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GENETIC AND PHENOTYPIC CORRELATIONS AMONG STUDIED TRAITS OF DIFFERENT ALFALFA CULTIVARS

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Abstract

In this paper are studied 15 cultivars of alfalfa (*Medicago sativa* L.) of different geographical origins. In the studied alfalfa cultivars were tested for correlations of some important traits in 2007. year. Morphological traits were studied: height of plants (cm), number of stems, number of internodes per stem, green mass yield per cutting and the total yield of green mass (g). In the first cut were recorded medium strong positive correlation between the height and yield of green mass (r = 0.76 *). Heritability properties of plant height was very high in the first year (2006, h = 80.52) in the first cut, while in the second year of investigation (2007, h = 56.96), in the second cut. Estimation of heritability properties for green mass yield varied according to age, the highest value was obtained in the first cut 2006. year (h = 72.75), indicating a high share of genotype, while the lowest value was obtained also in the first cut in the 2007. year (h = 29.55). Breeding material possesses desirable traits for breeding new cultivars and with the choice of an appropriate model of breeding possible selection activities cultivars for specific purposes.

Key words: *alfalfa, cultivar, correlation, trait.*

Introduction

Alfalfa is a perennial and most important for multiple cuts fodder plant, which gives high yields and excellent quality forage in different environmental conditions (Đukić and Erić, 1995). Depending on the genotypes, characterized by high variability in forage yield (CV=28.6%) (Štrbanović, 2010). It is grown in the world over an area of 33 million hectares, while in Serbia represented an area of about 190.000 hectares. Areal of alfalfa cultivation on all continents covers more than 80 countries, from moderately cold to the tropics. The wide geographical distribution of alfalfa is conditioned by its great adaptability to different climatic and soil conditions (Julier *et al*., 1995). During of breeding certain traits that are controlled by a larger number of genes often lead to undesirable changes in the direction of some other important traits, which is due to mutual correlation in characteristics caused by the attachment of genes or pleiotropic effect (Šurlan-Momirović *et al*., 2005). It is therefore important to know the properties of interdependence traits, or in what way and to what extent one trait affects the other, which will allow easier identification of criteria and predict the course of breeding (Falconer and Mackay, 1996). Particular attention should be paid to genetic correlation coefficients that determine relationships between traits based only on genotype, without the influence of environmental factors.

Material and methods

In this paper studied 15 cultivars of alfalfa (*Medicago sativa* L.). Nine of selected cultivars of alfalfa were of the US origin and six of selected cultivars of alfalfa were of Europe origin (Table 1). The experiment was placed at the experimental field of the Institute for forage crops in Globoder at an altitude of 149 m. Experiment was placed on soil type alluvial sediment and is characterized by good physical - chemical properties, has a neutral pH value

(about 7), which is very favourable for growing alfalfa. Sowing of individual plants was performed manually in the spring, at the beginning of April 2005. at a distance of 60 to 60cm. The experiment was a randomized block design with four replications, with 60 plants per variety. In the course of performing experiments implemented a complete agricultural technology. Morphological traits were studied: height of plants (cm), number of stems, number of internodes per stem, green mass yield per cutting and the total yield of green mass (g). Based on the analysis of variance have been calculated components of variance studied traits.

Genetic (σ_g^2) and phenotypic (σ_f^2) components of variance:

$$\sigma_g^2 = \frac{MS_2 - MS_3}{r}\ ; \qquad \sigma_f^2 = \sigma_g^2 + \sigma_e^2\ ; \qquad \sigma_e^2 = MS_3$$

On the basis of the components of variance is calculated heritability in a broader sense (x_b^2):

$$h_b^2 = \frac{\sigma_g^2}{\sigma_f^2} \times 100$$

The coefficients of genetic and phenotypic variation (CVG and CVF) were calculated as follows:

$$CV_G = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100 \qquad CV_F = \frac{\sqrt{\sigma_f^2}}{\bar{X}} \times 100$$

The analysis of covariance examined characteristics of the studied alfalfa cultivars, calculated coefficients of genetic and phenotypic correlations.

- genetic correlation coefficient

$$r_{g_{xy}} = \frac{COV_{g_{xy}}}{\sqrt{\sigma_{g_x}^2 \times \sigma_{g_y}^2}}$$

- phenotype correlation coefficient

$$r_{f_{xy}} = \frac{COV_{f_{xy}}}{\sqrt{\sigma_{f_x}^2 \times \sigma_{f_y}^2}}$$

Table 1. The origin of the studied alfalfa genotypes (*Medicago sativa* L.)

