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CORRELATION COEFFICIENTS OF MORPHOLOGICAL - PRODUCTIVE TRAITS OF SPECIES OF *SORGHUM* GENUS

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Abstract: Objective of the research were phenotypic and genetic correlation coefficients of three species of *Sorghum* genus – forage sorghum *S. bicolor* Moench. (genotype *NS-Džin*), Sudan grass *S. sudanense* L. (genotype *Zora*) and interspecies hybrid *S. bicolor* x *S. sudanense* (genotype *Siloking*). Studies were carried out on samples of plant material from the first cut. The following morphological-productive traits were studied: plant height, number of leaves per plant, mass of leaves on the stem, average stem mass and yield of green biomass. In the analysis of genetic and phenotypic coefficients, differences depending on the impact on studied morphological-productive traits are observed. The highest value of the stem height was recorded in Sudan grass (2.281 m), as well as number of leaves per plants (7.917). The greatest mass of leaves per plant was established in forage sorghum (49.05 g), and the highest average stem mass was recorded in interspecies hybrid plants (80.798 g). Variation of morphological-productive indicators per species was significant and very significant. Coefficients of simple correlations indicate the presence of very strong to almost complete, statistically very significant positive correlations, so these effects were expected. Plant height and number of leaves were not directly but indirectly statistically significant to yield of green biomass and varied from insignificant and very weak to sporadically medium strong and statistically significant.

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Key words: forage sorghum, Sudan grass, interspecies hybrid, genotype, correlations.

Introduction

Plant species of *Sorghum* genus recently have become very interesting, especially as forage plants, since in favorable weather conditions they regenerate

well and give, depending on the moisture regime, more cuts in the year of utilization *(Glamočlija et al., 2010)*. Main goals of improvement and breeding of sorghum for livestock food are to create cultivars/varieties of high production and good quality, of long life and tolerant to limiting conditions of the environment. Yield of green biomass and dry matter are the most important traits, which have the utmost importance for the process of improvement/breeding, and the ultimate goal is improvement or rarely maintaining of yields at the same level with simultaneous improvement of other important traits. It can be improved by selection *(Antoche et al.,* 2007*)*. Considering that modern programs of improvement of forage sorghum and Sudan grass are directed towards creating of F_1 hybrid with expressed potential for high yields of green biomass of good quality and stability, suitable for use as fresh biomass, hay or silage *(Pataki et al., 2006)***,** exceptional importance in realization of this goal is study of the combination ability of potential parent components *(Mihajlović et al.,* 2007*)*. Biomass of forage sorghum, Sudan grass and their hybrid is used fresh or for preparation of silage, and rarely for preparation of hay or grazing *(Camakci, 1999; Ikanović et al., 2010)*. Depending on the way of use of biomass (hay, silage or fresh), adequate agro-technical measures will be applied. Of all agro-technical measures, plant nutrition is the one with the highest impact on the quality of biomass *(Booker et al., 2007)*. Proper application of nitrogen mineral fertilizers shall enable better and more economical use of environment conditions (natural factors – edaphic, climatic) and genetic yield potential of these plants for higher production of livestock food per surface unit *(Booker 2007*). Yield is reflection of the plant's potential to accumulate dry matter, as well as its adaptability to various agro-ecological conditions. Main criteria used in determination of nutritional value are increase of the share of digestible matter and reduced lignin content *(Casler, 2001, Ermisani et al., 2007, Ikanović et al., 2011)*. In plant improvement, it is very important to know the relation between morphological traits, i.e. their mutual correlation (correlation coefficients) in order to determine the improvement criteria and potential selection response of genotypes for certain major traits *(Ikanović, 2010)*. Direct selection for yield of dry matter, lately considered as the most important trait from the aspect of agronomy, in species which have been domesticated for long time, do not always give satisfactory results, even though all modern methods are applied. So it is very important to better understand the morphological and physiological basis of the yield, which would make the improvement process more efficient *(Sokolović, 2006, Radović, 2009)*. In improvement of plants, it is very important to know relations between traits, i.e. their correlations (correlation coefficients) in order to determine the improvement criteria and possible response of genotypes in regard to certain major traits. The question is whether it is possible to improve plants for individual poly-gene controlled traits. In majority of cases, undesirable changes in values occur as well as other agronomically important traits due to mutual correlation *(Šurlan–Momirović et al., 2005)*. Previous studies focusing on the

chemical composition of alfalfa biomass *(Milić et al., 2011)* maize silage *(Gocevski and Cilev 2011)* and bird's foot trefoil *(Petrović et al., 2011)* indicate the importance of this issue on nutritional properties of these feeds.

