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EFFECT OF FORAGE SORGHUM HYBRIDS ON GREEN FODDER YELD
UTICAJ HIBRIDA KRMNOG SIRKA NA PRINOS ZELENE KRME

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ABSTRACT

Forage Sorghum is an annual herbaceous plant of the family grass. It is grown for feeding animals and people, and ranks among the millet grains. I disorders, sorghum is used as hay and to extract the starch, alcohol and glucose. Purpose of our paper is to determine which of the forage sorghum hybrids, among foreign selections, gives the best production results in the specific agroecological conditions on PSS Sremska Mitrovica experimental field and what are the possibilities of its use in our country. Five intraspecies hybrids (Sorghum bicolor x Sorghum bicolor) and two intraspecies hybrids (Sorghum bicolor x Sorghum sudanense) were analyzed in this paper. The difference in yield between the H7 hybrid that had the highest yield and H5 runner-hybrid was even 19 t ha^{-1}, which indicates exceptionally high yield potential of H7 hybrid in biomass production. In specific agroecological conditions H7 hybrid gave the 96 t ha^{-1} of green fodder and 25.2 t ha^{-1} of dry matter.

Key words: *forage sorghum, intraspecies hybrids, interspecies hybrids, green fodder yield.*

REZIME

Po obimu proizvodnje sirak zauzima u svetu peto mesto među najvažnijim žitaricama, posle pšenice, pirinča, kukuruza i ječma. Značaj ove biljne vrste ogleda se u velikom broju mogućnosti njegove upotrebe, počev od ljudske ishrane, ishrane stoke, industijske prerade i proizvodnje energije. U našoj zemlji se malo gaji, površine se kreću u proseku oko 2.200 ha. Sirak će teško postati konkurencija kukuruzu iako su prinosi zelene krme veći nego kod kukuruza, mada nešto manjeg, ali sasvim zadovoljavajućeg kvaliteta. Prinosi zelene mase krmnog sirka kreću se od 40-50 t ha^{-1}, u lošijim proizvodnim godinama, pa do 110-130 t ha^{-1} u navodnjavanju ili u povoljnim godinama. Cilj našeg rada bio je da ustanovimo koji od hibrida krmnog sirka, iz palete stranih selekcija, daje najbolje proizvodne rezultate u konkretnim agroekološkim uslovima na oglednom polju PSS „Sremska Mitrovica“ i koje su mogućnosti korišćenja njegovog gajenja kod nas. U ovom radu ispitivano je pet intraspecies hibrida (Sorghum bicolor x Sorghum bicolor) i dva interspecies hibrida (Sorghum bicolor x Sorghum sudanense). Tokom ispitivanja utvrđeni su: broj biljaka po hektaru, prosečna visina biljaka, prinos zelene krme i prinos suve materije za svaki od hibrida. Prinos suve materije po hektaru značajan je više sa aspekta proizvodnje biogasa, sa kojom stoji u pozitivnoj korelaciji. Prinos zelene krme bio je u korelaciji sa visinom biljaka i bio je veći kod intraspecies hibrida (H7, H5, H3 i H4), dok su najmanje prinose imali interspecies hibridi (H1 i H2). Razlika u prinosu između najprinosnijeg hibrida H7 i drugorangiranog H5 iznosi čak 19 t ha^{-1}, što ukazuje na izuzetno visok potencijal rodnosti hibrida H7 u proizvodnji biomase. Kada je u pitanju visina biljaka, najviši i najrobusniji su hibridi čistog sirka, dok su H1 i H2 nešto niži, jer im je linija oca poreklom sudanska trava, pa su genetski predodređeni za manji porast u visinu. U konkretnim agroekološkim uslovima gajenja, hibrid H7 dao je 96 t ha^{-1} zelene krme, odnosno 25,2 t ha^{-1} suve materije.

Ključne reči: *krmni sirak, intraspecies hibridi, interspecieshibridi, prinos zelene krme.*

INTRODUCTION

The volume of production sorghum occupies the fifth place among the world's most important cereal after wheat, rice, corn and barley. The importance of this plant species is reflected in the large number of possibilities for its use, starting from human food, livestock feeding, of industrial processing and energy production *(Mišković 1986)*. Accordingly, selection of sorghum ranged in several directions, leading to its division into several forms: grain sorghum, forage sorghum (sorghum biomass) and sugar sorghum.

By the middle of twentieth century in the production were represented exclusively cultivars of sorghum. Together with discovery of heterosis in sorghum (the fifties of the twentieth century), there was a possibility of increasing the yield by growing sorghum hybrids. The technology of hybrid seed production was based on the discovery of a male sterile line (cytoplasmic male sterility). The introduction of hybrids into production, yields of some form of sorghum were soon doubled, and after 20 years they have been growing larger and up to four times.

Besides the production of high-quality sorghum forage into over the last decade, were conducted numerous studies for obtaining and biogas-methane, which uses a complete above-ground part of the plant. From one hectare of sorghum, the biogas facility can provide about 4,800 m^3 of methane. This amount can produce around 18,500 kWh of electricity, which satisfies annually consumes four average households. *Dzeletović and Mihailović (2011)* point out that the area under crops for production of bio-energy in a continuous increasing. The aim of our study was to find out which of hybrid sorghum, one of the range of foreign selection, gives the best production results in agroecological conditions of Srem.

