Biblid: 1821-4487 (2018) 22; 3; p 122-124
UDK: 622.767.2

Original Scientific Paper
Originalni naučni rad

BIOMASS QUALITY OF DIFFERENT GENOTYPES OF SWITCHGRASS (*Panicum virgatum* L.) FOR ANIMAL FEED

KVALITET BIOMASE RAZLIČITIH GENOTIPOVA ENERGETSKE VRSTE *Panicum virgatum* L. ZA ISHRANU ŽIVOTINJA

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ABSTRACT

Switchgrass (Panicum virgatum L.*) originates from North America as one of the species found in the highland prairie. As an energy crop, it has great potential and is widely used in developed countries. It can be used for erosion prevention (due to a strong root system), bird feeding, and landscape architectural purposes (as an ornamental species). In low-quality soils, switchgrass provides protection against erosion and grass cover for grazing. In this paper, we examined the biomass quality of 14 genotypes of switchgrass for animal feed. The cutting of switchgrass was performed on the same day, including all the genotypes examined (mostly in the pre-flowering stage, or at the beginning of flowering). The following parameters of switchgrass biomass quality were analysed: crude protein, crude cellulose, fat content, ash content, NFE, ADF and NDF. In Serbia, this species can be a component of grass mixtures used in lesser quality soils and under dry agroecological conditions.*

***Key words**: biomass, quality, Panicum virgatum* L.*, animal feeding.*

REZIME

Vrsta Panicum virgatum L. *(engleski - switchgrass) potiče iz Severne Amerike gde je široko rasprostranjena i jedna je od dominantnih vrsta u visokotravnoj preriji. Prirodna oblast prostiranja ove vrste je od 55^{o} Severne geografske širine pa sve do centalnog Meksika, što znači da je prilagođena na širok raspon zemljišnih i kimatskih uslova. Kao energetski usev, ispoljila je veliki potencijal i uveliko se koristi kako u Americi, tako i u razvijenim zemljama Evrope. Može se koristiti u zaštiti od erozije zbog jakog korenovog sistema. Koristi se u pejzažnoj arhitekturi kao dekorativna vrsta, dok se seme koristi za ishranu ptica. Pošto dobro uspeva i na zemljištima slabijeg kvaliteta, može se koristiti i za ispašu naročito na nepristupačnim, kamenitim i peskovitim terenima gde ima dvojaku ulogu: kao zaštita od erozije i kao travni pokrivač za ispašu. U Americi se koristi za zasnivanje višekomponentnih sejanih pašnjaka zbog sposobnosti proizvodnje zelene mase tokom toplih letnjih meseci kada su ostale travne komponente u smeši malo ili nimalo produktivne. U srpskom jeziku ne postoji poseban naziv za ovu vrstu. Grupa autora je predložila naziv "prerijsko proso" kao srpski prevod za englesku reč "switchgrass" (Janković et al., 2017). U Institutu za krmno bilje postoji kolekcija energetskih vrsta trava poreklom iz SAD. U ovom radu je ispitivan kvalitet biomase četrnaest genotipova vrste Panicum virgatum. Košenje je izvršeno u jednom roku, kada su svi genotipovi bili u fazi pred klasanje ili na početku klasanja. Uzorci za ispitivanje kvaliteta uzeti su odmah posle košenja. Ispitivani su parametri kvaliteta biomase: sirovi proteini, sirova celuloza, sadržaj masti, sadržaj pepela, BEM, ADF i NDF. U našoj zemlji ova vrsta može biti jedna od komponenti u travnim smešama na zemljištima slabijeg kvaliteta i za sušne agroekološke uslove. Naravno, potrebna su dalja laboratorijska i poljska ispitivanja u našim uslovima.*

***Ključne reči**: biomasa, kvalitet, Panicum virgatum* L.*, ishrana životinja.*

INTRODUCTION

Switchgrass (*Panicum virgatum* L.) is native to North America, naturally extending from 55° North latitude to central Mexico. It has adapted to a wide range of soils and climatic conditions. As an energy crop, it has great potential and is widely used in North America and some European countries (*Lewandowski et al., 2003*). Furthermore, switchgrass can be used for erosion protection (due to a strong root system), ornamental purposes in landscape architecture, and bird feeding. As it grows well in low-quality soils, this crop can also be used for grazing in inaccessible, stony and sandy terrains. For good forage quality, switchgrass should be grazed before the maturity of stalks (*Mitchel et al*., 1994).