Materials and Methods

Two year research (2009-2010) was carried out on experimental field Radmilovac. Field micro-trials were set up according to random block system in 10 repetitions with the size of main parcels of 10 m^2 (5 m x 2 m). Object of the research were three genotypes selected in the Institute of field and vegetable crops, Novi Sad. They are forage sorghum cultivar *Džin*, selected in 1983, Sudan grass cultivar *Zora* selected in 1983 and interspecies hybrid *Siloking*, selected in 2007. Standard agro-technics used for sorghum cropping was applied. Cutting of plants was done in the second week of July, and samples were taken of fresh cut biomass for analysis of morphological traits. Yield of fresh biomass was determined by measuring of the cut above ground mass from every basic parcel and calculating per ha. In the first year, during vegetation period, precipitation amount was by approx. 9.5% higher compared to ten year average. April and May had less precipitation, whereas the summer months were more humid. Precipitation amount in the second year was higher compared to multiannual average by 27% and in relation to the first year by approx. 20%. Distribution of precipitation during vegetation period was equal, and maximum precipitation quantities were in June, 180 litres of rain per square meter. Distribution of heat in the first year and according to months showed that mean monthly temperatures during summer months were lower than multiannual average for this area. In the second year, spring and autumn had lower air temperatures, whereas the summer was at the level of previous year (Table 1).

Table 1. Precipitation (mm) and mean daily temperatures (^{0}C) for vegetation period, (Belgrade-Radmilovac)

Year	Parameter	*Month*						*Average Sum*
		IV	V	VI	VII	VIII	IX	
2009	Temperature	16	20	21	24	24	20	21
	Rainfall	6	34	153	79	45	45	362
2010	Temperature	14	18	21	24	24	18	20
	Rainfall	41	85	180	41	54	51	452
Ten years Average Sum	Temperature	15	26	23	25	25	18	21
	Rainfall	15	58	102	53	54	49	331

Analysis of obtained experimental data was done using analytical statistics using statistical package STATISTICA 8 for Windows (StatSoft). By analyzing the

covariance of investigated sorghum genotypes coefficients of phenotypic correlation were calculated. Indicators of the mutual correlation between studied traits were obtained from the relation of common variation and product of individual variation. In the analysis of covariance of studied traits of investigated sorghum genotypes, coefficients of genetic and phenotypic correlations were calculated *(Ivanović, 1984; Maletić, 2005)*.

Results and Discussion

Correlation relations of 6 morphological and productive traits of genotypes of studied *Sorghum* species were studied on analyzed samples. Statistically significant and very significant correlation expressed in phenotypic correlation coefficients was established between certain traits (Table 2).

Table 2. Genetic and phenotypic correlation coefficients for morphological and productive traits of sorghum, sudan grass and interspecies hybrid

2009							
Traits	Plant height	Number of leaves	Leaf mass	Stem mass	Share of leaves	Yield of green biomass	Genetic correlation coefficients
Plant height		0.21	-0.80	-0.59	0.49	-0.33	
Number of leaves	0.18		0.46	0.71	-0.81	0.93**	
Leaf mass	-0.8	0.44		0.96**	0.94**	0.83	
Stem mass	-0.59	0.69	0.95**		-0.99**	0.96**	
Share of leaves	0.47	-0.78	0.90*	-0.98**		-0.99**	
Yield of green biomass	-0.33	0.87*	0.83	0.95**	-0.98**		
2010							
Plant height		0.22	-0.74	-0.49	0.59	-0.24	Genetic correlation coefficients
Number of leaves	0.21		0.38	0.82	-0.84	0.93**	
Leaf mass	-0.15	0.43		0.99**	0.94**	0.93	
Stem mass	0.60	0.69	0.95**		-0.99**	0.99**	
Share of leaves	0.47	-0.87	0.98*	-0.98**		-0.98**	
Yield of green biomass	-0.4 3	0.97*	0.93	0.95**	-0.99**		
Phenotypic correlation coefficients							

According to the correlation coefficients given in the Table 2, the values of genetic correlation coefficients have been determined as slightly higher than the values of phenotypic correlation coefficients in both tested years. The analysis of morphological traits has shown a highly significant correlation between leaf mass and stem mass, as well as between stem mass and yield of green biomass. In other words, by increasing stem mass, leaf mass and yield of green biomass of the tested genetic coefficients also increase. Yield of green biomass shows a highly negative correlation (-0.99**) with share of leaves. By increasing share of leaves, yield of green biomass decreases. Share of leaves also shows a negative correlation with stem mass, so by increasing share of leaves, stem mass decreases. As for phenotypic correlation coefficients, we have obtained similar, yet lower values. A positive correlation have been determined between stem mass and leaf mass (0.95**), as well as between yield of green biomass and stem mass. A negative correlation has been determined between share of leaves and stem mass, and between yield of green biomass and share of leaves. The similar results have been obtained in the second year of testing, both with genetic and phenotypic correlation coefficients. Statistical significance of phenotypic correlation coefficients, obtained for certain morphological traits and their impact on yield of green biomass, is of great importance in efforts focused on creation of new genotypes within the species, but also for creation of interspecies hybrid. Direct selection for certain agronomically important traits do not always end in satisfactory results, in spite of use of all modern methods *(Sokolović, 2001)*. Therefore, it is important to have better understanding of the functional, morphological or physiological correlation of traits, i.e. how and to which extent one trait influences the other and vice versa. This is confirmed by results obtained by *(Šurlan–Momirović et.al. 2005)*. These authors concluded that in improvement of certain traits, controlled by majority of genes, often undesirable changes occur in some other traits, which happens due to mutual correlation between traits caused by association between genes. Coefficients of simple correlations indicate the presence of very strong to almost complete, statistically very significant positive correlations; therefore these effects could be expected. In previous researches of mutual correlation and direct and indirect effects of different morphological and technological traits of plant species, deviations are very often in results obtained by simple correlation and path analysis *(Zečević, 1996; Šurlan-Momirović, 2005)*. This, in case of yield of green biomass as economically most important trait, means that its expression is caused by very complex system of various physiological and morphological indicators. *Taylor (2004)* points out that analysis and study of certain morphological traits from various aspects is necessary for defining of reliable strategy in improvement of plant species and achieving expected results in increase of yield potential of new genotypes. The effects of studied morphological traits on yield of green biomass of these genotypes and their very complex mechanism of action on forming of total