Ordinal number	Cultivars	Origin
1	Mecca III	USA
2	Dynamic	USA
3	Pointer	USA
4	Weston	USA
5	DKA 50 – 18	USA
6	WL – 625 HQ	USA
7	Tru test	USA
8	Ameri stand	USA
9	Integrity	USA
10	K – 22	Serbia
11	K – 28	Serbia
12	Population Uzice	Serbia
13	Vali	Slovakia
14	Synteza 1	Slovakia
15	OS – 95	Croatia

Results and discussion

In the studied alfalfa, cultivars were tested for correlations of some important traits in 2007. year. Research in the first two cuts, which generate over 60% of the fodder and represent best performers and most importantly cuts alfalfa. Among individual characteristics were significant and highly significant correlation expressed genetic and phenotypic correlation coefficients (Tables 2. and 3.).

Table 2. Correlation coefficients of genetic and phenotypic traits studied alfalfa cultivars, 2007. the first cut.

Phenotype / Genotype	Height of plants	Number of internodes per stem	Number of stems	Green mass yield in the I cut	Total yield of green mass
Height of plants		0.57	- 0.57	0.76*	0.45
Number of internodes per stem	0.32		- 0.38	0.69	0.25
Number of stems	- 0.40	- 0.17		0.31	0.30
Green mass yield in the I cut	0.62	0.30	0.33		0.38
Total yield of green mass	0.46	0.17	0.29	0.31	

Table 3. Correlation coefficients of genetic and phenotypic traits studied alfalfa cultivars, 2007. the secund cut.

Phenotype / Genotype	Height of plants	Number of internodes per stem	Number of stems	Green mass yield in the I cut	Total yield of green mass
Height of plants		0.40	- 0.46	0.79*	0.44
Number of internodes per stem	0.21		0.02	- 0.33*	-0.22
Number of stems	- 0.14	0.24		0.49*	0.79*
Green mass yield in the II cut	0.65	- 0.35	0.44		0.32
Total yield of green mass	0.42	-0.15	0.57*	0.63	

In the first cut were recorded medium strong positive correlation between the height and yield of green mass (r = 0.76*). In the second cut were recorded medium strong positive correlation between the height and yield of green mass (r = 0.79*), number of stems and yield of green mass (r = 0.49*) and the number of stems and total yield of green mass (r = 0.79*). A

negative correlation was observed between the number of internodes per stem and yield of green mass (r = - 0.33*). For other traits calculated correlations were not significant. Radovic (2005) was found strong positive correlation between yield and number of stems (r = 0.66**), as well as medium strong correlation between the yield of green mass with the number of stems (r = 0.49*). Zonjić (1961) reported a high correlation between weight and plant height (r = 0.92**). In his research Zoric (1993) determined a strong correlation between the height of plants and yield of green mass (r = 0.69**), as well as number of stems and green mass yield (r = 0.78**). Strong positive correlations between height of plants and yield of green mass presented many authors in their research (Mijatovic, 1960, Zonjić, 1961, Ivanov, 1980, Hauptvogel, 1994, Katic, 2000). In examining the 36 alfalfa cultivars Varga et al., (1994), have determined a negative correlation between yield and number of internodes per stem (r = - 0.53**). The share of genetic variance is quite high for almost all the characters, which tells us that for the most part variation of the studied traits responsible genotype of the plant.

Plant height

Heritability properties of plant height was very high in the first year (2006) and reached h = 80.52 in the first cut, while in the second year of investigation (2007) reached h = 56.96, in the second cut. A very high share of genetic variation coefficient, which indicates that the value of phenotypic properties of plant height for the most part influenced by genotype.

In the estimation of heritability has a large influence plant density (Cristophe, 1973), so that with increasing plant density decreases heritability. Therefore, it can be concluded that the characteristics of plant height is highly heritable and that can be done on the basis of plant breeding level to improve the properties of yield (Table 4).

Table 4. The components of variance, heritability and coefficient of variation for plant height alfalfa cultivars studied from first to fourth cuttings in 2006. and 2007.