With sound practice and management, perennial energy crops can improve the quality of soil that has been overused for annual row crop production (*De La Torre Ugarte et al., 1999*).

Previous research suggests that hilly areas have a number of switchgrass varieties which are more resistant to drought (*Sanderson et al., 1996*). Due to the expressed ability to produce green matter during warm summer months, when biomass production of other components is low, switchgrass is used for the establishment of multicomponent sown pastures (*Moser and Vogel, 1995*). The adaptability of this species is high, but many researchers emphasise difficulties in establishing switchgrass (*Wolf and Fiske, 1995; Hsu et al 1985; Hope and McElroy, 1990*). The biggest problem is field germination as switchgrass does not germinate at soil temperatures below 15 ^{o}C. In Serbia, such soil temperatures are reached during May and June with the onset of the dry season (*Milenković et al., 2017*). Although switchgrass for biofuel production has been receiving increased attention, it can also be used as a forage crop. Provided switchgrass is cut while young and leafy, the nutrient content will be similar or equal to other perennial grasses (*Bates et al., 2007)*. For this feature, switchgrass could be used in Serbia as a component of grass mixtures for lesser-quality soils and dry agroecological conditions.

There is a collection of energy grasses originating from the United States grown in the experimental field of the Institute for

Forage Crops in Kruševac. The purpose of this paper is a preliminary research of switchgrass biomass as animal nutrition feed.

MATERIAL AND METHOD

The experiment was conducted at the Institute for Forage Crops in Kruševac during 2017. In this paper, a total of 14 genotypes of energy type switchgrass (*Panicum virgatum* L.) were examined. The samples for analyses were taken from the experimental field of energy grasses established in 2014 as a factorial trial set in a randomized block system with three replicates. Fertilization has not been applied in the experimental year. All the samples were taken on the same day (10.07.2017), when most of the genotypes examined were in the pre-flowering stage and a small number at the beginning of flowering. Quality assay samples were taken immediately after cutting. The following parameters of switchgrass biomass quality were analysed: crude protein, cellulose content, fat content, ash content, nitrogen free extract (NFE), acid detergent fibre (ADF), and neutral detergent fibre (NDF). Chemical parameters were determined in the laboratory of the Institute for Forage Crops in Kruševac according to the standard methods (*AOAC, 2002*). The crude protein value was computed indirectly from the amount of total nitrogen, measured using the *Kjeldahl* method (modified by *Bremner, 1996*) and multiplied by a factor of 6.25. Acid detergent fibre and neutral detergent fibre analyses were determined by *Van Soest (1963)*. The experimental data were statistically processed using the analysis of variance (ANOVA). For separating mean differences, the Fisher's least significant difference (LSD) test was used at a significance level of 0.05. All the analyses were conducted using the statistical software package Statistica 8.1. (StatSoft Inc. USA).

Table 1. Ash, crude protein, cellulose, and fat in the biomass of pre-flowering switchgrass (% in dry matter)

Genotype	Ash	LSD*	Crude protein	LSD*	Cellulose	LSD*	Fat	LSD*
SA1	6.67	g	8.70	a*	31.13	g*	1.88	a
SO	6.79	g	7.17	c	32.74	f*	2.90	a
BM3	7.04	fg	7.40	bc	34.85	b	2.40	a
FoR	7.45	de	6.45	d	34.06	bcde	1.91	a
Sn5	7.83	bcd	7.78	bc	34.56	bcd	1.65	a
Al2	8.92	a*	5.62	e*	36.25	a*	2.83	a
DcT	7.71	cdefg	8.46	a*	33.60	e	2.11	a
KnL	6.81	g	8.74	a*	34.35	bcde	2.35	a
NE9	8.06	bcd	5.82	e*	34.35	bcde	1.65	a
CrT	7.56	de	7.33	bc	36.79	a*	1.47	a
Prf	6.86	g	7.31	bc	34.78	bc	2.12	a
TrLB	8.69	a*	7.45	bc	34.74	bcd	2.77	a
BW3	7.41	ef	6.57	d*	34.02	cde	2.18	a
Cr14	8.11	bcd	7.33	bc	33.95	de	2.54	a