MATERIAL AND METHOD

The experiment is appointed at the experiment field Sremska Mitrovica in 2013 and 2014 years, on the site Zabran, Laćarak (44°58´ N; 19°36´E and a.s.l. about 80 m). We examined five intraspecies hybrids (*Sorghum bicolor x Sorghum bicolor*, H3, H4, H5, H6 and H7) and two interspecies hybrids (*Sorghum bicolor x Sorghum sudanense*, H1 and H2), foreign selections. Each hybrid is represented with six rows of the row spacing of 50 cm in length of 100 m. During the tests were determined: the number of plants per hectare, the average plant height, green forage yield, the share of dry matter and dry matter yield. In the stage of development of the fifth to the sixth leaf, crop density was determined by counting the plants in three replications (3 x 10 m^2) for each hybrid. Analyses of components of yield were done at the initial stage of milky-wax maturity. Plant height (cm) was measured at the time of harvest, based on the average sample from 3 x 30 plants, from the base to the top of the broom. At the stage of milky wax maturity yield was determined on the basis of green forage samples from three places with an area of 10 m^2 - (repetitions), where the plants are hand-cut to 5-10 cm from the surface of the land, for each hybrids. Determined by the share of dry matter after drying in an oven at 105 $^{\circ}$C to constant mass and then calculate dry matter yield (t ha^{-1}).

The results were analyzed using analysis of variance (ANOVA), for test the significance of differences between treatments using the LSD test and coefficient of variation (CV). For the correlational connection between the observed traits correlation coefficients were calculated (r). The program Minitab 16.1.0 was used for data processing.

Table 1. Meteorological data for the vegetation period 2013 and 2014 and for perennial period from 2005 to 2014. year, (Meteorological station Laćarak)

Months						
Years	V	VI	VII	VIII	IX	Average
The average monthly air temperature ($^{\circ}$C)						
2013.	17.3	20.0	22.1	22.8	15.3	19.5
2014.	16.0	20.3	21.4	20.7	17.1	19.1
2005- 2014.	17.3	20.6	22.4	21.7	17.2	19.9
The amount of precipitation (mm)						Total
2013.	119.0	62.5	44.2	18.0	60.9	304.6
2014.	189.0	37.2	74.9	55.7	114.8	471.6
2005- 2014.	86.6	71.8	55.0	54.9	49.9	318.2

The experiment was set up on the hydromorphic black soil type, which was the average fertility for this region (Table 2).

Table 2. Soil agrochemical analysis

Depth (cm)	pH		Humus (%)	Total N (%)	(mg/100g soil)	
	H_2O	KCl			P_2O_5	K_2O
0-30	8.1	7.3	2.5	0.17	16.2	24.9

Precrops forage sorghum in both years was soybeans, as one of the best possible options. For the experiment was conducted classical growing technology starting from the regular sowing date through crop tending measures to use.

RESULTS AND DISCUSSION

According *Stanisavljević (2001)*, in the first increase in cultivation of fodder sorghum, achieve the high yield of green fodder (NS-Šećerac 34.8 t ha^{-1}, NS-Silosirak 33.9 t ha^{-1}, with a significantly lower NS-Dzin 29.4 t ha^{-1}), while the corn hybrid NS-444 achieved silage yield 31.0 t ha^{-1}. Forage sorghum from the second cuts achieved an average of 17 t ha^{-1}, respectively from the first and second cuts in forage sorghum realized: 53.3 t ha^{-1} (NS-Silosirak), 49.7 t ha^{-1} (NS-Šećerac) and 48.5 t ha^{-1} (NS-Dzin). The significantly better soil and climatic conditions of the four cultivars sorghum (Sweet Sioux, NS-Šećerac, NS-Zora, NS-Srem) gave on average 94.4 t ha^{-1} of green fodder *(Đukić et al. 1995).*

In our tests soil fertility at the site can be considered typical for this region (Table 2) and favorable for the cultivation of sorghum.

Table 3. Yield components and yield of green forage fodder sorghum grown for two years in agroecological conditions of Srem

Year	2013			2014		
Hybrid	Crop density (000/ha)	Average height plant (cm)	Yield green mass (t ha^{-1})	Crop density (000/ha)	Average height plant (cm)	Yield green mass (t ha^{-1})
H1	237 a	260 ab	65.3 b	243 a	375 b	81.2 ab
H2	232 a	240 b	62.6 b	251 a	435 a	72.7 b
H3	211 ab	270 a	73.5 a	218 ab	420 ab	96.8 a
H4	211 ab	290 a	72.4 a	214 b	460 a	85.4 ab
H5	216 a	290 a	77.8 a	219 ab	445 a	95.7 a
H6	206 b	270 a	68.9 b	216 ab	385 b	85.2 ab
H7	215 a	310 a	96.4 a	226 a	510 a	118.7 a
Aver.	218	276	74.0	227	433	90.0
F test	*	*	***	*	*	*
CV (%)	5.33	8.34	15.1	6.41	10.6	16.3

Different letters within species and treatment combinations indicate significant difference (LSD test, p < 0.01).