Trait	Height of plants							
	1. cut		2. cut		3. cut		4. cut	
Parameters	2006.	2007.	2006.	2007.	2006.	2007.	2006.	2007.
σ^2_g	101.8	66.24	12.51	66.24	11.56	26.03	27.44	40.06
σ^2_f	126.5	116.3	26.84	116.3	25.37	57.0	65.10	114.3
h^2_b(%)	80.52	56.95	46.61	56.96	45.57	45.67	42.15	35.05
CV_G(%)	9.68	9.92	4.58	9.92	4.72	7.67	9.53	8.93
CV_F (%)	10.78	13.14	6.71	13.15	6.98	11.36	14.67	15.09

Number of stems

The heritability of the characteristic number of stems per plant was quite high in both study years. The highest value of the year 2006. showed in the third cut (h = 62.47), while in the second year of investigation (2007), the highest value was shown in the first cut (h = 57.11). Genetic coefficient of variation is quite high in both studied years. The highest values showed in the first cuts in both years, and was 20.98% in the year 2006., while in the 2007. year showed slightly higher value 25.31%. All this indicates that the phenotypic characteristic of component number of stems under the strong influence of genetic components. Sikora, (1974) for this property states that the genetic variance in total phenotypic variance was 89%. The

high heredity of this trait suggests that it can be used as selection criteria in the plant yield, because there is a strong correlation between the number of stems and plant mass (Table 5).

Table 5. The components of variance, heritability and coefficient of variation for stem number of alfalfa cultivars studied from first to fourth cuttings in 2006. and 2007.

Trait	Number of stems							
	1. cut		2. cut		3. cut		4. cut	
Parameters	2006.	2007.	2006.	2007.	2006.	2007.	2006.	2007.
σ^2_g	84.43	229.8	79.59	189.6	139.8	136.2	109.3	80.14
σ^2_f	155.9	402.4	138.6	404.7	223.7	483.8	181.7	338.3
h^2_b(%)	54.14	57.11	57.41	46.85	62.47	33.74	60.18	23.69
CV_G(%)	20.98	25.31	15.93	16.30	18.79	15.81	19.29	16.13
CV_F (%)	28.51	33.49	21.02	23.82	23.73	27.22	24.87	33.15

Number of internodes per stem

Number of internodes per stem directly influences the increase of green mass and thus the quality of alfalfa, so that is a very important trait. The greatest value of this property as far as the heritability was found in the first cut of 2006. year (h = 58.81), while the lowest value recorded in the second cutting of 2007. year (h = 14.04) (Table 6).

Table 6. The components of variance, heritability and coefficient of variation for number of internodes per stem of alfalfa cultivars, studied from first to third cuttings in 2006. and 2007.

Trait	Number of internodes per stem					
	1. cut		2. cut		3. cut	
Parameters	2006.	2007.	2006.	2007.	2006.	2007.
σ^2_g	1.42	0.349	0.49	0.18	0.51	0.59
σ^2_f	2.41	2.244	1.37	1.27	0.99	1.48
h^2_b(%)	58.81	15.53	35.76	14.04	51.49	40.22
CV_G(%)	7.58	4.19	6.03	3.28	5.47	7.81
CV_F (%)	9.88	10.62	10.09	8.77	7.63	12.32

Green mass yield per cutting and the total yield of green mass

Estimation of heritability properties for green mass yield varied according to age, the highest value was obtained in the first cut of 2006. year (h = 72.75), indicating a high share of genotype, while the lowest value was obtained also in the first cut in the 2007. year (h = 29.55). Similar values as heritability demonstrated genetic coefficient of variation, which is in the first cut of 2006. was 21.45%, while in the first cut of 2007. was 12.03%. Such results can be explained by the strong influence of climate, drought and actually very high temperatures. Jacquard and Hanan (1970) found that the size of heritability for green mass yield depends on the conditions in which the estimate is done, an example density of the plants, so they get a higher percentage of heredity in rare plant density (h = 77) compared to the compacted plant density (h = 54). Due to the differences in heritability and the total yield of green mass, we can conclude that the heredity of green yield in under the increasing influence of environmental factors (Tables 7. and 8).

Table 7. The components of variance, heritability and coefficient of variation for green mass yield per cutting alfalfa cultivars studied from first to fourth cuttings in 2006. and 2007.

Trait	Green mass yield per cutting							
	1. cut		2. cut		3. cut		4. cut	
Parameters	2006.	2007.	2006.	2007.	2006.	2007.	2006.	2007.
σ^2_g	23862.5	4350.3	923.8	10838.6	1381.1	6217.4	949.9	4876.1
σ^2_f	32801.3	14721.5	3358.3	19588.9	3772.6	10926.9	2242.4	8303.8
h^2_b(%)	72.75	29.55	27.51	55.33	36.61	56.90	42.36	58.72
CV_G(%)	21.45	12.03	8.95	15.89	11.71	21.80	15.69	26.25
CV_F(%)	25.15	22.13	17.07	21.36	19.36	28.80	24.11	34.25

Table 8. The components of variance, heritability and coefficient of variation for total green mass yield alfalfa cultivars studied in 2006. and 2007.

