Cel, 226-229 g/kg HC, 60.3-63.8% DDM and 57.2-62.2% OMD, 9.12-9.62 MJ/kg ME and 5.69-5.86 MJ/kg NEL; the hay dry matter contained 99-117 g/kg CP, 80-86 g/kg CA, 582-593 g/kg NDF, 356-366 g/kg ADF, 34-37 g/kg ADL, 351-356 g/kg Cel, 236-260 g/kg HC, 55.8-57.2% DDM and 51.4-53.3% OMD, 9.51-9.59 MJ/kg ME and 5.53-5.59 MJ/kg NEL, this fact indicates a optimal quality of the roughage feed for ruminants. The substrate for the anaerobic digestion, consisting of fresh mass of tall fescue, had a biomethane production potential of 349-354 L/kg of organic matter. The studied cultivars of tall fescue could be used in the Republic of Moldova for the restoration of degraded permanent grasslands, as a component of the mix of grasses for the creation of temporary grasslands and can be planted between rows in vineyards and orchards. Besides, the obtained biomass can be used as feed for animals or as substrate at biomethane production plants.

**Keywords:** biomethane production, cv. *Adela*, cv. *Brio*, cv. *Măgurele 5*, feed value, *Festuca arundinacea*, productivity.

### Introduction

Grasslands are important as habitat for many plant species, including species at risk, provide soil and water conservation, nutrient recycling, pollination, habitat for livestock grazing, genetic material for crops, recreation, climate regulation, and storage for about 34% of the terrestrial global carbon stock. Grasses are considered as one of the most important sources in low-cost feed for domestic herbivores animals [COTIGĂ, 2010; MARUȘCA & al. 2011; BAHCIVANJI & al. 2014], but also a feedstock for the production of renewable energy [ENIRY & O'KIELY, 2014; ROMAN & al. 2015; KANDEL & al. 2017].

An important component of the land resources of Romania is the area of 4.9 million hectares of permanent grasslands, considered, quite rightly, a national treasure because it represents 33% of the agricultural land, occupying, in Europe, the 5<sup>th</sup> place, 68% of which

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are pastures and 32% – hayfields [MARUȘCA & al. 2014]. Permanent grassland in the Republic of Moldova constitutes 10.1% of the territory, represented by 339000 ha of pastures and 2000 ha hayfields. The productivity of natural grasslands on slopes is low and of poor quality, reaching 400-600 kg/ha of hay, and that of floodplain grasslands is higher – 2000-2600 kg/ha of hay. Uncontrolled grazing has diminished the abundance and dominance of typical grassland species, and thus they have been replaced by adventitious, segetal, quarantine weeds and other non-fodder and poisonous species [BAHCIVANJI & al. 2014; LAZU, 2014; LEAH, 2016]. In the vegetation of the permanent grasslands, the most common plant species with high fodder value are representatives from *Poaceae* and *Fabaceae* families.

*The Plant List* includes 1741 scientific plant names of species rank for the genus *Festuca*, Family *Poaceae*, of these 646 are accepted species names. Globally, the species of the genus *Festuca* L. are common in the floristic composition of permanent and temporary grasslands.

Tall fescue *Festuca arundinacea* Schreber. (syn. *Lolium arundinaceum* (Schreb.) Darbysh.; *Schedonorus arundinaceus* (Schreb.) Dumort.) is a long-lived perennial grass, native to Europe, C<sub>3</sub> photosynthetic group, with vigorous and erect culms 60 to 200 cm tall. Leaves form basal tufts, blades are 20-70 cm long and 3-12 mm wide. A tuft produces 10 to 30 flowerstalks. The inflorescence is an open to narrow branched panicle 12 to 35 cm long. Spikelets are three to nine flowered. Lemmas are awnless to short-awned. The fruit is a caryopsis with adherent pericarp, brownish-yellow, glabrous, oblong to ellipsoid, 6-9 mm long, the weight of 1000 seeds 1.8-2.6 g. Tall fescue develops an extensive and robust root system which reaches up to 150 cm deep, is characterised by secretions that contribute to the mobilization and use of nutrients from the soil, adapts well to conditions of excess moisture as well as drought, at the same time, it develops normally on soils with pH 5.5-8.0, on eroded hills and slightly salty soil. Tall fescue reproduces by seed and increases vegetatively, produces new tillers from the root crown. It is perennial and is favored by the development of short stolons, thus, in periods with excess humidity, they provide the whole root system with oxygen. Tall fescue is common in wet, alluvial grasslands, and in various areas – from plains to mountains, it has medium feed value, is resistant to grazing, being an effective solution in preventing the problems related to rumen acidosis in cows [WALSH, 1995; COTIGĂ, 2010; MARUȘCA & al. 2011]. *Festuca arundinacea* is among the perennial species with the highest frequency in the floristic composition of temporary grasslands, buffer strips and lawns in green spaces. This species is almost always present in the mixtures of grassland species used in Switzerland, France and the Netherlands, as well as in the scientific recommendations developed and implemented by the Research and Development Institute for Grasslands Brașov, Romania [MARUȘCA & al. 2014].