** Means in the same column with different letters vary at a significance level of 0.05 according to the Fisher LSD test*

RESULTS AND DISCUSSION

Most biomass accumulation in switchgrass occurs in the first half of the growing season. *Bates et al*. (2007) argued that 56 % of annual biomass accumulation was obtained by late June each year. In addition, delaying the forage harvest would have adverse effects on forage production on account of a decrease in forage quality in the maturing stand. Under the agroecological conditions in Serbia, the pre-flowering stage (depending on weather conditions) lasts from late June to mid-July. Consequently, the experimental samples of all the switchgrass genotypes examined were taken at the same time in order to determine statistically significant differences in particular properties between the genotypes.

The ash content was in the range from 6.67 % (SA1) to 8.92 % (Al). An increase in the ash content was found to be dependent on the harvest time. Some experiments show a decrease in the ash content with subsequent harvesting, rendering the ash content inversely proportional to the maturity of the plant (*McLaughlin et al., 1999*). In our study, only two switchgrass genotypes were found to differ significantly in ash content (Al2 – 8.92 % and TrLB – 8.69 %). Lower nitrogen contents are usually associated with late harvest, relative to the maturity of genotypes, and not with differences in the biomass quality between genotypes (*Sladden et al., 1995*). Therefore, the quality of biomass depends on the date of harvest. The content of N is higher in summer cutting, provided there are two cuttings a year, than in the one-off autumn cutting (*Reynolds et al., 2000*). The crude protein content obtained was in the range from 5.62 % (Al) to 8.74% (KnL). On balance, low contents of crude proteins indicate that harvest should be performed in earlier stages of plant development. Six genotypes varied significantly according to the protein content, which could indicate that this feature is greatly dependent on the genotype (SA1 – 8.70 %; DcT – 8.46 %; KnL – 8.74 %; BW3 – 6.57 %; NE9 – 5.82 %; Al2 – 5.62 %). However, only three of the genotypes tested (SA1, DcT and KnL) were found to exhibit the crude protein content higher than 8 % (Table 1). The cellulose content obtained ranged from 31.13 % (SA1) to 36.25 % (Al2). A total of four genotypes differed significantly in cellulose content (SA1, SO, Al2 and CrT; Table 1), whereas two genotypes had significantly lower cellulose contents (SA1 – 31.13 % and SO – 32.74 %). The genotypes Al2 and CrT had significantly higher cellulose contents (36.25 % and 36.79 %). Our results were similar to *Tomić et al*. (2008), who recorded the following parameter values: a cellulose content of 30.3-31.2 % in English ryegrass, 32.2-33.6% in red fescue, 31.6-31.8 % in French ryegrass, and 34.6 % in Italian ryegrass. The fat content

Table 2. Acid detergent fibre (ADF), neutral detergent fibre (NDF), and nitrogen free extract (NFE) in the biomass of pre-flowering switchgrass (% in dry matter)

Genotype	ADF	LSD*	NDF	LSD*	NFE	LSD*
SA1	36.05	h	67.99	de	44.29	a
SO	42.79	abcd	68.32	de	43.34	ab
BM3	39.89	cdefg	71.19	abc	40.94	cdef
FoR	38.40	fgh	70.47	bcd	43.05	ab
Sn5	44.67	abcd	73.15	a	40.88	cdef
Al2	43.75	ab	72.92	ab	39.52	ef
DcT	42.63	abcd	72.39	ab	40.72	def
KnL	37.32	gh	67.02	e	42.08	bcd
NE9	39.58	defgh	69.08	cde	42.85	abc
CrT	42.08	abcde	72.59	ab	39.61	ef
Prf	41.59	abcdef	73.15	a	41.56	bcde
TrLB	43.24	abc	71.03	abc	39.08	f
BW3	40.78	bcdefg	69.79	cd	42.67	abcd
Cr14	38.95	efgh	70.95	abc	40.94	cdef