Trait	Green mass yield - total	
Parameters	2006.	2007.
σ^2_g	35345.6	60509.9
σ^2_f	65936.1	177206.1
h^2_b(%)	53.61	34.15
CV_G(%)	11.95	13.86
CV_F(%)	16.32	23.71

Conclusion

Significant differences were found both between and within the studied alfalfa cultivars for most traits depending on cuts and years of research. The recorded positive correlations in the first and second cuts in the second year (2007) research. In the first cut were recorded medium strong positive correlation between the plant height and yield of green mass (r = 0.76*). Similar results positive correlations were obtained in the second cut. The negative correlation in the second cutting was found between the number of internodes per stem and yield of green mass (r = - 0.33*). Analyzing the components of variance is a very high share of genetic variance in total, which indicates that the impact of environmental factors on gene expression is very low, that is, for the most part responsible genotype variability. This confirms the very high values for the coefficients of heritability in a broad sense, ranging from 34.28% to 72.76% for the total dry matter yield. Breeding material possesses desirable traits for breeding new cultivars, and with the choice of an appropriate model of breeding, possible selection activities cultivars for specific purposes.

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References

Cristophe, C. (1973): Action de la densite de population sur des parametres genetiques de la luzerne. Ann Amelior Plantes, 23 (I), 67-76.

Đukić, D., Erić, P. (1995): Alfalfa. Monograph. Faculty of Agriculture, Novi Sad. 256.

Falconer, D. S., Mackay, T. F. C. (1996): Introduction in quantitative genetics. Fourth edition, Longman group, London and New York.

Hauptvogel, P. (1994): Evaluation and utilization of alfalfa genetic resources in breeding programs in Slovakia. EUCARPIA, Section Lucerne, Rome, Management and breeding of perennial lucerne for diversified purpose, 177-181.

Ivanov, A. I. (1980): Lucerna, Kolos, Moskva, 349 s.

Jacquard, P. and Hanan, A. (1970): Variability Of Competition Responses For 14 Alfalfa "Genotipes". Eucarpia meeting, Lusignan, 237-258.

Julier, B., Porcheron, A., Ecalle, C., Guy, P. (1995): Genetic variability for morphology, growth and forage yield among perennial diploid and tetraploid Lucerne populations (Medicago sativa L.). Agronomie 15, 295-304.

Katić, S. (2000): Genetic and phenotypic correlations production characteristics of alfalfa (Medicago sativa L.). Doctoral dissertation, Faculty of Agriculture, Novi Sad.

Mijatović, M. (1960): Morphological, biological and production characteristics of alfalfa (Medicago sativa L.). Doctoral dissertation, Faculty of Agriculture, University of Belgrade.

Radović, J. (2005): Genetic variability of production characteristics and quality of selected population alfalfa (Medicago sativa L.). Doctoral dissertation, Faculty of Biology, Belgrade.

Sikora, I. (1974): Evaluation of phenotypic and genetic parameters in the Pannonian alfalfa and their use in breeding. Doctoral dissertation, Zagreb.

Štrbanović, R. (2010): Genetic variability for agronomical traits of different alfalfa genotypes (Medicago sativa L.). Master thesis, Faculty of Agriculture, Belgrade. 99.

Šurlan-Momirović, G., Rakonjac, V., Prodanović, S, Živanović, T. (2005): Genetics and Plant Breeding. Practicum. Faculty of Agriculture, Belgrade.

Varga, P., Dihoru, A., Schitea, M., Martura, T. (1994): International field trials with alfalfa cultivars at Fundulea Institute. Management and breeding of perennial lucerne for diversified purposes, Proceedings of meeting organized by INRA in Lusignan, 4-8 September, FAO Rome, 212-217.

Zonjić, I. (1961): The study of correlations between some characteristics of alfalfa (Medicago sativa L.). Book of Proceedings, Faculty of Agriculture, Belgrade. 1-12.

Zorić, J. (1993): Quantitative and qualitative traits of alfalfa hybrid (Medicago sativa L.) in Slavonija. Review of research work at the Faculty of agriculture. 38 (1), 39-46.