yield can be used as significant support in future work aimed at improvement of sorghum.

Table 3. Statistical significance of differences in productive traits of sorghum cultivars

Species,	Share of leaves, %	Green biomass yield, t ha^{-1}
Cultivar	$\bar{x} \pm S\bar{x}$	
NS Džin	$63.2^{c} \pm 0.036$	$59.31^{b} \pm 0.734$
Zora	$56.2^{a} \pm 0.039$	$53.83^{a} \pm 0.896$
Siloking	$48.9^{b} \pm 0.029$	$58.46^{c} \pm 1.399$
LSD 0.05	0.93	0.986
LSD 0.01	1.26	1.340

a, b, c –Values without same letter in superscript are significantly different ($p<0.05$)

Yield of green biomass was above 50 t ha^{-1} which indicated that cultivars of these species had intensive spring growth and high genetic yield potential. The lowest yield was recorded for cultivar *Zora*, and the highest in forage sorghum, and variations between genotypes were significant only in relation to Sudan grass.

Table 4. Significance of correlation coefficients for the yield of green biomass – direct and indirect effects

Phenotypic correlation coefficients				
Traits	Height	Number of leaves	Leaf mass	Stem mass
Height	0,243*	0,036	0,182	0,133
Number of leaves	-0,037	-0,249*	-0,110	-0,134
Leaf mass	-1,513	-0,832	-1,891**	-1,796
Stem mass	1,627	1,803	2,636	2,775**
Total	-0,23	0,84	0,83	0,95
Determination coefficient R2y.1234	92,96%			

Significant at the level of 0.05 (*), 0.01 (**), ns- no significance

Plant height and number of leaves were not directly statistically significant on yield of green biomass. In the analysis of simple correlations, it was established that correlation coefficients between plant height and yield of green biomass, and plant height and number of leaves were very unstable and varied from insignificant and very weak to sporadically medium strong and statistically significant (Table 4).

Conclusion

Results of the study of correlation coefficients on morphological production traits of genotypes of three species of *Sorghum* genus showed the following: morphological traits, height and mass of stem had significant effect on

yield of green biomass of sorghum varieties. Number of leaves, as well as their share in total biomass expressed negative effect on yield. Genotypes differed significantly in their morphological and production traits. In the analysis of simple correlations it was observed that correlation coefficients between plant height and yield of green biomass, and plant height and number of leaves were very unstable and varied from insignificant and very weak to sporadically medium strong to statistically significant.

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Koeficijenti korelacije morfološko-produktivnih osobina vrsta roda *Sorghum*

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Rezime

Predmet istraživanja ove studije su fenotipski i genetički koeficijenti korelacije tri vrste roda *Sorghum*, i to krmni sirak *S. bicolor* Moench. (genotip *NS-Džin*), sudanska trava *S. sudanense* L. (genotip *Zora*) i interspecies hibrid *S. bicolor* x *S. sudanense* (genotip *Siloking*). Ispitivanja su vršena na uzorcima biljnog materijala iz prvog otkosa, Proučavane su sledeće morfološko-produktivne osobine: visina biljke, broj listova po biljci, masa listova na stablu, prosečna masa stabla i prinos zelene biomase. Analizom genetičkih i fenotipskih koeficijenata uočavaju se razlike i zavisnosti u delovanju na ispitivane morfološko-produktivne osobine. Najveću vrednost visine stabla imala je sudanska trava (2,281 m), kao i broj listova po biljci (7,917). Najveća masa listova po biljci bila je u krmnog sirka (49,05 g), a najveću prosečnu masu stabla imale su biljke interspecies hibrida (80,798 g). Variranja ovih morfološko-produktivnih pokazatelja po vrstama bila su signifikantna i vrlo signifikantna. Koeficijenti prostih korelacija ukazuju na postojanje vrlo jakih do skoro potpunih, statistički vrlo značajnih pozitivnih veza, ovakvi efekti su se mogli očekivati. Visina biljke i broj listova nisu bili direktno statistički značajni na prinos zelene biomase, ali indirektno jesu i varirali su od beznačajnih i jako slabih do sporadično srednje jakih i statistički značajnih.

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