** Means in the same column with different letters vary at a significance level of 0.05 according to the Fisher LSD test* obtained varied from 1.47 % (CrT) to 2.90 % (SO). This feature did not significantly differ between the genotypes examined, which can be accounted for by a greater variation within replications (Table 1). Acid detergent fibre (ADF) is a measure of fibre concentration in biomass expressed as a percentage, i.e. the residue remaining after digesting (predominantly cellulose and lignin). In our research, the ADF content varied from 36.05 % (SA1) to 44.67 % (Sn5), and there were no statistically significant differences between the genotypes (Table 2). Neutral detergent fibre (NDF) is the structural component of the plant (structural carbohydrates) and a measure of the plant's cell wall content in the biomass (hemicellulose, cellulose and lignin). The NDF content obtained in this study was in the range from 67.02 % (KnL) to 73.15 % (Su5 and Prf). The genotypes examined did not differ significantly relative to this feature. In the study of *Tran et al. (2009*), involving a total of three types of grasses grown under tropical conditions, an ADF content of 28.8-32.9 % and an NDF content of 60.6-69.3 % were obtained. Our results of ADF and NDF contents were higher, which indicates that the harvest time could be in earlier phases. The most important constituents of the dry matter are protein, ash, fat content, and cellulose. The remaining part of the dry matter is of organic origin, and is primarily related to starch and lower carbohydrates, i.e. the nitrogen free extract (NFE). This is the fraction that contains sugars and starches plus small amounts of other materials. The NFE content obtained in our study ranged from 39.08 % (TrLB) to 44.29 % (SA1), and there were no significant statistical differences between the genotypes (Table 2). The results obtained are consistent with the results of *Tomić et al*. (2008), who researched the quality parameters of new domestic cultivars of perennial grasses. These authors recorded the following NFE contents: 43.5-45.8 % in English ryegrass, 38.4-40.6 % in red fescue, 39.6-42.4 % in French ryegrass, and 38.7 % in Italian ryegrass. These results indicate that switchgrass possesses good quality features comparable to other perennial grasses.

CONCLUSION

For forage crop production, it is of paramount important to produce higher yields per hectare and good nutrient quality of forage crops. The results obtained indicate that switchgrass could possess the desirable quality of biomass. Further laboratory and field tests under the existing conditions in Serbia are needed relative to the biomass yield. On the basis of the preliminary results obtained in this study, it can be argued that several genotypes can be used for animal feed according to their quality features. A total of three genotypes (SA1, DcT and KnL) were found to exhibit a protein content of more than 8 % with a lower content of cellulose, which indicates that they can be considered for further use. The ADF and NDF contents recorded in the SA1 and KnL genotypes were lower than those recorded in the other genotypes examined, whereas the NFE content was satisfactory.

ACKNOWLEDGEMENTS: This paper is part of the project TR.31057, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

REFERENCES

Bates, G., Keyser, P., Harper, H., Waller, J. (2007). Using Switchgrass for Forage. University of Tennessee Biofuels Initiative Factsheet, SP701-B.

Bremner J. M. (1996). Nitrogen-total. In: Methods of soil analysis, Part 3. Chemical methods (Ed. D. L. Sparks), 1085-1121, SSSA, Madison.

De La Torre Ugarte, D.G., Walsh, M.E., Shapouri, H., Slinsky, S.P. (1999). The Economic Impacts of Bioenergy Crop Production in U.S. Agriculture, Online at bioenergy.ornl.gov/papers/wagin/index.html.

Hope, H.J., McElroy, A. (1990). Low-temperature tolerance of switchgrass (*Panicum virgatum* L.). Canadian Journal of Plant Science (70), 1091-1096.