The valorification of renewable energy is a very topical subject at global and local level, and, the production and use of phytomass to obtain different types of fuel is very promising in our region [ROMAN & al. 2015]. The research carried out has helped us find out that the solid biofuel from the dried biomass of *Festuca arundinacea* has specific density of 600-660 kg/m<sup>3</sup>, calorific value of 16.82-17.34 MJ/kg and ash content of 2.3-3.6% [ȚÎȚEL, 2015].

The aim of the current study consisted in determining the productivity of some Romanian cultivars of *Festuca arundinacea* grown under the conditions of the Republic of Moldova, the quality of the green mass and hay as roughage feed for ruminant animals, as well as substrate for the production of biomethane by anaerobic digestion.

## Material and methods

The Romanian cultivars of tall fescue, *Festuca arundinacea*: 'Adela', 'Brio', 'Măgurele 5', created at the Research-Development Institute for Grasslands Braşov, România and cultivated in the experimental plot of the National Botanical Garden (Institute) "Alexandru Ciubotaru", Chişinău, latitude 46°58'25.7"N and longitude N28°52'57.8"E, served as subjects of the research.

The green mass was harvested manually. The samples were collected after cutting the plants for the 1<sup>st</sup> time in the second growing season, in the pre-anthesis period, in 2018. The leaf/stem 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 dry matter content was detected by drying the samples to a 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), digestible dry matter (DDM), organic matter digestibility (OMD) have been evaluated using the near infrared spectroscopy (NIRS) technique PERTEN DA 7200 of the Research and Development Institute for Grassland Braşov, România. The concentration of hemicellulose (HC) and cellulose (Cel), the relative feed value (RFV), the digestible energy (DE), the metabolizable energy (ME) and the net energy for lactation (NEL) were calculated according to standard procedures.

The carbon content of the substrates was obtained from data on volatile solids, using an empirical equation reported by BADGER & al. (1979). The biochemical biogas potential (Y<sub>b</sub>) and the methane potential (Y<sub>m</sub>) were calculated according to the equations elaborated by DANDIKAS & al. (2015), based on the chemical compounds – protein, acid detergent lignin (ADL) and hemicellulose (HC) indices:

$$\text{biogas } Y_b = 670 + 0.44PB + 0.16HC - 3.02ADL$$

$$\text{metan } Y_m = 370 + 0.21PB + 0.05HC - 1.61ADL$$

## Results and discussions

The leaf/stem ratio essentially influences the chemical composition of the harvested phytomass to be used as feed for animals or as feedstock for biorefinery and obtaining different industrial products. The results regarding some agrobiological peculiarities of the studied cultivars of tall fescue, *Festuca arundinacea*, and the structure of the harvested biomass are presented in Table 1. We would like to mention that the studied cultivars of tall fescue, at the time of harvest, in the middle of May 2018, reached the height of 68.3-75.0 cm, the plants of the cv. 'Brio' being the highest. In the tall fescue harvested biomass the leaves content was 53.9-57.1%, the amount of dry matter – 23.4-25.8%. The green mass productivity did not differ essentially of the cv. 'Adela' and cv. 'Brio' (36.34-36.96 t/ha) being higher in comparison with the cv. 'Măgurele 5' (30.83 t/ha).

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**Table 1.** Some agrobiological peculiarities and the structure of the harvested biomass of the studied cultivars of tall fescue *Festuca arundinacea*

Cultivars	Plant height, cm	Leaf, g		Stem, g		Productivity, t/ha	
		green mass	dry matter	green mass	dry matter	green mass	dry matter
<i>Adela</i>	73.8	1.63	0.36	1.71	0.42	36.34	8.51
<i>Brio</i>	75.0	1.59	0.36	1.83	0.48	36.96	8.98
<i>Măgurele 5</i>	68.3	1.48	0.34	1.62	0.42	30.83	7.96

Because feeding costs can account for over 50% of the cost of livestock production, knowing forage quality and the needs of animals can have a significant impact on profitability. Analyzing the results of the evaluation of the biochemical composition of the dry matter from the harvested mass of the studied cultivars of tall fescue, Table 2, we found that the cultivar 'Adela' was characterized by a higher content of proteins (13.6%), as compared with the cultivar 'Brio' (11.4%). The cultivars 'Adela' and 'Măgurele 5' did not differ essentially in the amount of ADF and NDF, cellulose and ash in the dry matter. The cultivar 'Brio' had a lower concentration of ADF, NDF, ADL, cellulose and ash, which had a positive effect on digestibility. The cultivars 'Brio' and 'Măgurele 5' had similar concentrations of hemicelluloses in the dry matter, but lower concentrations compared with the cultivar 'Adela'.