During the two years of investigation differed significantly according to the amount and distribution of rainfall (Table 1). Climatic features of the region and the genetic basis of hybrid have affected yield components (the average number of plants in 2013 amounted to 218 thousand plants / ha, and the average height of stems 276 cm; 2014 the average number of plants was 227 thousand plants / ha, and the average height of the stems 433 cm). It can be considered that this is the main reason for the higher yield of green fodder (16 t ha^{-1}), which was achieved in a more favorable 2014 year (Table 3). For the height of the stems sorghum hybrids showed high level of variability (CV = 8.34 %). Also between plant height and yield of green fodder was found a high correlation (r = 0.760 P≤0.001), while there was no significant correlation between crop density and yield (r = -0.149; Table 5). This can be explained by the fact that the biological traits of sorghum are prone to tillering (especially hybrids with Sudan grass), thereby substantially compensate the missing plant density. Height-yield hybrid *Sorghum bicolor* x *Sorghum sudanense* (H1 and H2) are generally achieved lower yields compared to hybrids *Sorghum bicolor* x *Sorghum bicolor* (H3-H7), which is particularly pointed yield hybrid H7 (96.4 t ha^{-1}) (Table 3). But it is evident that the yield variability depending on the hybrids was similar in both years (2013 - CV=15.1 %; 2014 - CV=16.3 %).

According to the results of numerous studies, preparation of silage from forage sorghum, Sudan grass and maize, the most favorable proportion of dry matter in the time of harvest 28-32 % *(Hnatyszyn et Guais 1988)*. This is a compromise between yield and quality of forage *(Stanisavljević et al., 1996 and Księżak et al., 2012)*. The dry matter content of 15 maize inbred lines, and if it is smaller than the share of dry matter in sorghum, indicating that the local population can be a significant source of desirable genes for obtaining higher quality corn hybrids for silage *(Milenković et al., 2014)* Generally hybrid *Sorghum bicolor* × *Sorghum sudanense* (H1 and H2) are in less favorable conditions (2013) characterized by significantly higher ($p \leq 0.01$) dry matter content. In favorable conditions (2014) these hybrids showed increased dry matter content (Table 4).

Table 4. Share (%) and dry matter yield, forage sorghum grown for two years in agroecological conditions of Srem

Year	2013		2014	
Hybrid	Dry matter (%)	Yield dry matter (t ha^{-1})	Dry matter (%)	Yield dry matter (t ha^{-1})
H1	33.6 a	21.9 b	30.3 a	24,6 b
H2	33.0 a	20.7 b	29.9 a	21,7 b
H3	29.9 ab	22.0 ab	31.9 a	30,9 a
H4	30.1 ab	21.8 b	30.5 ab	26,0 ab
H5	29.7 ab	23.1 ab	29.0 a	27,8 ab
H6	29.0 b	20.0 b	30.1 ab	25,6 ab
H7	29.8 ab	28.7 a	28.1 b	33,4 a
Average	30.7	22.6	30.0	27.1
F test	*	***	*	**
CV (%)	5.85	21.7	3.99	10.0

Different letters within species and treatment combinations indicate significant differences (LSD test, p < 0.01)

However, due to significantly lower yield of green fodder they gave significantly lower ($p \leq 0.01$) dry matter yields.The strongest connection between the green forage yield and dry matter indicates the correlation coefficient ($r = 0.970$ $P \leq 0.001$). According to dry matter yield, in favorable and unfavorable climatic conditions, pointed to a hybrid H7 (2013 - 28.7 t ha^{-1}; 2014 - 27.1 t ha^{-1}).

Table 5. The coefficients of correlation between the yield of green fodder and other investigated parameters (seven hybrids in two years, n = 14)

Yield green mass (t ha^{-1}) I	Crop density (000/ha) II	Average height plant (cm) III	Dry matter (%) IV	Yield dry matter (t ha^{-1}) V
I	-0.149 ns	0.760 ***	-0.531 *	0.970 ***
II		0.192 ns	0.331 ns	-0.098 ns
III			-0.443 ns	0.730 **
IV				-0.316 ns

*Statistical significance level: *P≤ 0.05; ** P≤0.01; ***P≤0.001; ns not significant*

CONCLUSION

Cultivation of forage sorghum can provide high and stable yields forage and raw materials. Agroecological conditions, especially rainfall are of significant impact on the yield of forage sorghum. Generally hybrids of *Sorghum bicolor* x *Sorghum bicolor* is characterized by higher yields than hybrids of *Sorghum bicolor* x *Sorghum sudanense*. According to the amount of yield is emphasized hybrid H7, yield of green fodder from 96.4 t ha^{-1} (2013) and 118.7 t ha^{-1} (2014). The strongest positive correlation interdependence ($P \leq 0.001$) was found between the yield of green fodder and dry matter yield ($r = 0.970$) as well as the height of the stems and green forage yield ($r = 0.760$).

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