Hsu, F.H., Nelson, C.J., Hatches, A.G. (1985). Temperature effects on germination of perennial warm season forage grasses. Crop Science (25), 215-220.

Janković S., Glamočlija Đ., Prodanović S. (2017). Energetski usevi – tehnologija proizvodnje i prerade. Monografija. Institut za primenu nauke u poljoprivredi, Beograd. (ISBN 978-86-81689-35-6, COBISS.SR-ID 229916172)

Lewandowski, I., Scurlock, J.M.O., Lindvall, E., Christou, M. (2003). The development and current status of perennial rhizomatous grasses as energy crops in the US and Europe. Biomass and Bioenergy (25), 335-361.

McLaughlin, S.B., Bouton, J., Bransby, D., Conger, J.B., Ocumpaugh, W., Parrish, D., Taliaferro, C., Vogel, K., Wullschleger, S. (1999). Developing switchgrass as a new crop. In: Janick J. ed.: Perspectives of New Crops and New Uses. Proceedings Fourth National News Crops Symposium, Phoenix, AZ; Alexandria, WA. ASHS Press, 282-299.

Milenković, Jasmina, Stanisavljević, R., Vasić, Tanja, Anđelković, Snežana, Terzić, D., Đokić, D., Radović, Jasmina (2017). Seed germination and seed quality of some energy grasses. Proceedings of the „Fifth international conference sustainable postharvest and food technologies Inoptep 2017“, 23-28 April, Vršac, Serbia, 198-202.

Mitchel, R., Moser, L., Anderson, B., Waller, S. (1994). Switchgrass and big bluesten for grazing and hay. In: Nebraska Cooperative Extension Service, Ed. NebGuide G94-1198-A, G. Lincoln, NE, USA.

Moser, L.E., Vogel, K.P. (1995). Switchgrass, Big Bluestem, and Indiangrass. In: Barnes, R.F., Miller, D.A., Nelson, C.J. editors. Forages, An introduction to grassland agriculture, 5th ed. Ames, IA: University Press, 409-420.

Reynolds, J.H., Walker, C.L., Kirchner, M.J. (2000). Nitrogen removal in switchgrass biomass under two harvest systems. Biomass and Bioenergy (19), 281-286.

Sanderson, M.A., Reed, M.L., McLaughlin, S.B., Wullschleger, S.D., Conger, B.V., Parrish, D.J., Wolf, D.D., Taliaferro, C., Hopkins, A.A., Ocumpaaugh, W.R., Hussez, M.A., Read, J.C., Tischler, C.R. (1996). Switchgrass as a sustainable bioenergy crop. Bioresource Technology (56) 83-93.

Sladden, S.E., Bransby, D.I., Kee, D.D., Nepal, P. (1995). The effects of row spacing and nitrogen fertilization on biomass production of switchgrass in Alabama. In: Proceedings of American Forest and Grassland Council, 45-48.

Statistica (Data Analysis Software System), v.8.0 (2006). Stat-Soft, Inc, USA (www.statsoft.com).

Tomić, Z., Sokolović, D., Lugić, Z., Radović, J., Nešić, Z. (2008). New domestic cultivars of perennial grasses in Serbia. Proceedings of 43rd Croatian and 3rd International Symposium on Agriculture, 673-676.

Tran, H., Salgado, P., Lecomte, P. (2009). Species, climate and fertilizer effects on grass fibre and protein in tropical environments. Journal of Agricultural Science, 147, 555–568.

Van Soest P.J. (1963). The use of detergents in the analysis of fibrous feeds. II. A rapid method for determination of the fiber and lignin. J. A. O. A. C., 46, 829-835.

Wolf, D.D., Fiske, D.A. (1995). Planting and managing switchgrass for forage, wildlife, and conservation. Extension agronomist Forages. Virginia Tech. Virginia Polytechnic institute and State University Publication.

AOAC (2002). Official methods of analysis of AOAC international. 17th ed. Association of Official Analytical Chemists, Washington, DC.

Received: 12. 03. 2018. Accepted: 01. 08. 2018.