The amount of nutrients in fodder and their digestibility influence the health of animals and the amount and quality of animal products. The digestibility of dry matter and organic matter in the cultivar 'Brio' reached 63.8% and 62.0% respectively, being higher in comparison with other cultivars. We found that the cultivar 'Măgurele 5' was characterized by lower digestibility, determined, among other things, by the increased content of acid detergent lignin.

**Table 2.** Biochemical composition and nutritive value of the green mass of the studied cultivars of tall fescue *Festuca arundinacea*

Indices	Cultivar <i>Adela</i>	Cultivar <i>Brio</i>	Cultivar <i>Măgurele 5</i>
Crude protein, g/kg DM	136	114	128
Acid detergent fibre, g/kg DM	364	356	366
Neutral detergent fibre, g/kg DM	593	582	592
Acid detergent lignin, g/kg DM	35	34	37
Cellulose, g/kg DM	329	322	329
Hemicellulose, g/kg DM	229	226	226
Crude ash, g/kg DM	89	74	89
Digestible dry matter, %	62.2	63.8	60.3
Organic matter digestibility, %	59.1	62.0	57.2
Digestible energy, MJ/ kg	11.46	11.75	11.09
Metabolizable energy, MJ/ kg	9.37	9.62	9.12
Net energy for lactation, MJ/ kg	5.86	6.02	5.69
Relative feed value	95	98	95
Potential crude protein, kg/ha	1157	1024	1020
Potential metabolizable energy, GJ/ ha	79.74	86.39	72.60

The relative feed value (RFV) is an index that characterizes the quality of the feed by the potential capacity of the animals' body to assimilate the digestible dry matter from the feed. The studied cultivars of tall fescue had a relative feed value of 95-98 points, being of moderate to high quality in comparison with alfalfa. The experimental data indicated above reveal that the metabolizable energy of the tall fescue feed was 9.12-9.67 MJ/kg, and the net energy for lactation reached 5.69-6.02 MJ/kg. The highest potential for accumulation of crude protein was found in the cultivar 'Adela' (1157 kg/ha) and the highest metabolizable energy – in the cultivar 'Brio' (86.39 GJ/ha).

Hay is a very popular form of preserved fodder 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. To most livestock farmers, crude protein (CP) and relative feed values (RFV) are the basis on how much hay to buy or feed livestock [ANGIMA & KALLENBACH, 2008]. The quality of the hay prepared from studied cultivars of tall fescue *Festuca arundinacea*, are presented in Table 3. The prepared hay prepared contained 99-117 g/kg CP, 80-86 g/kg CA, 582-593 g/kg NDF, 356-366 g/kg ADF, 34-37 g/kg ADL, 351-356 g/kg Cel, 236-260 g/kg HC, 55.8-57.2% DDM and 51.4-53.3% OMD, 9.51-9.59 MJ/kg ME and 5.53-5.59 MJ/kg NEI. 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.

**Table 3.** Biochemical composition and nutritive value of the hay prepared from of the studied cultivars of tall fescue, *Festuca arundinacea*

Indices	Cultivar <i>Adela</i>	Cultivar <i>Brio</i>	Cultivar <i>Măgurele 5</i>
Crude protein, g/kg DM	117	99	108
Acid detergent fibre, g/kg DM	392	386	392
Neutral detergent fibre, g/kg DM	638	646	628
Acid detergent lignin, g/kg DM	36	34	41
Cellulose, g/kg DM	356	352	351
Hemicellulose, g/kg DM	246	260	236
Crude ash, g/kg DM	86	99	108
Digestible dry matter, %	57.2	56.3	55.8
Organic matter digestibility, %	52.0	53.3	51.4
Digestible energy, MJ/ kg	11.59	11.66	11.59
Metabolizable energy, MJ/ kg	9.51	9.59	9.51
Net energy for lactation, MJ/ kg	5.53	5.59	5.53
Relative feed value	85	87	86

Different results regarding the biochemical composition and the nutritive value of the green mass and hay from *Festuca arundinacea* are given in the specialized literature. Thus, the research conducted in Argentina by SCHENEITER & al. (2014), revealed that, depending on the harvest time, the yield increased from 0.64 to 2.82 t/ha DM, the NDF content increased from 503 to 604 g/kg and the digestibility decreased from 684 to 558 g/kg. FLORES & al. (2017), mentioned that, in the USA, tall fescue contained 56.5-67.8% NDF, 27.7-34.9% ADF, 28.8-34.0% hemicellulose, 25.0-28.1% cellulose, 3.61-10.05% lignin. ENIRY & O'KIELY (2014), mentioned that, in Ireland, the biomass of *Festuca arundinacea*,

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harvested on 12 May, contained 15.2% protein, 8.6% ash, 52.9% NDF, 26.7% ADF, 16.1% soluble carbohydrates, and the biomass harvested on 9 June contained 11.2% protein, 9.0% ash, 62.3% NDF, 37.2% ADF, 9.2% soluble carbohydrates. POČIENĚ & KADŽIULIENĚ (2016), found that the biomass of tall fescue, depending on the amount and type of applied fertilizers, contained 14-20% hemicellulose, 34-36% cellulose and 6-9% lignin. In Turkey the hay yield in pure *Festuca arundinacea* stands varied from 3.7 to 11.6 t/ha and concentration of crude protein from 10.0 to 10.9% depending on the dose nitrogen fertiliser (KOC & al. 2004), in USA hay prepared from tall fescue cv. Kentucky 31 contained 6.37-7.85% crude protein with RFV 96-98 [ANGIMA & KALLENBACH, 2008].

**Table 4.** Chemical composition and biomethane production potential of green mass substrates from the studied cultivars of tall fescue, *Festuca arundinacea*

Indices	Cultivar <i>Adela</i>	Cultivar <i>Brio</i>	Cultivar <i>Măgurele 5</i>
Crude protein, g/kg DM	136	114	128
Minerals, g/kg DM	89	74	89
Carbon, g/kg DM	506.1	514.4	506.1
Nitrogen, g/kg DM	21.8	18.2	20.5
Carbon/nitrogen ratio	23	28	25
Acid detergent lignin, g/kg DM	35	34	37
Hemicellulose, g/kg DM	229	226	226
Biogas potential, L/kg VS	661	654	651
Biomethane potential, L/kg VS	354	351	349
Methane productivity, m <sup>3</sup> /ha	3013	3152	2778

The biomass is converted into biogas by anaerobic digestion in special devices, called anaerobic digesters, by a wide variety of microorganisms, and this process results in fuel gas, which consists of methane and carbon dioxide, and digestate, which is rich in macro- and micronutrients and can be used as fertilizer in organic farming. The carbon nitrogen ratio (C/N) of biomass plays a crucial role in the process of decomposition of organic matter by microorganisms. DOBRE & al. (2014) mentioned that the optimal C/N ratio was expected to be in the range 15-25, when the anaerobic digestion process was carried out in a single stage and for the situation when the process developed in two steps, the optimal C/N ratio ranged between 10-45 for step I and 20-30 for step II. The results regarding the quality of the substrate and the potential for obtaining biogas and biomethane from the freshly harvested mass of the studied cultivars are shown in Table 4. We found that the substrate of *Festuca arundinacea*, according to the C/N ratio, which constituted 23-28, the amount of acid detergent lignin (34-37 g/kg) and hemicellulose (226-229 g/kg) met the established standards. No essential differences were observed between the studied cultivars, in the potential for biogas (651-661 l/kg organic matter) and biomethane production (349-354 l/kg organic matter). Methane productivity ranged from 2778 to 3152 m<sup>3</sup>/ha. The cultivars 'Brio' and 'Adela' were characterised by higher indices due to a higher yield of biomass. KANDEL & al. (2017), indicated a potential methane productivity of tall fescue biomass, from the 1st harvest, of 401-428 l/kg and an annual productivity, from three harvests per growing season, of 6871 m<sup>3</sup>/ha, in Denmark. ENIRY & O'KIELY (2014), mentioned that the potential methane productivity of tall fescue biomass was 216-268 l/kg, varying depending on the harvest time.

## Conclusions

Tall fescue, *Festuca arundinacea*, is a perennial grass with economic and social interest, and the Romanian cultivars 'Brio' and 'Adela' can be used in the Republic of Moldova to restore degraded permanent grasslands, as a component of the mixtures of plants sown to create temporary grasslands, grass strips in vineyards and orchards, and the harvested biomass can be used as fodder for animals and as substrate for the production of biomethane in anaerobic digesters.

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